25 years of Landscape Ecology: Scientific Principles in Practice

Part 1, Plenary sessions, Theme 1-5

Proceedings of the 7th IALE World Congress
8 – 12 July Wageningen, The Netherlands
July, 2007

Editors: R.G.H. Bunce, R.H.G. Jongman, L. Hojas and S. Weel

ISBN 978-90-78514-02-2

This publication should be cited as follows:
Bunce, R.G.H., Jongman, R.H.G., Hojas L. and Weel S. (Eds) 2007. 25 years Landscape Ecology: Scientific Principles in Practice. Proceedings of the 7th IALE World Congress 8 – 12 July Wageningen, The Netherlands, IALE Publication series 4

Published by IALE,
This publication has been made possible with support of the Dutch Ministry of Agriculture, Nature and Food Quality, The Dutch Ministry of Spatial Planning and Environment, Alterra, Wageningen UR, ArgoBecas (Spain)
This publication is available from IALE:http://www.landscape-ecology.org
Price: € 40 for members including handling and mailing
Price: € 50 for non members including handling and mailing

Cover drawing: Bob Bunce
The cover drawing is a model landscape designed to show the Congress themes as follows:
Theme 1: The landscape contains policy issues e.g. wind power , urbanization and tourism.
Theme 2: Urban areas, industrial development and motorways are all present.
Theme 3: Agriculture dominates in the centre of the drawing with the mtotrway causing fragmentation Urban development and tourism are also involved.
Theme 4: There is a large lake with a river flowing into it.
Theme 5:Monitoring is needed to follow changes taking place.
Theme 6: The mountains have tourist pressures and High Nature Value land.
Theme 7: Many changes are taking place e.g. the construction of a ski resort.
Theme 8: The power plant and the wind farm show the impacts of global energy demand.
Theme 9: Many planning issues are included e.g. urban expansion.
Theme 10: The motorway cuts through forests on the mid-slopes.
Theme 11: Forests are being conserved in priority areas

Cover design: Silvia Weel

Printed by Ponsen and Looijen bv Wageningen, The Netherlands

Content

Introduction

The present volume contains the abstracts of the 7th International Association of Landscape Ecology (IALE) World Congress. The Congress celebrates the first 25 years of IALE, which was founded in a divided world by western and central European participants in the Symposium on Landscape Ecological Problems in Piestany, Slovakia in 1982. IALE initially developed in North America and Europe but has now extended to all continents and to many countries, as is evident from the approximately fifty national representatives in the present volume. IALE continues to expand and new regions are being set up, for example in 2005 and 2006 in Brazil and Argentina
Two other books will be launched at the Congress, one by Landscape Europe and one by the Dutch landscape ecological organization (WLO). The present volumes serve a different purpose, which is to bring together in one document the full range of topics covered by modern landscape ecology and to serve as a guide to the oral presentations and posters of the Congress. They will also be useful after the Congress as a source of reference material on subjects and authors..
We have done our best in the time available to get the book into a consistent format but inevitably with such a large number of abstracts the standards are not as high as in a scientific journal or report. However, we considered it to be more important to include all the abstracts that were sent in rather than being selective. We hope you find them as useful as previous collections of Congress abstracts
The Congress of is being held in Wageningen and Ede, The Netherlands and represents a great opportunity for landscape scientists from the whole world to share their ideas. This book of abstracts presents an overview of the work that will be presented at the congress.
The Congress focuses on the scientific principles of landscape ecology and their practical applications to conservation, land and water management, as well as their relationship with land use planning, both now, and in the future. Many abstracts show the increasing importance of remote sensing and Geographic Information Systems, spatial statistics and modeling. The Congress also demonstrates the way in which landscape ecology is playing an increasingly important role in spatial planning for landscape and biodiversity objectives.
Landscape ecology can be defined as the holistic understanding of the relationships between ecological components of landscapes, including the impact of human activities through planning and management. The underlying motivation for many landscape ecologists is that their research should lead to potential applications for social benefit. Within landscape ecology there is also a strong recognition of the role of man in the functioning of many landscapes as well as in their past development.
The Scientific Committee invited IALE members to propose Symposia and 25 were selected from those who reacted. These Symposia form the core of the Congress and the organisers accepted the challenge to coordinate programmes in their field. Many additional papers and posters were also forwarded to the Organising Committee. All of these contributions were accepted, although many needed editing before being included in the book of abstracts. The Organising Committee first examined whether the contributions could be assigned to existing symposia, but then looked for common topics and scheduled these to complementary Open Sessions. In addition about 250 posters were also sent in, which were subsequently linked to eleven overarching themes, which form the basic structure of the Congress programme. The abstracts of all contributions are included in this book , with two pages for oral presentations and one page for posters. In most cases the full posters are also included in the CD-ROM in the back of the book. The eleventh theme consists of posters describing Landscape oriented EU-Life projects.

The Congress programme has been structured as far as possible to ensure that related Symposia and Open Sessions are not in conflict. Participants can therefore choose to listen to presentations with minimal conflicts of interest, although inevitably some problems will occur. The Workshops have also been integrated within the programme, although at first, because of the number of participants, this was not possible. As the posters are linked to the themes, they will be set up under these headings in sections of the hall in the Congress venue so that participants can see which posters they wish to visit.

The Congress and the book of abstracts have been made possible with internal support from the Environmental Science Group of Wageningen UR, The Dutch Ministry of Agriculture, Nature and Food Quality, the Dutch Ministry of Environment and Spatial Planning, The Dutch Royal Academy of Sciences, Argos Becas in Salamanca Spain, CTA, the Wageningen Research Schools PE&RC and WIMEK-SENSE, ESF-Eurodiversity, the province of Drente, the Dutch State Forestry and the Dutch Society for Nature Conservation (Natuurmonumenten). The town of Wageningen will also give a reception at the start of the Congress. Finally, the Wageningen Congress Organization Bureau (OBW, Yvonne van Hezik and Ingrid Luitse-Looijen) not only helped with the organization for two years before the Congress but also arranged the social programme.

Bob Bunce, Rob Jongman, Lorena Hojas and Silvia Weel

Wageningen
12-5-2007

Plenary lectures

The role of landscape ecology in planning and decision-making

A.N. van der Zande,
E-mail: A.n.vanderzande@wur.nl

Land Use Planning Groups, Wageningen University, The Netherlands

Since the realisation of the Ecological Network started in 1990, ecology is a part of decision-making in the Dutch legislation. But since, problems to solve in society are becoming more complex. The complexity partly originates by EU and international legislation, the water directive and Kyoto protocol, but also by interference of economic and social problems. The development in agriculture influences the development of the rural area and the possibilities of the Ecological Network and Natura2000. The recent knowledge about climatic changes is adding to that.
Development in landscape ecology is not following this development (van der Zande, 2007).
There are different reasons that development in landscape ecology and complex problems in society are not developing parallel.
There is not one simple factor to declare the differences in development, scientists, policymakers and society, all are taking their share.
When we analyse where (landscape) ecology is adding to policymaking or to public discussions, we come to a variety of experiences.
The Netherlands Environmental Assessment Agency reports annually about the state of nature and environment in the Netherlands. Usually this results in some public or political awareness, but has not yet resulted in strong political actions or changes in research questions.
These reports are usually descriptive and building on existing knowledge and usually doesn't have breaking news. Reports influencing political discussions usually originate from international background; Millennium assessment and the IPPC reports on climatic changes are examples.
In recent years universities and research institutes are able to add in discussions on very specific topics in decision making on national level. Examples in the Netherlands are for instance policy making on NH4 in the environment of Natura2000 areas. Localisation of Natura 2000 areas. Landscape ecology is used in a descriptive way or on very specialised issues like NH4 models.
More fundamental research is usually done in a European or international context, for instance ecology in relation to climate changes. Public and political discussions following usually years after scientists discovered the phenomena and therefore do not often add directly in national decision-making.

The most innovative development in landscape ecology is happening in community of practise while implanting the national legislation on the local and regional level. An example is given
Community of practise
To compensate environmental problems subsidies is granted for owners to restore ecosystems. To help owners expert groups are active per ecosystem type. These expert groups include scientists and also representatives of nature management organisations, ngo's and water boards and policy makers. Selection of people is based on knowledge of the specific ecosystem of the nature reserve where experiments take place. Scientists are form different background, depending of the ecosystem ecologists, hydrologist, soil scientists etc. These expert groups recognize actual field problems more quickly and are to innovate new management methods. In the past 15 years, dozen of nature sites have been restored and more than hundred rare of even long lost species have returned to the treated sites.

Recently are comparable expert group is established for meadow birds. Scientists, farmers, nature management organisations, ngo's, local policymakers are included in this expert groups.
So developed knowledge moves from the expert group into the organisations from which people were part of the group. Spreading knowledge by "own "people works relatively easy, but needs attention.

More innovation of landscape ecology in the near future is necessary. Implementation of Natura 2000 and of the Water Directive combined with climatically changes in a heavily populated and industrial society, as the Netherlands needs all the creativity and innovation we can think of. We have to learn from history how innovation can occur. Many innovations develop in a non-institutional environment, where unexpected disciplines and persons meet each other. Community of practise is an example of a non-institutional instrument, proven to be a working instrument but not necessary the only one.
For the future an important target is to realise a better communication between the problems in the society, the world of policymakers and scientists. Beside communication, a targeted process, where using adequate knowledge during the process of decision-making is absolutely necessary.
To realise a more knowledge intensive and more innovative policymaking, a number of things have to change.
Scientific institutions should reward researcher for research applications, not only for scientific status.
Working with real expectations on both sites. For policy makers, complex problems cannot be solved by science in a couple of month.
Scientists have to accept that society defines the problems with they should solve, not single issue but with all the different disciplines necessary. A common developed research agenda could be one of the instruments.
Learning from the community of practise, more flexible networks on specific topics should be created to help the national and international policymakers.

Landscape Ecology and Agriculture

J. Baudry[1], S. L. Poggio[2]

[1] INRA (National Institute for Agronomic Research), SAD Paysage, Rennes, France.
e-mail: jbaudry@rennes.inra.fr
[2] Facultad de Agronomía, Universidad de Buenos Aires, Av. San Martín 4453, (C1417DSE) Ciudad de Buenos Aires, República Argentina

Introduction

Agriculture is a major factor driving landscape changes at a global scale. It has been so for millennia, centuries and even shorter periods in some regions .Contrasting historical backgrounds mean that landscapes have different structures and ecological characteristics. Currently, changes in the ecology of agricultural landscapes are progressively driven by global factors such as international commerce and technological advances. We propose to explore those dynamics at different scales taking the Rolling Pampas of Argentina and the Atlantic bocage of Western Europe as case studies. These two areas are not only currently linked by the flow of agricultural commodities from Argentina to Europe, but also by the cultural heritage that built Argentinean agriculture and rural landscapes due to European immigration during the XIXth century. They also offer strong contrasts in terms of agricultural history and vegetation before the arrival of agriculture. The Pampas were strictly grassland vegetation without trees, while forest was the dominant land cover in Western Europe.

A diversity of farming and landscapes situations

In the Atlantic bocage, farms are diverse, even though they are mostly oriented toward stock farming. The amount of permanent grassland and hedgerow density is an important difference as is the amount of fertilization, which increases with the amount of arable fields and decreases with more hedgerows. Farm size varies from 20 to 100 ha.

The farms of the rolling Pampas have become increasingly specialised in the production of crops during the 1990's. Formerly farms were more diverse, including cattle and more crop species. Nowadays few mixed farms remain and are mainly restricted to the lowlands. Landscapes are characterised by fields ranging from 30 to 100 ha, which are surrounded by a complex network of linear elements. Furthermore, abandoned small patches near settlements and the outskirts of small towns and cities, are also characteristic features of Pampean landscapes.

The driving forces

In the 1950's, the pressure in some regions (e.g. the bocage of Brittany) came from the willingness of young farmers to stay on farms. This created a major pressure on the land and led to more intensive land use involving higher stocking rats and fertilization). Starting in the 1960's the European Common Agricultural Policy encouraged farmers to produce more so that the Community could become self-sufficient. Many farmers left to provide labour to industries, allowing farm enlargement and further increases in productivity. The WTO is becoming a major agent trying to regulate the world commerce of agricultural commodities and to change agricultural policies toward more liberalization and less public subsidies in Europe. In contrast agriculture in Argentina is under a free market regime with high tax rates on the export of agricultural commodities.

Agricultural and environmental policies have been, and still are, important tools in shaping agricultural systems and the landscapes they produce. Labour is becoming a scarce resource in Western Europe and now influences the maintenance of landscape elements such as hedgerows and field margins In Argentina, unlike Western Europe, there was an important migration of people from rural areas to urban areas during the 1940's and 1950's. An important process of agricultural expansion started during the 1970's, in order to increase foreign currency income through the export of grain crop commodities.

The pressures

Similar pressures prevail in Argentina and Western Europe, with the three dominant types being 1) changes in land cover (increasing area of arable land at the expense of permanent grassland; fewer crops), 2) changes in landscape structure (hedgerow removal, filed enlargement) and 3) changes in land management (higher fertilization and usage of pesticides; less varieties of a given crop). The use of herbicides has also been extended from fields to field boundaries and road verges that were formerly refuge habitats for species.

The ecological impacts

The ecological impacts have been extensive in Europe, with losses of biodiversity, at least in certain taxa such as birds and butterflies at the European scale with other declines at the landscape scale. Nowadays, habitat fragmentation is caused by practices such as pesticide as much as land cover change. Eutrophication of terrestrial and aquatic habitats is also a major cause of biodiversity loss. Mineral fertilization is now however a minor impact. The main cause is organic nitrogen coming from pig and cattle slurry; these animals being largely fed in some areas by imported feedstuffs e.g. from Argentina..

Landscape homogenisation and habitat loss are the most important ecological impacts of the agricultural intensification in the Pampas, negatively affecting associated biodiversity. Field enlargement, fencerow removal, and the permanent replacement of pasture land by crops, has reduced remnant habitats for native flora and fauna. Furthermore, agriculture intensification has changed the seasonal dynamics of ground-cover and productivity affecting food and shelter availability for wildlife.

The policy responses

Policy responses are very different in the EU and Argentina, because of the historical factors referred to above. The EU has a long tradition of subsidizing agriculture, starting in the 1960's and 1970's to increase production and the efficiency of the sector. Since the 1990's a minor proportion of the subsidies has been shifted toward agri-environmental schemes aimed at reducing pressures on the land and restoring landscapes.

Since the exportation of agricultural commodities is the most important foreign income of Argentina, policies are strongly oriented to increase agricultural productivity promoting crop breeding and the adoption of new technologies. Unlike the EU agri-environmental schemes, Argentina lacks of clear policies aiming to reduce the negative impact of agriculture on land and to restore rural landscapes.

The role of landscape ecology

The development of landscape ecology, often originating from landscape design and management questions, has been essential for understanding the causes and mechanisms of ecological change in agricultural landscapes. The issues of habitat fragmentation, diminishing landscape permeability, interactions between crops and their surroundings were all made possible by the emergence of the concepts and methods of landscape ecology. The discipline is also very helpful as it strongly emphasizes the linkages between social and ecological systems and has strong spatial and temporal components.

There are still many themes to develop. In Europe pastoral, bocage landscapes are more studied than cereal prairies; the later harbour different types of species, some of which are very valuable. The complementarity of landscapes at national and continental scales is not well understood. In addition there is the compatibility of landscape requirements for different types of species as well as a further understanding of the relationships between biodiversity and water quality. The intention should be to progress towards a more comprehensive understanding of landscape functions, in both ecological and socio-technical terms.

Landscape ecology and north-temperate forests

K.J. Kirby

Natural England, Northminster House, Peterborough, PE1 1UA, UK,.
e-mail: Keith.kirby@naturalengland.org.uk

Introduction

Anton Chekov in his play *Uncle Vanya* (c1889) refers to the clearance of Russian forest and the consequent loss of species. Worldwide, forest cover continues to decline, mainly through conversion to agricultural land. However, in the north-temperate zone the decline is less and in Europe forest cover is increasing (FAO, 2006). Locally the scale of reforestation can be substantial: in the Eastern United States forestry cover had dropped to about 25% cover in the 19th century, but grew back so it is now 60-90% as farms were abandoned by settlers who moved west (Foster and Aber, 2004). In Europe alpine meadows are scrubbing up as traditional grazing is abandoned. In Britain forest cover has risen from about 5% c1900 to 12% (Forestry Commission, 2002); the National Forest (c520km^2 in the middle of England) has gone from 6% to 17% forest since 1991 (www.nationalforest.org).

Changes to the pattern of patches as used by different species do not necessarily reflect those of the forest cover as a whole. Some species are confined to coniferous forest, some to broadleaved; within broadleaved forest some plants are restricted to acid soils, some to base-rich ones; within base-rich broadleaved woodland some invertebrates are associated with old decaying trees, others with the ground flora of canopy gaps.

Forests are often associated with stability, but for the species in them conditions may be far from stable. A patch of ground moves from being an open gap, through a dense thicket stage, to being a patch of mature or over-mature trees. For a species associated with a particular stage, eg a butterfly of open glades, the number and distribution of suitable patches change over time. The classic metapopulation model, with stochastic loss from suitable patches, needs to be super-imposed on a shifting suite of patches.

To what extent however are forest species limited by fragmentation in practice (Bailey, 2006)? Forest species differ considerably in their colonisation abilities, from large herbivores and birds that may migrate over thousands of kilometres each year to woodland plants that appear to spread at only a metre or two a year (eg Brunet and Oheimb, 1998). The most sedentary species pose a particular challenge: if rates are so low how did the species spread back through Europe after the last glaciation: are we missing the rare long-distance dispersal, is a dispersal agent missing, or have species dispersal characteristics changed?

Drivers of change in temperate forests and their surroundings

Within the cultural landscapes and forests that characterise much of Europe, and parts of the temperate zone elsewhere, changes in forest management practice are leading to changes in the extent and distribution of different forest age classes (patch types). For example shifts from coppice management to high forest systems lead to a reduction in proportion of open space (Hopkins and Kirby, in press).

Across much of the temperate zone rising deer populations have led to changes in the structure and composition of forests. Increased movement of deer between forest patches may help disperse some seeds, but for other species the changes lead to reduced populations and hence increased risk of stochastic extinction events and reduced dispersal.

Changes in landscape diversity through removal of other semi-natural habitats may increase the effective isolation of forest species populations through reduced landscape permeability. Major developments such as roads create additional barriers to species movement. On farmland use of pesticides and fertilizers has increased, leading to impacts on the vegetation at woodland edges. More general eutrophication and acidification effects have been detected in woods, presumably from the effects of atmospheric deposition (Thimonier *et al*., 1994). However forest nutrient levels may be increasing because fewer nutrients are removed, for example as wood-fuel (forest biomass in Europe is increasing) (Hofmeister *et al*., 2004).

Climate change effects have been found in woods (Kirby *et al*. 2005) and models produced on potential future species distributions. There are however uncertainties as to how individual species responses will be affected by interactions with other species through competition, predation, expansion of alien species, changes in herbivory etc.

Policy and practice responses

Managing to maintain species richness within existing sites may be the most effective short-term response to enhance the future spread of forest species through a landscape. Policies and incentives can be developed to promote traditional-type management (in cultural landscapes), control of high deer populations, and buffering of small woods against the effects of adjacent agricultural operations.

Agri-environment schemes and forest grants can be used to encourage the maintenance and creation of features that improve the permeability of the landscape to forest-species movement. Opportunities should be taken to incorporate trees and woodland associated with urban and transport developments, as part of sustainable drainage systems, in public access land, and as part of greenways (Jongman and Pungetti 2004).

We must also recognise that through climate change our forests will alter – we cannot keep all as it is, but we should aim to develop a forest landscape of at least equal value.

References

Bailey, S. (in press). Increasing connectivity in fragmented landscapes: an investigation of evidence for biodiversity gain in woodlands. *Forest Ecology and Management*

Brunet, J. & Oheimb, G.Von (1998) Migration of vascular plants to secondary woodlands in southern Sweden. *Journal of Ecology* **86:** 429-438.

FAO (2006) *Global forest resources assessment 2005*. FAO, Rome.

Forestry Commission (2002) *National inventory of woodland and trees: Great Britain*. Forestry Commission, Edinburgh.

Foster, D.R. & Aber, J.D. (2004) *Forests in time*. Yale University Press, New Haven and London.

Hofmeister, J., Mihaljevic, M. & Hosek, J. (2004) The spread of ash (*Fraxinus excelsior*) in some European oak forests: an effect of nitrogen deposition or successional change. *Forest Ecology and Management* **203**: 35-47.

Hopkins, J.H. &Kirby, K.J. (in press) Ecological change in British broadleaved woodland since 1947. *Ibis* .

Jongman, R. & Pungetti, G. (2004) *Ecological networks and greenways*. Cambridge University Press, Cambridge.

Kirby, K.J., Smart, S.M., Black, H.I.J., Bunce, R.G.H.,Corney,P.M.& Smithers,R.J. (2005) *Long term ecological change in British woodland (1971-2001).* Peterborough: English Nature.

Thimonier, A., Dupouey, J.L., Bost, F. & Becker, M. (1994) Simultaneous eutrophication and acidification of a forest in north east France. *New Phytologist* **126**: 533-539.

Landscape ecology and urban development

J. Iverson Nassauer

e-mail: nassauer@umich.edu
School of Natural Resources and Environment, University of Michigan, USA.

While each of the plenary themes addresses landscapes that are affected by human activities, the theme of urban development puts us squarely in the realm of culture and *intentional* landscape change. Furthermore, this theme confronts us with the challenging global trend of an increasingly urban population -standing at more than 50 per cent living in urban areas today. In this urbanized world of culturally constructed landscapes, landscape ecology offers key insights for urban development by:

- reminding us of fundamental material realities that exist with or without culture: biogeochemical processes, ecological functions, and spatial patterns,
- investigating these material realities in the context of cultural phenomena, and
- demonstrating the interdisciplinarity that has been recognized as essential for understanding urban ecosystems.

I frame this review of by characterizing several advances in our understanding of landscape ecology and urban development. These include:

- similarities and differences between the landscape ecology of urban landscapes and other landscape types,
- spatial patterns of urban development and related biogeochemical and ecological processes of urban and peri-urban landscapes,
- ecological functions and services of urban landscapes,
- cultural interpretations of and human effects upon these patterns, functions, and services.

The underlying assumption of my framework is that cultural interpretation of landscapes both initiates and limits certain spatial patterns, disturbance regimes and dynamics of landscape change, and that, conversely, these patterns, regimes, and dynamics affect the quality of biogeochemical and ecological processes and ecological services.

Future options of Landscape Ecology: Development and research

Xiuzhen Li [1,2]

[1]Institute of Applied Ecology, Chinese Academy of Sciences, P.O.Box 417, Shenyang 110016, China. [2]State Key Laboratory of the Estuarine and Coastal Research, East China Normal University, Shanghai 200062, China.
e-mail: landscape2001@sina.com

The last 25 years have seen the rapid progression of landscape ecology from Europe to the whole world. One of the driving forces of this development is the need of scientific knowledge to guide human activities towards a sustainable future. In countries where spatial heterogeneity is fundamentally important, landscape ecology can play an active role with its integrated ideas derived from a variety of theoretical backgrounds.

The top 10 hot topics of Landscape Ecology were addressed by Wu and Hobbs (2002), with Turner (2005) also describing the present "scientific status" of the discipline. How about the future development and research fields of Landscape Ecology?

It is impossible for us to ignore the past and start our future research completely independently. Some of the points will still be valid in the future, for example, "Integrating humans and their activities into Landscape Ecology", and "Optimization of landscape pattern". As Turner (2005) pointed out, Landscape Ecology should continue to push the limits of understanding of the reciprocal interactions between spatial patterns and ecological processes and seek opportunities to test the generality of its concepts across systems and scales. However, there should be new focuses in the future, corresponding to the new needs of human being, as well as the theoretical and methodological development of Landscape Ecology itself. In this contribution I will only be able to outline a few ideas:

1) Marine Space Ecology: in comparison with the predominately terrestrially oriented landscape ecological studies, phytoplankton and its associated habitats in the marine space have yet to be investigated, due to difficulties in data collection and the uncertainty of the study object. Whether or not the methods used for terrestrial landscape ecology can be transferred into the marine environment is also under consideration. However, the need for large scale ecological studies in marine or seascape systems is still increasing, due to the ever-expanding human demand for resources.
2) Large scale ecological response of the nival zone to global changes: at high altitudes and latitudes, global climate change and ubiquitous human disturbance have caused major changes to the landscape and its functions. The surface layers are very sensitive to changes in temperature, soil moisture, and physical stress. Vegetation productivity, species composition, decomposition process, and hydrological process will also change correspondingly. Since population density is relatively low, the ecological studies that have been conducted in these regions are fewer in comparison with temperate zones.
3) Multi-regional Ecology: bird-flu around the world reminds people that different regions can be affected by the same diseases due to migration of the avi-fauna. The habitats for birds in different regions need to be considered, both for scientific reasons and for disease control. Similar problems have been introduced by the intensification of international communication among different regions and populations: for example SARS, exotic species invasion, and the extinction of endemic species. More attention and emphasis should be paid to multi-regional ecological relationships.
4) Disaster prevention and control: with rapid economic growth, the annual average world economic losses associated with natural disasters has increased exponentially since 1960s (UNDP, 2004). The new millennium even sees ever more devastating disasters such as the Tsunami in South-east Asia (December, 2004), and the Hurricane Katrina in the US (August, 2005). Landscape Ecology can play an active role in planning development choices for disaster risk reduction, as well as for post-disaster reconstruction.

5) Natural resource management and bio-protection: although Landscape Ecology has played an active role in providing theoretical and methodological ideas for natural resource management, much can still be done in this field of research with newly developed techniques. For example, remotely sensed data with increased resolution and improved transmitter sensors can greatly help us to track animals and strategic habitats. The quality and quantity of natural habitats can also be measured more precisely.
6) Integration of visual landscapes and ecological landscapes: evaluation of the visual aesthetic quality of the landscape provides a new perspective for the discipline, which complements to its traditional ecological research. We might need more knowledge about aesthetics to develop this line of research. So far pioneering studies have been done with the help of representative photographs, at different scales and periods, in combination with remotely sensed images and aerial photos.
7) The role of human beings in landscape evolution: including construction of buildings, roads, farms; management of pastures and forest. The different types and intensities of human activities have resulted in the multiple directions and complex intensities of flows, from population to materials and energy as well as between source and sink landscapes. The landscape as the habitat of human beings, or *Homo sapiens*, is often less well understood than the habitat of many wild animal species.

As the study of “ecology at the human scale” and a transdisciplinary science, Landscape Ecology should continue to serve as the “decision support system” for sustainable development of the human race. Throughout the world, landscapes are being altered more rapidly, more extensively, and more profoundly than at any point in human history (IALE mission statement). Landscape ecologists should play a more active role in comprehensive land use planning and the development of sound land use policies in the future.

References

Bastian, O. (2001) "Landscape Ecology: Towards a unified discipline?" Landscape Ecol. 16: 757-766

Tanner, J.E. (2006) “Landscape ecology of interactions between seagrass and mobile epifauna: The matrix matters” Estuarine, Coastal and Shelf Science 68(3-4): 404-412.

Tress, G., Tress, B., Fry, G. (2005) "Clarifying integrative research concepts in landscape ecology" Landscape Ecol. 20: 479-493

Turner, M.G. (2005) “Landscape ecology in North America: Past, present, and future: Landscape ecology” Ecology 86(8): 1967-1974.

Wu, J., Hobbs, R. (2002) "Key issues and research priorities in landscape ecology: An idiosyncratic synthesis" Landscape Ecol. 17: 355-365

Theme 1. Landscape, stakeholders, land use and policy

1.1 Symposium 1: Globalisation and the sustainability of agricultural landscapes

Agricultural liberalisation, multifunctionality and the WTO: competing agendas for the future of Europe's farmed landscapes

C.A.Potter
Imperial College London – Centre for Environmental Policy, London, United Kingdom.
e-mail: c.potter@imperial.ac.uk

Introduction

The international policy context is becoming increasingly important in any discussion of farmland sustainability and landscape change (Potter, 2006). An emerging infrastructure of trade rules, subsidy codes and dispute procedures means that the governance of farming activities through domestic public policy is more and more being decided in forums like the World Trade Organisation (WTO). The Agreement on Agriculture which concluded the Uruguay trade round already sets boundaries on what national governments can do in terms of offering subsidies to farmers and we have seen changes to the pattern of farm support in the European Union (EU) that have been a direct response to the politics of the more recent round of negotiations under the still to be concluded Doha trade round. This paper argues that we can expect to see a much more fundamental reform of agricultural support in the years ahead as signatories to any eventual Doha agreement seek to reduce the trade distorting effects of farm policy and strengthen the principle of market rule in agriculture. The implications of this liberalisation of agricultural markets for the pattern of farming and for landscape change are likely to be profound.

Competing policy models

A specific concern of recent debates has been how best to ensure the continued provision of public environmental goods in a much more neoliberal context. The paper suggests that there are two competing policy models on offer here. The first, aligned with the concept of 'multifunctionality', is generally pessimistic that sufficient farmers or levels of farming activity would be possible at world market prices to sustain the sort of managed countryside that European citizens appear to value and wish to see continue. A key assumption here is that nature conservation and landscape goals need to be achieved as a by-product of agricultural production. The policy implication is that large numbers of farmers need to be retained on the land in order to continue producing an essentially managed countryside. Trading partners, however, see multifunctionality as an excuse for continued high (and trade distorting) levels of agricultural support. The difficulty for advocates of a multifunctional model is being able to separate their interests in public goods from the rent seeking motivations of a farm lobby anxious to defend their traditional policy entitlements.

An alternative model is that of the 'public goods' approach to sustainable farmland management. This shifts the focus away from farmers and their occupancy of land towards the environmental outputs that need to be achieved. Critically, landscape outcomes are viewed as potentially separable from the activity of farming and thus capable of being paid for and secured under a (presumably very extensive) system of agri-environmental contracts and private agreements that pay by results and outcomes. Largely in line with the decoupled model favoured by the WTO, such arguments have the support of many of the EU's trading partners. However, questions remain about the delivery mechanisms available and the degree to which these can be made fit for purpose (Dobbs and Pretty, 2005). Administrative costs tend to be high and there are difficulties in targeting and delivering geographically differentiated outcomes. At the same time there is concern about the sustainability of a set of landscapes that would increasingly depend on government schemes for their existence and construction. Far better, and more authentic, say the multifunctionalists, to retain the idea of farmed landscapes as working environments, underpinned and sustained by the activities of the individuals and families seeking to gain a livelihood there.

The paper concludes by suggesting that, rather than being a debate about farmland sustainability as such, the essential focus of recent international discussion in the context of Doha has been how far the multifunctionality of European agriculture could be put at risk by a long term restructuring of farming due to increased world market exposure. For many, this debate has a causal emphasis that the often rather vaguely prescribed notion of sustainability lacks. It draws attention to the difficulty of reconciling globalising tendencies with local attributes and processes and has offered something of a counter to the dominant narrative of market rule as a governing discourse. The question of how far governments have a responsibility to sustain the countryside by protecting the incomes of farmers is still one that remains unresolved after over a decade of contestation and debate.

References

Dobbs, T and Pretty, J (2005) Agri-Environmental Stewardship Schemes and Multifunctionality, *Review of Agricultural Economics*, **26**, 2, 220-237

Potter, C (2006) Competing narratives for the future of European agriculture: the agri-environmental consequences of neoliberalization in the context of the Doha round, *The Geographical Journal***,** **172,** 190-196

US federal agricultural policy in the context of world trade: Linking global change to local landscapes

J. I. Nassauer

School of Natural Resources and Environment, University of Michigan, USA.
e-mail: nassauer@umich.edu

American agricultural policy is being set in a new, more explicitly global context by world trade policy, particularly negotiations occurring within the World Trade Organization (WTO), which is pushing governments of the developed world away from subsidizing the production of commodities or protecting markets but not necessarily requiring withdrawl of other forms of farm income support. Interestingly, this *global* context may create opportunities for federal policy to support American farm income by promoting a wide array of ecologically beneficial *local* landscape changes in land cover and management. In America, global trade policy is linked to possibilities for local landscape changes through federal agricultural policy.

As new American federal agricultural policy is considered over the next decade, American policymakers are unlikely to discontinue massive federal subsidies to privately owned and operated farms (over the past decade, an approximate average of US $20 billion/year), even if global trade policy presses them to do so. The structure of the United States Senate gives great power to relatively sparsely populated agricultural regions which benefit enormously from these subsidies. However, policymakers *may* find it politically viable to replace some existing commodity and production related payments with payments for environmental improvements to agricultural landscapes. Changing the target of subsidies to explicitly supporting farmer incomes as well as environmental outcomes rather than supporting farmer incomes through payments related to commodity production could allow policymakers to continue payments to agricultural regions in a way that benefits the broader tax-paying public by addressing pressing increasingly well-known environmental degradation from existing agricultural practices (e.g., hypoxia of coastal waters, contamination of local wells for potable water, drawn-down of regional aquifers, dramatic reduction of wildlife habitat).

In addition, some new agricultural enterprises (e.g., production of biofuels) could affect environmental degradation, either increasing loss of habitat and downstream water quality degradation or enhancing the quality of these environmental benefits. As new agricultural practices, enterprises, and land uses (like reserves and wetlands) are implemented in the agricultural landscape matrix, policy directing resulting landscape patterns could aim to also assure that new agricultural landscapes are immediately recognized as valuable by the broader American public – providing even more tangible rewards for subsidies. Such an approach could be developed by adapting conservation policies and practices that are already familiar to American farmers and policy makers – from the reserve lands approach of the highly successful Conservation Reserve Program (CRP) to the working lands approach begun under the Conservation Security Program (CSP) under the current farm law. By providing agricultural subsidies for a broad array of environmental benefits, American agricultural policy could address real, pressing environmental problems, continue agricultural subsidies in a way that may be more broadly acceptable to the American electorate, and, at the same time, conform with expectations of global trading partners to move away from commodity subsidies.

Globalisation and the local agricultural landscape: Change patterns and policy developments in three OECD countries

J. Primdahl

Danish Centre for Forest, Landscape and Planning, University of Copenhagen, DK-1958 Frederiksberg C.
e-mail: jpr@life.ku.dk

Introduction

The local agricultural landscape is increasingly being affected by central policy decisions and worldwide events – through the opening of markets, through technological developments, through changing urban-rural relationships, and through changes in public policy interventions. Two international policy agendas are affecting agricultural landscapes – the open market agenda institutionalised by WTO and the sustainability agenda institutionalised through the UN's program for sustainable development. Although the first one is based on centralised decisions taken at national and international level as opposed to the sustainability agenda which is filtered down to the regional and local levels – the two agendas eventually meet in the local landscape. And often they do not meet in any 'symmetrical' or 'balanced' way.

The decisions related to agricultural production for the market taken by the farmers are decisions connected to more or less closely to global networks in "space of flows" whereas the decisions made for the local landscape as a living place – as a "space of place" – are not any more closely linked to production. It is argued that the functionality of the agricultural landscape and the changes in landscape patterns are increasingly being affected by the way the two policy agendas are integrated (Figure 1).

Case studies

Based on case studies in New Zealand, Portugal and Denmark current change patterns are analysed in relation to the two agendas and the two spatial dimensions, 'space of flows' and 'space of place'. New Zealand and Denmark represent two countries both with highly developed agricultural sectors closely linked to world food markets, whereas Portugal and Denmark represent two contrasting EU member states affected by the same "common agricultural policy" unlike New Zealand which more or less abandoned a subsidy based agricultural policy more than 20 years ago. In each of the three countries two case study areas has been selected - one with relatively good conditions for arable and livestock farming, the other with more poor conditions and a more unstable landscape history. The role of productivist agriculture, counter urbanisation, tourism and public policy interventions including nature agricultural policy, environmental policy, nature conservation and physical planning are analysed and dominating driving forces and overall change patterns are identified. At the level of concrete landscape decisions, the different roles of "producer's" versus "property owner's" is analysed by use of detailed data on recent landscape changes and the farmer's perception of the changes occurring in the local landscape.

Similarities and contrasts between and within the countries and the landscape types are discussed in the framework of globalisation and sustainable development. Finally, some implications for multifunctional landscape research is presented and ways towards more integrated and collaborative landscape policies are proposed.

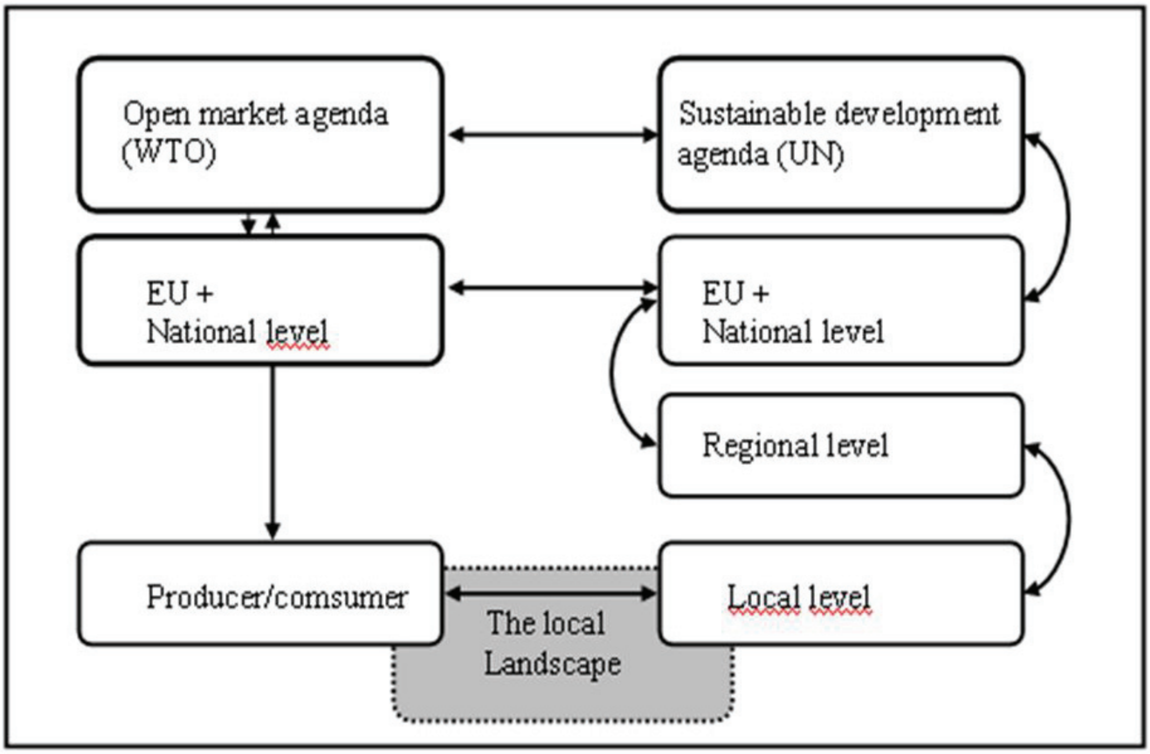


Figure 1. Two international policy agendas affecting the local agricultural landscape, the WTO's open market agenda and the UN's sustainable development agenda

New urban-rural relationships and the peri-urban landscape; new approaches in Dutch spatial planning.

M.C.Hidding[1], M.Pleijte[2]

[1] Land Use Planning Group, Wageningen UR, Wageningen, The Netherlands.
e-mail: marjan.hidding@wur.nl
[2] Alterra, Wageningen UR, Wageningen, The Netherlands.

Planning in the face of growing complexity

Urban-rural relationships have been radically changed in the last few decades. The idea that town and country are to be considered as 'separate entities' (Hidding et al. 2000) loses its validity more and more. Instead, the interwovenness of both is stressed. This is also reflected in the domain of spatial planning. Here, the growing interwovenness of town and country goes together with the rise of new policy discourses, institutional settings and planning strategies. Table 1 summarizes some characteristics of spatial planning for town and country as 'separate entities' and as a 'complex whole' respectively.

Table 1. Characteristics of spatial planning for town and country as 'separate entities' and as a 'complex whole'

	Town and country as 'separate entities'	Town and country as a 'complex whole'
Leading policy discourse for town and country	Town and country as separate entities (compact cities and green open spaces)	Regionally differentiated policies, according to the situation and potentials of the area
Leading plan concepts	Stressing 'place' characteristics	Stressing the position and potentials of the area in the 'space of flows' (Castells, 1995)
Institutional settings for planning and development of town and country	Separate institutional settings on local, provincial and national levels	Intermingling of institutional settings for planning and development of town and country on the regional level
'Normal' practices	Urban planning and development on the municipal level: combination of 'planning by permission' and 'facilitating urban land development' Rural planning and development: through 'land-consolidation' on area-level	Area-based policies through cooperation of actors from state, market and civil society, focussed on the realisation of 'integrated' projects
Governance style	Hierarchical relations between national, provincial and local planning levels	Multi-actor, multi-level and multi-sector governance.
Dominant planning style	Physical engineering, in accordance with an age-long tradition (The Netherlands as a 'man-made country')	Social engineering; bringing together different parties with their respective assets (powers, ideas, experiences, land, money, etc)

The position of agricultural landscapes

Although The Netherlands are a strongly urbanised country, the major part of the land is used for agriculture and so, agricultural landscapes still predominate. In the postwar period agricultural landscapes have been transformed into modern agricultural production landscapes on a large scale, fit for a highly productive agriculture. Today, the societal claims on agricultural landscapes go far beyond agricultural production as such, due to the sustainability agenda and growing urban influences. The strong interwovenness of town and country in The Netherlands is an important factor in the dynamics of these landscapes. 1.The position of the most urbanized parts of the country in the 'space of flows' offers also favourable conditions for highly industrialized agro-complexes, especially horticulture and intensive husbandry. 2. The demand for 'green services' by urban dwellers is strong and growing. 3. The claims on agricultural land in behalf of urban and infrastructural development are large, especially in highly urbanized regions; here agricultural landscapes are a threatened category. 4. Agricultural landscapes represent differentiated 'price landscapes' for urban investors. Urban developers are increasingly active on the rural land market, taking strategic positions with regard to possible future urban developments.

New planning approaches for peri-urban areas

From the eighties of the 20th century on a new planning approach has been evolving on a regional level, which also applies to peri-urban areas. Its main characteristics today: 1. Area based, exceeding the borders of individual municipalities. 2. Governance oriented, bringing actors from state, market and civil society together, each with their respective assets (powers, knowledge, ideas, experiences, land, money, etc) 3. Oriented towards the introduction of new or better qualities in the area, through combining red, green and blue functions according to a coherent view. 4. Combining the assets of strategic planning and project development. 5. Linking sectoral investments to strategic spatial plans. 6. Strongly market-oriented.

Case studies

This planning approach is further explained through two case studies: 'Duivenvoorde corridor' and 'Groningen Meerstad'. Both cases include agricultural landscapes in peri-urban areas. The 'red for green strategies' ('red' pays for the improvement of 'green' qualities) as followed in both cases are illustrative for the market-oriented character of this planning approach. In both cases landscape qualities – existing or to be created– were seen as a strategy to strengthen the position of the area and the enterprises involved in the space of flows.

Reflection

The cases illustrate that the future of agricultural landscapes in peri-urban areas highly depends on their landscape value, as defined by urban dwellers and project developers. Profit driven 'red for green strategies', often launched under the heading of 'sustainable development', can be harmful to existing values of agricultural landscapes. The domination of market rationality in recent planning strategies raise questions about the definition of the public domain in todays spatial planning, and so about the position of spatial planning itself.

References

Hidding, M., Needham, B & Wisserhof, J. (2000) Discourses of Town and Country. *Landscape and Urban Planning* **48**, 121-130

Castells, M. (1995) *The rise of the network society*, Blackwell, Oxford.

Urban agro-activities in Asian mega-cities

M. Yokohari

Graduate School of Frontier Sciences, The University of Tokyo
Kashiwanoha, Kashiwa, Chiba, 277-8563, Japan
e-mail: myoko@k.u-tokyo.ac.jp

Shrinking cities

The declining birth rate and one of the world's most rapidly ageing populations has meant that cities in Japan are starting to shrink for the first time in their history. There has been an increase in the number of patches of abandoned land within these cities because they are shrinking in terms of their populations, economies and land areas. These abandoned patches of land are particularly prevalent in new towns, which were hurriedly built-up during the 1960s and 1970s. New towns have long-since deteriorated into "old" towns, populated by residents that moved there in the 30s and 40s and never moved out. Finding a use for the abandoned urban land that lies interspersed among the tenement blocks of the new towns is an urgent task.

Agriculture in the city

To solve the problem of increasing abandoned land, understanding the traditional structure of the Japanese urban fringe area is necessary. During the Edo period (i.e. pre-1868) urban fringe areas in Japan were characterized by a mixture of developed areas and agricultural areas. Edo, former Tokyo, was not an exception. Edo was already one of the largest cities in the world with over one million populations at the beginning of the 18th century. Despite such enormous accumulation of population Edo was a city with agriculture. A number of varieties in vegetable on market today are given their name by the area in Edo where they were grown during Edo era, e.g. Komatsu-na (variety of Chinese cabbage) and Nerima-daikon (variety of radish).

Fujii, *et al.* (2002) estimated the land use of Edo in 1850s by using various documents and maps and identified that over 40% of the the land area of Edo was for agricultural use. Another feature which characterizes the land use of Edo is the mixture of urban and agricultural land uses in its fringe areas. By calculating the join value of agricultural land patches Fujii, *et al.* (2002) estimated that the area between 4km to 6km from the core of Edo was the area where series of small and segmented patches of agricultural lands remaining inside residential neighborhoods were identified. The agriculture on each area not only provided nutrition, but each area also accepted organic wastes from the surrounding residential areas.

Ecological functions of urban agricultural areas

Today, agricultural areas in the city may fulfill a variety of modern ecological functions. These functions could range from reducing the summer heat of surrounding residential areas, to controlling floods and improving the aesthetic quality of an area (Yokohari, *et al*, 1994). From the consumers' point of view, urban agriculture may also have a number of benefits. Because of food-scares in Japan, Japanese consumers are extremely concerned about obtaining safe food. If the fruit and vegetables they consume are grown locally consumers may have more confidence in them. These consumers may therefore be willing to pay a premium for such food, which will support local farming in the area.

If a recycling system that accepts wastes and reduces the amount of waste each household produces were implemented at the same time, it could help to realize the ideal of a sustainable city. Hirohara, *et al.* (2002) identifies that such a recycling system may be realized in a residential neighborhood with remaining patches of agricultural land, where organic wastes from surrounding houses are brought to agricultural lands as a material for organic fertilizer, and vegetables grown on the fields will be feed-backed to houses which provided wastes.

Agro-activities by urban residents

Agricultural lands in residential neighborhoods are not only for farmers. Today, rapidly growing demands on agricultural activities can be found among urban residents in Japanese urban fringe areas. Many of those who had been involved in industrial and commercial businesses and retired at around age 60 are now choosing agriculture as their second career, resulting in new agro-activities. Namiki, *et al.* (2006) surveyed such new activities practiced by urban residents in the suburbs of Tokyo and identified that the characteristics of those activities were represented by their intermediate character in the cultivated area per person, smaller than traditional farming but far larger than backyard gardening, and the number of grown vegetables; less than backyard gardening but more than traditional farming.

Agriculture in Japan is sharply deteriorating. Although it has been regarded that the revitalization of agriculture is an urgent task for the food security of Japan, raising the self-sufficient rate of food, now less than 40%, cannot be expected only by encouraging agriculture in a traditional manner. Agro-activities by urban residents in urban fringe areas are still a minor portion, resulting in a very limited amount of the land area that may be cultivated. However, by realizing the reality that the average age of farmers now on the fields are already nearly 70 and most of their following generations are not willing to succeed farming, we have to encourage new agro-activities by urban residents by admitting that urban residents are indeed one of the very limited successors of Japanese agriculture.

Land use in the fringe of Asian mega-cities should not be achieved by a simple application of Western urban planning concepts, but by an application of a fresh approach, which regards agro-activities as a vernacular element of the area (Yokohari, *et al*, 2000) The integration of agro-activities in the urban fabric is one of the key issues for bringing a new order to the urban fringe landscapes of Asian mega-cities.

References

Fujii, M, Yokohari, M and Watanabe, T. (2002) Identification of the distribution pattern of farmlands in Edo. *City Planning Review Special Issue*, **37**: 931-936 (*in Japanese with English abstract*)

Hirohara, T, Yokohari, M, Kato, Y, and Watanabe, T. (2002) A study of the small-scaled material cyclic between urban and rural and land uses in urban fringe areas of Tokyo. *Journal of Japanese Institute of Landscape Architecture*, **65 (5)**: 889-892 (*in Japanese with English abstract*)

Namiki, R, Yokohari, M, Hoshi, T, Watanabe, T, and Amemiya, M. (2006) Agro-activities by urban residents on the farmlands of urban promotion area. Journal of Rural Planning Association Special Issue, **25**: 269-274 (*in Japanese with English abstract*)

Yokohari, M., Brown, R.D, and Takeuchi, K. (1994) A framework for the conservation of rural ecological landscapes in the urban fringe area in Japan. *Landscape and Urban Planning*, **29**: 103 - 116

Yokohari, M, Takeuchi, K, Watanabe, T, and Yokota, S. (2000) Beyond Greenbelts and Zoning: A new planning concept for the environment of Asian mega-cities. *Landscape and Urban Planning*, **47**: 159-171

The future role of agriculture in a differentiated countryside: example of a typology of rural areas in Portugal

T.Pinto-Correia

Dept.Landscape and Biophysical Planning, University of Evora, 7000 Evora, Portugal
e-mail: mtpc@uevora.pt

Introduction

Throughout Europe, the role of farming as the private provider of public goods and services increasingly valuated by society is today generally acknowledged. As defined by OECD, the joint production of commodity and non-commodity outputs is the main characteristic of the multifunctional agriculture that corresponds to the new European model. Nevertheless, in the turn towards rural development concerns, multifunctionality as an attribute of rural space has emerged. As stated by C.Potter (2004), such territorial approach is justified by the fact that farming is no longer the economic activity supporting the rural economy, but rather the opposite, and it has the clear advantage of being able to be exploited by a wider community of stakeholders than the farmers alone. The production function is thus combined and integrated with other functions, displayed mostly at the landscape level, with more or less economic value, but also with social and environmental values (Wiggering et al 2006).

The situation is nevertheless not the same in all European regions, and even within countries there is a clear differentiation of the countryside between various regions, which by all means is getting strengthened in the transition towards post-productivism (Murdoch et al 2004). In some regions there is a productivist orientation and production has a dominant economic role, while others will need to be supported on other functions to survive economically and socially, or may be best suited to environmental functions alone. The multifunctionality challenge is not the same in these separated types of regions. And even within the regions which will depend on their capacity to provide non-production functions, there are specific potentialities and limitations to be taken in consideration. The vocation of the rural territories is different, and thus also the functions they are able to support.

In order to face the challenges raised by new demands, the management of rural landscapes needs to be anchored in an understanding and evaluation of this differentiation. This has to be reflected in strategies as well as in policies and related instruments.

One of the characteristics of the differentiated development of rural areas means there are, on one side, no clear-cut relations between marginalization, abandonment and the loss of dynamics and diversity, and, on the opposite, no clear relation between a dynamic farming and a dynamic countryside. Therefore, a more detailed and separated analysis of each of the processes occurring, and of their drivers and consequences, is required.

The Portuguese example

Portugal is a good example of these various processes going on, as it is naturally a country of biophysical contrasts and diversified landscapes, and it has both very dynamic and very fragile rural areas, areas with a strong farming sector and others with a very traditional and non competitive agriculture. In this country, a range of recent studies is showing an increasing differentiation in the development of rural areas, which develop at present along diverse trajectories. Some regions are developing very dynamically, but this can happen with or without a strong role of agriculture. Other regions are affected hard by marginalization processes, that raise concern as they are often related to socio-economical decay, the loss of cultural landscapes (Meeus et al., 1990), land abandonment and decreasing biodiversity, and also physical desertification.

Separating the various components of the countryside may lead to a more clear analysis of the processes going on. This has been applied in a study undertaken in 2006 for the Ministry of Agriculture, in Portugal, which aimed at assessing the differentiated characteristics and dynamics of the Portuguese rural territory.

Methodological Approach

The analysis focus separately on three dimensions: 1) the land use/land cover, based on Corine data; 2) the farming sector and its production and structure, based on Agricultural Statistics; and 3) the community characteristics and behaviour, based on the Population Census. Specific indicators, concerning data from 1990 and 2000, at the level of the municipality, have been used for a cluster analysis, for each of the three dimensions. This cluster analysis resulted in the classification of the municipalities following their behaviour in each dimension. Combining the three analysis, it was possible to identify different broad vocations of the rural space, and the role that farming could have in the future for the multifunctionality of the landscape. Accordingly, the municipalities have been grouped in types, pre-defined as ideal types. These types consider the characteristics and trends of the rural landscapes and the functions (commodity and non commodity) they may secure, but also the role that farming may play, if the transition of perspectives from sectoral to territorial is fulfilled.

Results and Discussion

This presentation will discuss the concept of multifunctionality of the rural areas, and of the role of farming for these functions. Furthermore, it will present the possible methodological approach towards the identification of the different types of rural areas in Europe, based on the identification of ideal types, supported on the analysis of selected indicators. Furthermore, the ten different types identified for Portugal, as well as their distribution by municipalities, will be presented, and examples in some of the types will be discussed. This examples will stress the potential future functions to be integrated at the landscape level in each specific context.

This paper is based on what was a first approach to an understanding of the differentiation of the rural territory in Portugal, that needs to be further developed in detail. It shows nevertheless that not all rural areas, even those that are excluded from a possible competitive agriculture, should be considered in a similar way in strategic guidelines and policies, as they have different opportunities and threats in relation to the dynamics of the community, alternative economic activities, landscape character or environmental quality. It also shows that a territorial approach to agriculture may be the key for the maintenance of the sector in many areas where production by itself will soon not be viable any more.

References

Murdoch J., Lowe P., Ward N. and Marsden T., 2004. The Differentiated Countryside. Studies in Human Geography. Routledge, London.

Potter C., 2004. Multifunctionality as an agricultural and rural policy concept. In:Brouwer F. (Ed.). Sustaining Agriculture and the Rural Environment. Governance, Policy and Multifunctionality. Advances in Ecological Economics. Edward Elgar. Pp. 15-35.

Wiggering H., Dalchow C., Glemnitz M., Helming K., Muller K., Schultz A., Stachow U. And Zander P., 2006. Indicators for multifunctional land use – linking socio-economic requirements with landscape potentials. Ecological Indicators, 6: 238-249

Local landscape consequences of macro scale policy reform

S R Swaffield

Lincoln University, PO Box 84 Lincoln University, Canterbury, New Zealand
e-mail: swaffies@lincoln.ac.nz

Introduction

Analysis of change in a range of agricultural landscapes following macro scale policy reform in New Zealand reveals landscape ecological consequences of trade globalization. Using existing data from recent studies, the analysis is based upon five dimensions of landscape structure and function - land use, land tenure, vegetation cover, water management, and landscape management. Factors that may be critical in sustaining agricultural landscape systems under a global free trade regime are identified.

Aotearoa- Britain of the South

New Zealand was first settled by Polynesian migrants, and became part of an international trading system following colonization by Europeans in the early 19th century. For the majority of the 20th century it was effectively an agricultural outpost of Britain, trading commodities for imported manufactured goods. However, although part of a world economy, it was not yet fully globalised in the contemporary sense of the word [Baragwanath et al 2003], and was highly regulated until the 1980s [Easton 1997].

The bio-geographical consequences of these historical migration and trading relationships have been profound [Holland 2000]. New Zealand has a high level of endemism, with a unique biota. Human induced fires, hunting, introduction of grazing animals and numerous other exotic plant and animal species, combined with extensive forest clearance to create agricultural land, have caused dramatic changes in its landscape ecology [McGlone 1989]. Most lowland forest, wetlands and scrublands were replaced by exotic agricultural grasslands, shelterbelts, and plantations, with consequential dramatic effect on indigenous flora and fauna [Pawson and Brooking 2002].

The NZ Experiment in trade reform

UK entry into the European Common Market in 1972 precipitated a significant decline in the terms of trade for NZ [Easton 1997]. When combined with the oil shocks and growing internal political tensions, by 1984 the country was in socio-economic crisis. The response was to liberalise the economy [Kelsey 1995]. In a few short years NZ became one of the most open economies in the world and its society, economy and landscape have rapidly become globalised [LeHeron and Pawson 1996].

Landscape Change

Using a regional case study, five dimensions of landscape change during this period of globalization are analysed. The analysis is based upon different parts of the Canterbury Region, which extends from the watershed of the Southern Alps eastward across extensive outwash plains to the outlying volcanic remnant known as Banks Peninsula.

Removal of agricultural production subsidies and development grants in the mid 1980s was a major shock to the predominant system of dryland pastoral agriculture and has over time lead to increasing differentiation of *land use* regimes. Some farms have specialized and intensified within vertically integrated global commodity systems; others have diversified, with many new lifestyle farms drawing income from urban sources, as the landscape has become a focus of consumption rather than production. Liberalisation of controls on land subdivision has enabled fragmentation of *land tenure,* particularly in locations suitable for urban commuting, or in areas of high landscape quality such as the coast and hills. There has also been amalgamation of titles in some locations, where land use economics require larger farms, and where the City Council has purchased land for recreation, conservation and stormwater management. Changes in tenure and land management have led to differentiation in *vegetation cover*, exemplified by the removal of mature exotic shelterbelts and plantations on the plains to create dairy pasture, and the reversion of marginal hill country to indigenous bush. Intensification has also created conflicts over allocation of *groundwater*, with intense debate over both the causal relationships involved, and the future management options. Finally, shifts in land use and tenure have diversified *landscape management regimes*. There is a growing disjuncture between urban and rural values, and between different types of land management. In some locations, new institutions have emerged to encourage cooperation and collaboration. They face the challenge of spatially integrating adjoining land uses that are functionally dislocated, and linked to diverse global markets.

Discussion

Globalization and ‘opening up’ of the NZ economy over the past two decades has increased local landscape differentiation, both in structure and function. Reforms have enabled increased economic efficiencies in agriculture [Johnston 2001], and stimulated significant rationalisation and differentiation of land use. However there has been an ‘implementation gap’ in environmental management [Barnett and Pawling 2005] as local and regional government has struggled to manage the landscape consequences of change. The NZ experiment reveals that trade reform must be matched by enhanced local knowledge, and improved management capacity. New institutions are needed to ‘sustain’ agricultural landscape systems within the context of the global economy.

References

Baragwanath L; McAloon J; Perkins H. **2003**. Globalisation and New Zealand: anchoring the Leviathon in a Regional Context. *New Zealand Geographer* **59[2]**:16-26

Barnett J; Pawling J. 2005 The environmental effects of NZ free market reform *Environment Development and Sustainability* **7(2)**:271-289

Easton B. 1997 *In Stormy Seas:The Postwar New Zealand Economy* Otago University Press, Dunedin.

Holland P. 2000 Cultural Landscapes as Bio-geographical experiment : A New Zealand Perspective. *Journal of Biogeography* **27(1):**39-43

Johnston RWM. 2001. *Agricultural reforms and their international implications.* Institute of Economic Affairs, London.

Kelsey J. 1995.*The New Zealand Experiment: A world model for structural adjustment?* Auckland University Press, Auckland.

Le Heron R; Pawson E 1996 *Changing Places : New Zealand in the Nineties*. Longman Paul, Auckland.

McGlone MS. 1989 The Polynesian settlement of NZ in relation to environmental and biotic changes. *New Zealand Journal of Ecology* **12**:115-129

Pawson E Brooking T [eds] 2002 *Environmental Histories of New Zealand* Oxford University Press, Melbourne.

Vulnerability of forested landscapes and landscape changes in Slovenia

D. Hladnik, J. Pirnat

University of Ljubljana, Biotechnical Faculty, Department of Forestry and Renewable Forest Resources, 1000, Ljubljana, Slovenia;
e-mail: janez.pirnat@bf.uni-lj.si

Slovenia is 60% covered by forest. Forests and forested landscape types are therefore among the most significant visual characteristics of the country. Present rural landscapes are now facing developing of intensive agriculture in suitable areas and lack of human activity, resulting in marginalisation of agriculture and spontaneous afforestation in other areas (Hladnik, 2005). Forestry turned into close to nature orientation in the second part of the 20th century, yet former orientation into the forests with artificial dominance of Norway spruce is still significant in some areas.

Teuffel has estimated (Teuffel *et al*., 2004) that there are 6-7 million ha of forests with artificial dominance of Norway spruce in Europe, with 4-5 millions on sites of original broadleaved species. Norway spruce on such sites turns out to be highly sensitive to drought, bark-beetles, storms (Larsen, 1995) and has negatively influenced the soils.

Factors which help us understand a landscape are its structure, functioning and changes occurring in it. For all the three factors, the relationship between natural and social factors is of significance. The latter are the most important factors that affect the changes in the cultural landscape. An assessment of the landscape structure has been carried out at the karst region of Slovenia on the basis of Slovenian forest maps, data on the present land use, an assessment of forest cover of the region at the end of the 18th century and data from the 19th century Franciscean land register.

It was estimated that natural factors mainly affected the forms of past settlement and that humans left indelible imprints on the landscape of the region at least 200 years ago. The physiographic factors do not result in a sharp delineation that would justify the differences between preserved and changed forested landscapes.

A model of landscape functioning was established based on comparison of recent changes in respect to native spruce and fir forests as opposed to forests with artificial dominance of Norway spruce stands that have resulted from high artificial energy inputs in the past. All artificial energy (human labour, machine work including depreciation of machinery and spare parts needed for felling, skidding) and material inputs needed for silvicultural and protective measures, were calculated as “artificial energy input” needed for functioning of managed forests (Pirnat, 1995).

When the spatial model was designed, the temporal differences were assessed in the last 15 years – the period of the most significant changes in the landscape structure. The vegetation indices were collected using satellite images Landsat TM from years 1992, 2000, 2005 to show the areas of stable landscape structure and the areas of marginalisation. Intensive forests with artificial dominance of Norway spruce turned out to be most energy consuming and especially demanding in terms of silvicultural and protective measures. The result show that forest areas with former highest artificial energy input (0.92 MJ/m^2/year) turned out to be the most unstable part of the forested landscapes in the last decade.

Within a climate change scenario approach, the possibility of extreme weather conditions is increasing, resulting in an extreme vulnerability of changed forest stands with artificial dominance of Norway spruce in the lowlands.

References

Hladnik, D. (2005) Spatial structure of disturbed landscapes in Slovenia. *Ecological Engineering* **24:** 17-27.

Larsen, J.B. (1995) Ecological stability of forests and sustainable silviculture. *For. Ecol. Manage.* **73:** 85-96.

Pirnat, J. (1999) Natural and Artificial Energy Flows in Forest and Agricultural Landscapes of Kočevsko. *Geografski zbornik* **39:** 29 - 50.

Teuffel, K, v. Heinrich, B. Baumgarten, M. (2004) Present distribution of secondary Norway spruce in Europe. H. Spiecker, E.Klimo, J.P. Skovsgaard, H. Sterba. K.v. Teuffel (Eds). *Norway spruce conversion – options and consequences*. European Forest Institute Research Report 18. Brill NV, Leiden, Boston, pp. 63-96

1.2 Symposium 22: The Young Landscape Ecologist

The avifauna of agricultural land mosaics: how do the structural properties and countryside elements of productive landscapes affect bird occurrence?

A. Haslem and A. F. Bennett

Landscape Ecology Research Group, School of Life and Environmental Sciences, Deakin University, 221 Burwood Highway, Burwood, Victoria 3125, Australia.
e-mail: adona@deakin.edu.au

Introduction

The global expansion of human-dominated environments means that productive landscapes have an important role in future biodiversity conservation. Two key features of agricultural environments affect their potential contribution to conservation: the structural properties of landscapes (Andrén, 1994) and the types, and heterogeneity, of countryside elements present within the production zone (Benton *et al.*, 2003). Yet few studies have incorporated both considerations at the level of the entire landscape: this was our aim in a study of bird occurrence within an agricultural region in Australia.

Methods and Results

Birds were sampled in all landscape element types within 27 agricultural land mosaics, each 1 x 1 km (100 ha) in size. Study mosaics were selected to incorporate variation in two factors: native vegetation cover and number of different landscape elements. Seven types of landscape element were recognised: native vegetation, linear vegetation, non-indigenous tree plantation, scattered paddock trees, pasture, natural wetland, and farm dam. Data collected from 90 bird point counts conducted in each mosaic (15 fixed sampling locations x 6 survey rounds) was used to determine species richness and incidence values for each mosaic as a whole. Each study mosaic was also classified on the basis of its structural properties. Eight independent variables described different aspects of the extent and diversity of landscape elements, the spatial configuration, and the landscape context (in terms of native vegetation cover) of mosaics.

Regression analyses were used to investigate the relationship between mosaic properties and the richness of all species, and of three habitat-association groups (woodland, open-tolerant, open-country) of birds, in study mosaics. Overall bird richness was strongly related to measures of mosaic diversity (number of different landscape elements/mosaic) and landscape context (surrounding cover of native vegetation) while sub-groups of birds responded more strongly to measures of mosaic composition (cover of preferred element type). For example, woodland birds were positively related to the extent of native vegetation within mosaics while open-tolerant and open-country species showed a closer relationship to the extent of countryside elements (e.g., pasture and scattered trees) in mosaics.

Ordination analysis revealed that variation in bird assemblages across mosaics followed a gradient in tree cover extent (native vegetation and tree plantation) within mosaics and native vegetation extent in the surrounding landscape. To test whether this community gradient resulted from variation in the ecological and biological characteristics of birds, all species were classified by six life-history traits widely identified as responding to habitat fragmentation. Species incidence in relation to three trait groups (nesting substrate, foraging substrate and clutch size) showed significant variation along the community composition gradient.

Discussion and Conclusions

Our results indicate that properties of mosaic composition, diversity, configuration and broader landscape context are important influences on bird occurrence in our study region. The relative effect of these mosaic properties on species richness varied between different types of birds as defined by their habitat requirements. Our findings are consistent with those of related studies: species reliant on natural vegetation are often strongly affected by its extent and configuration within agricultural landscapes (McGarigal and McComb, 1995; Radford *et al.*, 2005) while broader taxonomic assemblages are more strongly related to the heterogeneity of these systems (Böhning-Gaese, 1997; Atauri and de Lucio, 2001). We found, as have others (e.g., Benton *et al.*, 2003), that countryside elements make an important contribution to the heterogeneity of agricultural landscapes.

The importance of wooded vegetation to the birds of agricultural landscapes was further confirmed by the strong influence of tree cover extent (native vegetation and tree plantation) on bird community composition in study mosaics. The alignment of tree plantation with native vegetation on this tree cover gradient appears to support the hypothesis that structurally complex countryside elements may enhance the connectivity of agricultural landscapes (Renjifo, 2001).

Our results highlight the particularly important role of two features of agricultural landscapes in affecting the conservation value of these systems: native vegetation cover and the heterogeneity of landscape element types. In summary, we found that: 1) mosaic properties affect the richness and composition of bird communities in agricultural landscapes; 2) the influence of mosaic properties on bird occurrence differs between types of birds; 3) countryside elements make an important contribution to the heterogeneity, and bird richness, of productive environments; and 4) individual land-owners, by preserving/enhancing wooded vegetation cover and maximising landscape heterogeneity, can make a real contribution to sustaining rich bird assemblages in Australian agricultural landscapes.

References

Andrén, H. (1994) Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. *Oikos* **71:** 355-366.

Atauri, J. A. & de Lucio, J. V. (2001) The role of landscape structure in species richness distribution of birds, amphibians, reptiles and lepidopterans in Mediterranean landscapes. *Landscape Ecology* **16:** 147-159.

Benton, T. G.; Vickery, J. A. & Wilson, J. D. (2003) Farmland biodiversity: is habitat heterogeneity the key? *Trends in Ecology and Evolution* **18:** 182-188.

Böhning-Gaese, K. (1997) Determinants of avian species richness at different spatial scales. *Journal of Biogeography* **24:** 49-60.

McGarigal, K. & McComb, W. C. (1995) Relationships between landscape structure and breeding birds in the Oregon Coast Range. *Ecological Monographs* **65:** 235-260.

Radford, J. Q.; Bennett, A. F. & Cheers, G. J. (2005) Landscape-level thresholds of habitat cover for woodland-dependent birds. *Biological Conservation* **124:** 317-337.

Renjifo, L. M. (2001) Effect of natural and anthropogenic landscape matrices on the abundance of Subandean bird species. *Ecological Applications* **11:** 14-31.

Here today, gone tomorrow? Quantifying the decline in occurrence of Malleefowl (*Leipoa ocellata*) in Western Australia.

B.C. Parsons[1,3], J.C. Short[2] and J.D. Roberts[3]

[1]CSIRO Sustainable Ecosystems, Private Bag 5, Wembley WA, 6913, Australia.
email: blair.parsons@csiro.au
[2]Wildlife Research and Management Pty Ltd, Kalamunda WA, 6926, Australia.
[3]School of Animal Biology M092, University of Western Australia, Crawley WA 6009, Australia.

Introduction

The Malleefowl (*Leipoa ocellata*) is one of many terrestrial fauna species that has experienced a decline in its distribution and abundance in Australia (Burbidge and McKenzie 1989; Recher and Lim 1990; Garnett and Crowley 2000). It is listed as endangered at the national level and the national recovery plan (Benshemesh 2000) suggests a contraction of 45% in the western portion of its range. Studies in south-eastern Australia (Frith 1962, Priddel and Wheeler 1999) have reported rapid and widespread declines of Malleefowl in response to agricultural development and the introduction of exotic predators. These threatening processes operate in Western Australia also and so there is concern that similar declines may have occurred. However, previous estimates of decline have been restricted to detailed studies of individual populations (e.g. Priddel and Wheeler 2003) or crude broad-scale estimates based on expert opinion and anecdotal evidence (Benshemesh 2000). As a consequence, the pattern and extent of decline of Malleefowl across Australia are not well understood.

There is a need to more accurately quantify the decline of Malleefowl in Western Australia and assess the relative contributions of various processes that threaten Malleefowl persistence. Currently, a wealth of presence-only data exists for the species and despite the recognised shortcomings of this type of data (Austin 2002; Wintle *et al.* 2005); it has potential to answer key questions about the status of Malleefowl. This study addresses the following questions:

- Can we use presence-only data to quantify species decline?
- Has the Malleefowl suffered a range contraction in Western Australia, and more specifically, within the Western Australian wheatbelt?
- Is there a relationship between changes in the range of Malleefowl and landscape-scale environmental predictors?

Methods

We sought to quantify changes in the range of Malleefowl in Western Australia by basing our methods on those used in the national recovery plan and applying them to an expanded dataset of community collected sightings data dating from 1839 to 2006. We also collected presence-absence data for the Western Australian wheatbelt, allowing us to more rigorously examine decline. Areas where Malleefowl populations were apparently stable were compared with those where numbers had declined, and various landscape attributes were considered as possible causes of change. Issues relating to scale, bias and false absence were also explored.

Results

Our results suggest that Malleefowl have suffered a range contraction within Western Australia but this contraction is smaller than previously claimed. In contrast to south-eastern Australia, Malleefowl appear to have persisted across much of their former range within the agricultural landscapes of south-west Western Australia, with declines largely confined to the western margin of the species' former range. The contraction in the range of Malleefowl was correlated with the number of years since commencement of agricultural activity and also with land clearing. Analysis of sightings data also showed that false absences had the potential to exert substantial influence on estimates of species decline.

Conclusion

The Malleefowl has suffered less of a range contraction in Western Australia than previously claimed, particularly within the Western Australian wheatbelt. This conclusion is in part due to the compilation of a larger dataset than was previously available to researchers assessing this species. However, it is also likely that the species has persisted within large areas of the wheatbelt because agricultural development has been relatively recent (< 50 years ago) compared with areas in eastern Australia. As a result, these landscapes are of higher quality in that they are less fragmented and the remaining habitat has had less exposure to agents of degradation such as grazing, altered fire regimes and weed invasion. It is probable that the decline of Malleefowl is likely to continue unless these processes are mitigated. The correlation between Malleefowl decline and land clearing suggests that the future extinction of Malleefowl from highly fragmented areas within the wheatbelt is likely, particularly given the presence of exotic predators.

This study was limited to making broad estimates of Malleefowl decline using relatively coarse-scale spatial data but nevertheless represents a step forward in the use of presence-only data to assess species decline. Presence-only data can provide a useful starting point for understanding patterns of decline, provided an appreciation of bias within the data (e.g. false absence) is incorporated into the analysis. Collection of absence data via community survey is an effective way to account for such bias on a broad scale, particularly when studying a high-profile iconic species such as the Malleefowl. However, collection of spatially and temporally structured presence-absence data across a range of environmental gradients is necessary to provide rigorous assessments of population trends in decline over time.

References

Austin, M.P. (2002) Spatial prediction of species distribution: an interface between ecological theory and statistical modelling. *Ecological Modelling* **157:** 101-118.

Benshemesh, J. (2000) *National Recovery Plan for Malleefowl,* Department for Environment and Heritage, Adelaide.

Burbidge, A.A. and McKenzie, N.L. (1989) Patterns in modern decline of Western Australia's vertebrate fauna: causes and conservation implications. *Biological Conservation* **50:** 143-198.

Frith, H.J. (1962) Conservation of the mallee fowl, *Leipoa ocellata* Gould (Megapodiidae). *CSIRO Wildlife Research* **7:** 33-49.

Garnett, S. and Crowley, G. (2000) *The Action Plan for Australian Birds 2000,* Environment Australia, Canberra.

Priddel, D. and Wheeler, R. (1999) Malleefowl conservation in New South Wales: a review. R.W.R.J. Dekker, D.N. Jones, and J. Benshemesh (Eds). *Proceedings of the Third International Megapode Symposium, Nhill, Australia, December 1997. Zoologishe Verhandelingen 327,* pp. 125-141.

Priddel, D. and Wheeler, R. (2003) Nesting activity and demography of an isolated population of Malleefowl (*Leipoa ocellata*). *Wildlife Research* **30:** 451-464.

Recher, H.F. and Lim, L. (1990) A review of current ideas of the extinction, conservation and management of Australia's terrestrial vertebrate fauna. *Proceedings of the Ecological Society of Australia* **16:** 287-301.

Wintle, B.A., Elith, J., and Potts, J.M. (2005) Fauna habitat modelling and mapping: a review and case study in the Lower Hunter Central Coast Region of NSW. *Austral Ecology* **30:** 719-738.

Fragmentation and plant dispersal capacity in Dutch wetlands

H. Soomers[1], M.J. Wassen[1], P.A. Verweij[2]

[1]Environmental Sciences, Faculty of Geosciences, Utrecht University – Heidelberglaan 2, 3584 CS Utrecht, the Netherlands.
e-mail: H.Soomers@geo.uu.nl
[2]Science, Technology and Society, Faculty of Science, Utrecht University – Heidelberglaan 2, 3584 CS Utrecht, the Netherlands.

Introduction

Wetlands fulfil important ecological functions as regulators of worldwide water regimes and carbon-, and oxygen cycles (Best *et al.*, 1993) and there biodiversity is often large (Mitsch and Gosselink, 1993). In the Netherlands, plant diversity is especially large in the groundwater dependent, nutrient poor floating fens, belonging to the community of *Caricion davallianae* (Best *et al.*, 1993). However, wetlands are declining rapidly worldwide (Finlayson and Moser, 1991), and only 80 hectare floating fen is left in the Netherlands (Beltman *et al.,* 2001).
Many studies investigated the causes of deterioration of these low productive fens (e.g. Barendregt *et al.*, 1995; Bootsma and Wassen, 1996). However, most studies only considered abiotic processes, ignoring the importance of seed dispersal for plant occurrence. In fragmented habitats, such as the Dutch wetlands, dispersal capacity can become limiting, resulting in a decreasing connectivity of the remaining subpopulations and thereby affecting the persistence of plant species (Hanski and Gyllenberg, 1993).
We hypothesise that habitat fragmentation has negative effects on floating fen plant viability, in addition to changes in site factors. To gain more insight in both the effect of abiotic factors and of habitat fragmentation on floating fen species occurrence, several datasets comprising data on site factors, plant species composition and spatial configuration of plant populations in the Dutch Vecht river plain were subjected to a logistic regression analysis.
To gain more insight in seed dispersal and colonization capacity of the considered fen plant species in a fragmented area, several field experiments were carried out. As soil moisture is strongly positively related to the percentage of hydrochorous species (Ozinga et al. 2004), it is expected that dispersal by water plays an important role in the wet fen ecosystems. Therefore, focus in this study is on hydrochory.

Methodology

Logistic regression analysis

To gain insight to the key-factors that determine plant presence, a forward stepwise logistic regression analyses was performed with abiotic variables and variables related to fragmentation as independent factors and presence/absence of plant species as dependent factor.
Abiotic variables considered in the analysis were Electro-Conductivity (EC25) pH, groundwater table, soil temperature, nutrients (K^+, NO_3^-, NH_4^+, $H_2PO_4^-$, P_{tot}) and ions (Ca^{2+}, Mg^{2+}, Na^+, Cl^-, HCO_3^-, SO_4^{2-}, Fe_{tot}, Al_{tot}, Mn_{tot}, S^{2-}, SiO_2, Cu_{tot}, Pb_{tot} and Zn^{2+}) in the groundwater samples. Both the first order and second order polynomials were candidate predictors.
Patch area and perimeter, number of populations within 500 metres, distance to the neighbouring hill ridge and height are variables related to habitat fragmentation or spatial configuration that were used as independent variables in the analysis.
For the present study, two floating fen species (*Carex diandra* and *Menyanthes trifoliata*) and one fen meadow species (*Lychnis flos-cuculi)* were selected.

Seed dispersal experiments

To assess the dispersal and colonization capacity of the considered fens species, painted seeds were released on fens and in water bodies, and recaptured with nets in the water and astroturf mats on the banks. Results of these experiments are not available yet, as the study is ongoing.

Results

Logistic regression analysis

Preliminary results show a highly significant positive relation between the number of populations within 500 meters of each sampling point and the probability of occurrence of *C. diandra* and *M. trifoliata.* Furthermore, highly significant positive (*C. diandra* and *M. trifoliata*) and optimum (*L. flos-cuculi*) relations between plant occurrence and Ca^{2+} content were found. Other significant predictors for plant occurrence were the area of the suitable habitat (*L. flos-cuculi*, positive relation), temperature (*M. trifoliata*, positive relation) water table (*C. diandra* and *M. trifoliata*, optimum relation), Cl^- content (*L. flos-cuculi*, positive relation) and Al_{tot} content (*L. flos-cuculi*, negative relation).

Discussion

The fact that the number of populations within 500 meters of a location (*C. diandra* and *M. trifoliata*), and the size of the habitat patch (*L. flos-cuculi*) are positively related to the occurrence of the species is in line with metapopulation theory (Hanski and Gyllenberg, 1993) and indicates the negative effect of fragmentation on plant species viability. The positive relation of occurrence of all three species with Ca^{2+} content indicates the dependency of the species to discharge of calcareous groundwater. This endorses the efforts of nature managers to restore the original groundwater flow with seepage water discharging near the hill ridge.

References

Barendregt, A; Wassen, M.J. & Schot, P.P. (1995) Hydrological systems beyond a nature reserve, the major problem in wetland conservation of Naardermeer (the Netherlands). *Biological conservation* **72:** 393-405.

Beltman, B; van den Broek, T; Barendregt, A; Bootsma, M.C. & Grootjans, A.P. (2001) Rehabilitation of acidified and eutrophied fens in the Netherlands: effects of hydrologic manipulation and liming. *Ecological engineering* **17:** 21-31.

Best, E.P.H; Verhoeven, J.T.A. & Wolff, W.J. (1993) The ecology of The Netherlands wetlands: characteristics, threats, prospects and perspectives for ecological research. *Hydrobiologia* **265:** 305-320.

Bootsma, M.C. & Wassen, M.J. (1996) Environmental conditions and fen vegetation in three lowland mires. *Vegetatio* **127:** 173-189.

Finlayson, C.M. & Moser, M. (eds.) (1991) *Wetlands*. Facts On File Ltd., Oxford

Hanski, I. & Gyllenberg, M. (1993) 2 General Metapopulation Models And The Core-Satellite Species Hypothesis. *American Naturalist* **142**:17-41.

Mitsch, W.J. & Gosselink, J.G. (1993) *Wetlands.* Second edition. Van Nostrand Reinholt, New York.

Ozinga, W.A; Bekker, R.M.; Schaminee, J.H.J. & Van Groenendael, J.M. (2004) Dispersal potential in plant communities depends on environmental conditions. *Journal of Ecology* **92**: 767-777.

How are landscape and environmental factors related to forest tree species richness in a Mediterranean context?

O. Torras, A. Gil-Tena and S. Saura

Department of Agroforestry Engineering. ETSEA. University of Lleida, Spain.
e-mail: otorras@eagrof.udl.es

Introduction

Factors determining patterns of biodiversity have received considerable attention from scientists in recent years. Different hypothesis have been proposed to explain latitudinal gradients of richness; in particular, correlations between global patterns in species richness and climate are widely known, and climatic factors as predictors of plant distributions have been analysed by a large number of studies. However, biodiversity patterns are strongly influenced by multiple variables, both biotic and abiotic, at multiple scales (Huston, 1994). In this context, factors operating at the landscape level could be related with vegetation spatial distribution at different scales, although there is a considerable lack of knowledge in this respect, particularly in the Mediterranean areas. From a landscape ecology approach, effects of landscape structure on abundance and distribution of organisms can be explored (Turner, 1989), and could be analysed as a factor explaining biodiversity. In this sense, forest landscape fragmentation has been shown to be in some cases a determinant of biodiversity loss, and shape complexity is also considered a key landscape pattern characteristic in this respect. This study intends to provide further insights into the understanding of Mediterranean tree species richness patterns from a landscape ecology perspective, investigating to what degree forest landscape structure can explain forest tree species richness distribution in a Mediterranean region at the scale of 100 km2.

Material and methods

Our case study was carried out in Catalonia (NE Spain), located within 42º53'00''N and 40º31'23''N and with a total extension of 32,098 km^2, where 38% of the territory is covered by forests. The main forest tree species are *Pinus halepensis, Pinus sylvestris* and *Quercus ilex*. The dominant climate is Mediterranean, although a great contrast in altitude and a complex relief favours climatic diversity at the micro scale.

The analysis was performed in a grid of UTM 10 x 10 km cells, considering only those cells with at least 90% of its area falling within the territory of Catalonia and excluding those not covered by forest area, which resulted in a total of 278 cells.

The recent Spanish Forest Map at scale 1:50,000, developed within the Third Spanish National Forest Inventory (Ministerio de Medio Ambiente, 1997-2006), was the information source used for obtaining the tree species richness and the rest of forest landscape variables related to composition (forest area, forest canopy cover, forest development stage, land cover diversity) and configuration (fragmentation, shape irregularity). Environmental variables included topographic (elevation, slope, aspect) and climatic information (temperature, precipitation, radiation) and were obtained from different official sources. Spatial factors were also analysed through the geographic coordinates of the centre of each UTM 10 x 10 km cell.

We evaluated how much of the variation in species richness could be attributed exclusively to landscape structure compared to other spatial and environmental factors (topography and climate) through partial linear regression (Legendre and Legendre, 1998) and the variation partitioning method proposed by Bocard et al. (1992). Then, we conducted a new multiple linear regression by backward stepwise method focusing on the effect of forest landscape characteristics on tree species richness, in order to explore which of them were more relevant to explain tree species richness at the scale of study.

Results and discussion

The whole set of variables considered explained a considerably large amount of total tree species richness variation, nearly 60%. The largest fraction (28%) resulting from the variation partitioning corresponded to the join effects of the three types of variables, which indicates that both environmental and forest landscape factors present similar spatially structured patterns highly influencing species richness. Among the pure fractions, forest landscape factors were those that most contributed to explain tree species richness (15.2%), much more that the pure effect of environmental (2.3%) and spatial factors (1.8%). This result highlights the importance of forest landscape variables at this scale of analysis (10 x 10 km).

The forest landscape regression model identified several factors related to forest landscape composition (forest canopy cover (FCC), forest area and land use diversity) as those explaining the largest amount of tree species richness variation, and revealed that a high FCC is more related to tree species richness than the amount of forest area itself. Composition variables were followed, with a lower importance in the regression model, by shape metrics (minimum circle circumscribing index, area-weighted shape index and density of shape characteristic points), agreeing with previous studies showing that shape complexity is a potentially valuable measure of plant species richness (Moser et al., 2002, Saura and Carballal 2004). On the contrary, no fragmentation variables were selected in the model.

We believe that these results may provide valuable guidelines for the analysis of forest diversity and for forest landscape management in the Mediterranean. However, considering the scale dependence of ecological patterns, we recognise that further research at other spatial scales is also needed.

Acknowledgments

The Spanish Forest Map for Catalonia was provided by the Dirección General para la Biodiversidad (Ministerio de Medio Ambiente, Spain). This study was funded by the IBEPFOR project (CGL2006-00312/BOS, Ministerio de Educación y Ciencia, Spain). A. Gil-Tena benefited from a predoctoral research grant from the Catalan Government.

References

Bocard, D; Legendre, P. & Drapeau, P. (1992) Partialling out the spatial component of ecological variation. *Ecology* **73:** 1045-1055.

Huston, M.A. (1994) *Biological diversity: the coexistence of species on changing landscapes*. Cambridge University Press, Cambridge.

Legendre, P. & Legendre, L. (1998) *Numerical ecology, 2nd edn.* Elsevier, Amsterdam.

Ministerio de Medio Ambiente (1997-2006) *Tercer Inventario Forestal Nacional.* Dirección General para la Biodiversidad, Madrid.

Moser, D.; Zechmeister, H.G.; Plutzar, C.; Sauberer, N.; Wrobka, T. & Grabherr, G. (2002) Landscapes patch shape complexity as an effective measure for plant species richness in rural landscapes. *Landscape Ecology* **17:** 657-669.

Saura, S. & Carballal, P. (2004) Discrimination of native and exotic forest patterns through shape irregularity indices: an analysis in the landscapes of Galicia, Spain. *Landscape Ecology* **19:** 647-662.

Turner, M.G. (1989) Landscape ecology: the effect of pattern on process. *Annual Review of Ecology and Systematics* **20:** 171-197.

A farmer typology for modelling multiple land-use change at the regional level

D. Valbuena, P. H. Verburg, A. Bregt , A. Ligtenberg

Wageningen University and Research Centre. Environmental Sciences Group. Wageningen.
The Netherlands.
e-mail: diego.valbuena@wur.nl.

Introduction

Land-use patterns have been shaped by the spatial and temporal interaction between people and the environment (Moss 2000; Veldkamp and Verburg 2004). Although this interaction is affected by many biophysical and socio-economic factors and processes, the accumulation of individual human decisions is the main direct cause of current land-use change processes. These decisions are taken based on many different aspects such as: individual knowledge, experience and attitudes, family and social structure, the environment (e.g. soil, water availability, climate and slope), resources (e.g. savings, loans, subsidies, number and size of farms), previous land-use type, the degree of uncertainty (about the environment and the market), and policies (Gasson 1973; Willock et al. 1999). The intricate interactions of all these aspects, together with the lack of data, makes it impossible to take into account all human decisions and actions that are continuously reshaping the landscape structure. The aim of this study is to simplify the representation of the diversity of land-use decisions, and in particular those related to implement non-agricultural practices, by using the concept of farmer typology.

Selected parameters

A typology is an abstract way to simplify and order reality (McKinney 1950; Jollivet 1965). The criteria to construct a typology, as well as to evaluate it, primarily depend on the objectives of its implementation (Escobar and Berdegué 1990). For instance, a study of how policies affect nature conservation at the regional level requires a different approach than a study of what are the production systems in a village.

Because several typologies have been already well defined and implemented, this study aims only to adjust one of them by combining three main aspects related to the farmer: perceptions, personal and socio-economic characteristics, and the surrounding landscape.

<u>Farmers' perceptions</u>
Whether a farmer implements non-agricultural practices partially depends on his/her perception of the role of agriculture (Guillaumin et al. 2004). Farmers with a positive perception of nature and landscape conservation and society's demands are more likely to participate in conservation programmes and to develop recreational facilities than those who do not consider these aspects important.

<u>Personal and socio-economic characteristics</u>
Decisions on (multiple) land-use are also influenced by personal (e.g. age, educational level, family size) and socio-economic characteristics (e.g. farm size, main agriculture activity, economic and technical resources, etc) of the farmer (Willock et al. 1999). For example, land-use decisions of a young farmer who practice intensive pig farming might differ from those of a farmer who practice dairy farming in an extensive way.

<u>Spatial location: landscape characterization</u>
Human land-use decisions affect the structure and dynamics of the landscape. At the same time, the nature of these landscape properties also influences farmers' land-use

possibilities and decisions. For instance, a farmer whose holding is located in an area dominated by intensive agriculture does not have the same possibilities than one whose farm is located in a landscape with small-scale farming and with some nature areas. Thus, a landscape characterization was spatially defined.

By simplifying the diversity of land-use decisions with a farmer typology, it is not only possible to understand better the complexity of land-use change processes, but also to include partially farmers´ decisions in land-use modelling at the regional scale, which in turn can improve the relevance of such tools in spatial planning and policy-making processes.

References

Escobar, G. and J. Berdegué (1990). Conceptos y metodologías para la tipificación de sistemas de finca: la experiencia de RIMISP. Tipificación de Sistemas de Producción. G. Escobar and J. Berdegué. Santiago de Chile, RIMISP**:** 13-43.

Gasson, R. (1973). "Goals and Values of Farmers." Journal of Agricultural Economics **24**(3): 521-542.

Guillaumin, A., D. Bousquet and A. Villaret (2004). Multifonctionnalité de l'agriculture: demandes locales et attitudes des agriculteurs. Les Cahiers de la Multifonctionnalité. C. Laurent and J. Rémy.

Jollivet, M. (1965). "D'une méthode typologique pour l'étude des sociétés rurales." Revue Française de Sociologie **VI**: 33-54.

McKinney, J. C. (1950). "The role of constructive typology in scientific sociological analysis." Social Forces **28**(3): 235-240.

Moss, M. R. (2000). "Interdisciplinarity, landscape ecology and the `Transformation of Agricultural Landscapes'." Landscape Ecology **15**(3): 303-311.

Veldkamp, A. and P. H. Verburg (2004). "Modelling land use change and environmental impact." Journal of Environmental Management **72**(1-2): 1-3.

Willock, J., I. J. Deary, M. M. McGregor, A. Sutherland, G. Edwards-Jones, O. Morgan, B. Dent, R. Grieve, G. Gibson and E. Austin (1999). "Farmers' Attitudes, Objectives, Behaviors, and Personality Traits: The Edinburgh Study of Decision Making on Farms." Journal of Vocational Behavior **54**(1): 5-36.

How landscape ecology concepts can be applied to make policy for landscape reclamation

F. Azari-Dehkordi[1], D. Minai-Tehrani[2], N. Mashayekhi-Kerahroodi[1], N. Khazaee[1]

[1] Graduate Faculty of Environment, University of Tehran, Tehran-Iran. PO Box 14155-6135, e-mail: fazari@ut.ac.ir
[2] Department of Biology, Faculty of Science, Bio-Research Lab, Shahid Beheshti University, Tehran-Iran.

Introduction

Almost two thirds of Japan is not habitable due to mountainous topography or forest coverage (FAO, 2002). On the other hand, population density in this country is quite high (MIAC of Japan, 2005) and needs a very complex road-network for transportation. For example, till 1999 there was 129,190 km of constructed rural-road category in Japan that was actually increased into 278,000 km (Nihon Rindo Kyokai, 2001). This network of rural roads provides a highly fragmented rural and forest landscapes.

We have introduced a landscape reclamation approach in rural Japan for policy making to reduce landscape fragmentation (Azari Dehkordi, 2005). The study site was decided as Haizuka Dam Watershed, with 21,130 ha that is located in Eastern Hiroshima Prefecture, Japan. In this area, ten sub watersheds were delineated as working units, according to river system ordering of Strahler (1964) (Fig. 1).

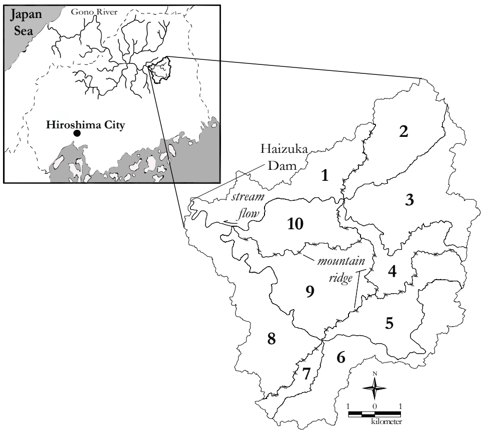


Fig. 1: Study area, 10 sub-watersheds, in Eastern Hiroshima, Japan

The road (scale; 1:25,000) and vegetation layers were overlaid to compute fragmentation for the study area. Then, the Number of Patches (NumP) in the fragmented vegetation layer was plotted against the length of each type of roads in the whole area. It was clear that Type 5 road has the highest correlation with landscape fragmentation (Table 1). The Type 5 road is categorized as *rural roads*, (some times forest roads) with 1.5 m width on Japanese topographic maps.

Table 1: Number of patches was plotted against types of roads

	Type 5 Road	*Type 4 Road*	*Type 3 Road*
R square	*0.82*	*0.79*	*0.58*
P-value	*0.81*	*0.25*	*0.01*

No Rural Roads: A scenario approach

In a scenario approach in the working units, all roads of Type 5 were removed and the fragmented patches were combined together in the fragmentation layer using ArcMap8.3®. Then, for the 10 sub-watersheds, spatial statistic analysis was conducted to compute NumP (number of patches), median, and mean of patches in two scenarios of before and after landscape reclamation (Table 2).

Table 2: Scenario approach for landscape reclamation removing Type 5 road category. (NumP: Number of Patches; Pr: Statistics of the patches at present; RmR5: Statistics of patches removing 5th type of roads; MedPS: Median Patch Size; MPS: Mean Patch Size; TLA: Total Landscape Area.)

Study Units	Landscape metrics								TLA (ha)
	NumP		***reclaimable***	MedPS		***reclaimable***	MPS		
	Pr	RmR5	**(NumP)**	Pr	RmR5	**(MedPS)**	Pr	RmR5	
1	558	396	**162**	1.3	1.6	**0.3**	3.9	5.4	2152
2	472	300	**172**	1.4	2.0	**0.6**	4.6	7.3	2190
3	867	632	**235**	1.2	1.7	**0.4**	3.4	4.6	2922
4	441	323	**118**	0.9	1.2	**0.3**	3.0	4.1	1317
5	700	425	**275**	1.0	1.1	**0.1**	2.8	4.6	1968
6	716	443	**273**	1.0	1.3	**0.3**	3.5	5.6	2487
7	172	98	**74**	1.2	1.5	**0.3**	2.9	5.2	505
8	928	654	**274**	1.3	1.5	**0.2**	3.2	4.5	2958
9	1035	704	**331**	0.9	1.1	**0.2**	2.8	4.2	2940
10	687	443	**244**	0.9	1.2	**0.3**	2.4	3.8	1671

Discussion: SLOSS and Policy Making for Landscape Reclamation

Several major ecological values of large patches are known. Some advantages are known for small patches (Forman, 1995). Arguments will remain between ecologists concerning SLOSS (Single Large Or Several Small) patches. However, for rural landscape reclamation in Japan, compilation of several small patches are more reasonable as many kilometers of rural access roads are already remote and covered by stones or debris.

Given these facts, our preliminary findings show that for example, removing the Type 5 roads will lead to a reduction of NumP in sub watershed 9 from1035 to 704 (saving 331 patches), or the median of the patches will increase from 1.4 ha to 2.0 ha and the mean has an increase of 4.6 to 7.3 in sub watershed 2. Therefore, policy making for landscape reclamation in Japan should concentrate on the Type 5 roads, which can be prioritized within working units according to the landscape ecology metrics.

References

Azari Dehkordi, F. (2005) Environmental Impact Assessment of Dams in Japan and Iran: a landscape ecological modeling perspective, PhD Dissertation. Hiroshima University, Hiroshima 358 pp.

FAO (2002) *State of the World's Forests*, FAO, Rome.

Forman, R.T.T. (1995) *Land Mosaics: the ecology of landscapes and regions,* Cambridge University Press, New York.

MIAC (Ministry of Internal Affairs and Communications) of Japan (2005) *Statistical Handbook of Japan*, Retrieved 2007-01-26 from www.stat.go.jp/English/data/handbook/c02cont.htm.

Nihon Rindo Kyokai (2001) New forest road construction – approach from the experience, Nihon Rindo Kyokai (in Japanese), Tokyo, 217 pp.

Strahler, A.N. (1964) Quantitative geomorphology of drainage basin and channel networks. V.T. Chow (ed). *Handbook of Applied Hydrology*, McGraw Hill, New York, section 4-11.

1.3 Open Session 4: Biodiversity Conservation and Agriculture

Eco-structure cartography in a Mediterranean Delta

R. Pérez Campaña, A. Matarán Ruiz, L.M. Valenzuela Montes

Dep. of Urban and Spatial Planning, University of Granada, Edificio Politécnico, Laboratorio de Urbanística y Ordenación del Territorio, Campus Universitario de Fuente Nueva, Granada. Spain.
e-mail: rociopc@ugr.es.

Introduction

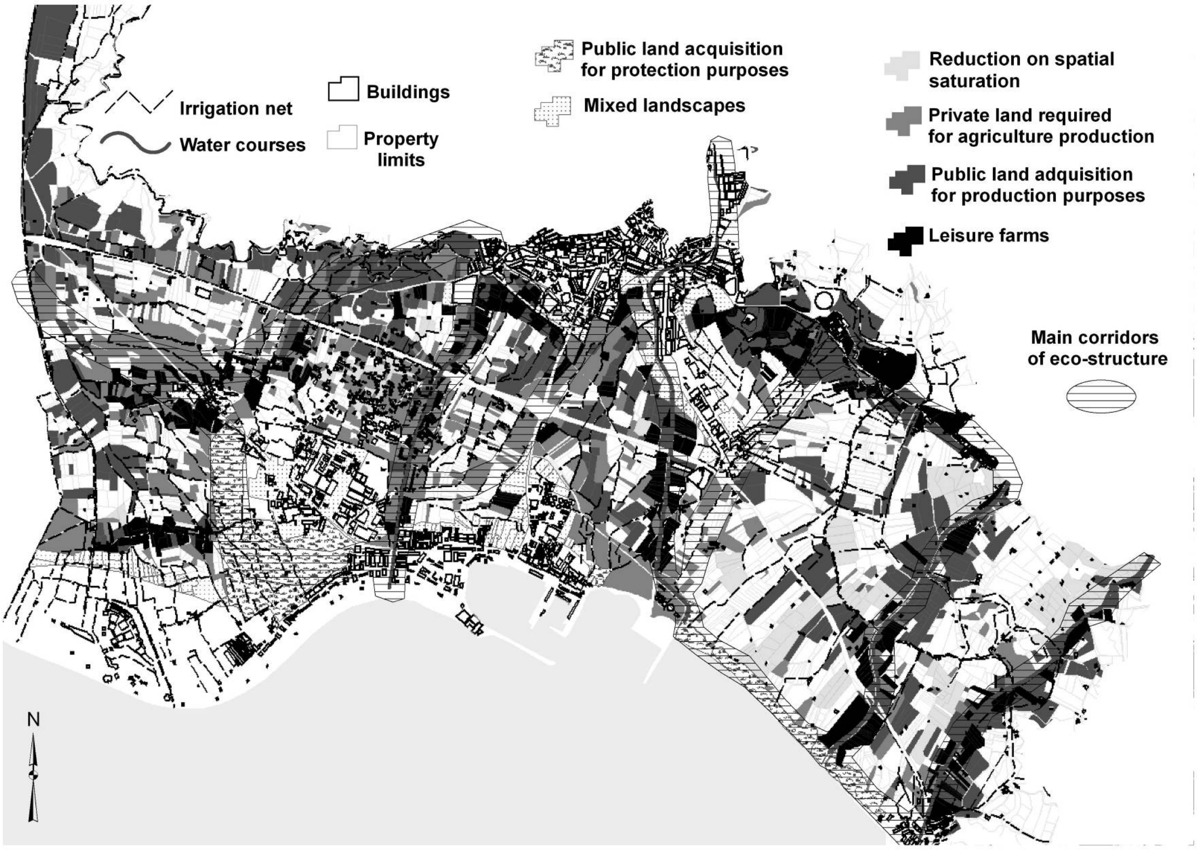
In this article we present an innovative zoning of the Motril Local Council in the Guadalfeo Delta (south of Spain, coast of Granada) based on an eco-structure, that could be defined as a physical support for the environmental fluxes and processes essential to maintain the main functions of the ecosystem in the context of multifunctional landscapes and spatial development. The main objective of this planning proposal is to define a multifunctional strategy leading to an Agrarian Park (Diputación de Barcelona, 2003) for an agricultural plain with great environmental values (the so called Vega) articulated by this eco-structure but threatened by the spatial grown of greenhouses, industries, urban areas and tourism as elsewhere of the Mediterranean Coast (Terra, 2002) (Imbroglini, 2003) (Matarán, 2005).

<u>Zoning proposal</u>

On the basis of the agricultural habitats and the main structural elements (rural roads, irrigation nets, fences and water courses) we propose a zoning cartography (Figure 1) including new planning tools that are more efficient to regenerate degraded areas, to reinforce the eco-structure and to increase the multifunctionality:

- Protect and promote agrarian farms against urban expansion.
- Improve agrarian landscapes that constitute and produce fundamental eco-structure functions, such as: habitats, corridors, buffer or sinks.
- Generate transition areas and diverse landscapes based on the coexistence of different agrarian typologies together with urban open spaces and even other land uses.
- Generate agrarian open spaces or with a low rate of urban occupation.
- Considerate the carrying capacity of the area and of any farming.

As seen in Figure 1 we are proposing a new territorial model for the Vega of Motril, where most of the planning efforts are focused on the central and western areas, because there we found the highest environmental values (e.g. biodiversity) and the most important conflicts of urban expansion and subsequent agricultural land abandonment. The proposal for the eastern areas is trying to reduce the saturation of greenhouses (Matarán, Aguilera and Valenzuela, 2005) and the reinforcement of corridors (e.g. rivers and litoral). We have also proposed most of the interventions along our interpretation of the main corridors of the eco-structure. Finally, this zoning strategy must be developed in a more detailed scale within the involvement of stake holders and citizens in the participative councils and management structure of the proposed Agrarian Park.



References

Diputación de Barcelona. (2003). “Plan Especial de Protección y Mejora del Parque Agrario del Bajo Llobregat”. Diputación de Barcelona.

Imbroglini, C. (2003). “Le infrastrutture ambientali. Matrici del progetto territoriale”. Quaderni dei Dipartimenti di Architettura e Urbanistica di Pescara nº 14.

Matarán Ruiz, A. (2005). La valoración ambiental-territorial de las agriculturas de regadío en el litoral Mediterráneo: el caso de Granada. PhD Thesis. University of Granada.

Matarán, A.; Aguilera, F. y Valenzuela, L.M. (2006). Modelling future landscapes: greenhouse **expansion in the Mediterranean coast. In Meyer, B.C. (Ed.), 2006**. Sustainable Land Use in Intensively Used Agricultural Regions. Landscape Europe. Alterra Report No.1338, Wageningen.

Terra. (2002). “The percolating urban plan”. Terra SRL

Arresting woodland bird decline in Australian agricultural landscapes: potential application of the European agri-environment model

S.E. Park[1], S.J. Attwood[2], M. Maron[2], S.J. Collard[2], K. Reardon-Smith[2]

[1]CSIRO Sustainable Ecosystems, 203 Tor Street, Toowoomba, Queensland, 4350, Australia.
e-mail: sarah.park@csiro.au
[2]Australian Centre for Sustainable Catchments and Faculty of Sciences, University of Southern Queensland, Toowoomba, Queensland, 4350 Australia.

Introduction

Temperate Australia's wheat/sheep zone and much of Western Europe have both experienced dramatic declines in native bird populations associated with agricultural landscapes, with many species exhibiting range contractions and greatly reduced abundance (Ford *et al*. 2001; Donald *et al*. 2002). We present a comparison of European farmland and Australian woodland bird declines and a critique of the recent strategies for addressing declines. Finally we offer an evaluation of the European agri-environment model, as represented by England's Environmental Stewardship scheme, as a potential policy mechanism for delivering targeted on-farm management for declining Australian woodland birds and their habitat through providing financial incentives and support to participating landholders.

Context

In both Australia and Europe, recent bird diversity declines in agricultural landscapes have been attributed to a loss of habitat heterogeneity, resulting from moves towards broadscale agriculture and homogenous management. However, there are at least two key differences in the nature and cause of declines in the two regions. The declining species at threat in Australian agricultural regions are largely woodland specialists, whereas in Europe they are species dependent upon centuries-old traditional management of semi-natural habitats. The former depend upon natural systems of mid to late successional stages; the latter upon intermediate levels of intervention indicative of early to mid successional stages (Sutherland 2004).

The distinction is largely due to differing land use histories of these regions. In Western Europe, large areas of indigenous vegetation were converted to farmland over a long time-period, dating from prehistoric times (Donald *et al*. 2002); many species have either adapted to the changes or followed the gradual spread of agriculture from open habitats. In Australia, the conversion to farmland is recent, ongoing and rapid, leaving scant opportunity for woodland species to adapt to the new, more open environments.

Current conservation models

Biodiversity decline is engendering widespread scientific and government concern in both regions. Increasing recognition of the problem is evidenced by recent changes in land use policy, including a shift from production subsidies to agri-environmental payments in Europe (Donald *et al.* 2002) and the introduction of legislation to police land-clearing in Australia.

While Australia's conservation efforts have historically focused on the establishment of conservation reserves, there is increasing pressure to address biodiversity conservation priorities on private lands. Approaches have to date centred on one-off, short-term schemes, administered through a wide variety of government and non-government organisations and often relying on voluntary landholder involvement. Payments are generally one-off leveraged contributions towards the direct financial cost of the capital works (landholders are often expected to make an in-kind contribution to the work). Whilst this demonstrates landholder willingness to undertake environmentally beneficial activities on their land, there are ample indications that many are unable to do so for lack of financial resources (Cocklin *et al.* 2006).

These issues have been addressed to a considerable extent by the European model of agri-environmental payments. In England, the Environmental Stewardship (ES) scheme is national government managed and regionally delivered by one dedicated agency, the Rural Development Service. One of the explicit, underpinning objectives of the scheme is biodiversity conservation, with the stated target of "reversing the long-term decline in the number of farmland birds by 2020" (Gregory *et al.* 2004). Payments consist of both one-off reimbursement for capital works and ongoing 'income-foregone' payments for the loss of intensive production land to more extensive practices.

Economically the stewardship model offers ten-year management agreements and allows for much greater ongoing financial support for landholders. Organisationally it has a dedicated agency and trained staff to administer, advise and police. Ecologically it has targeted management options developed by ecological authorities, ongoing consultation with external experts and organisations and specifically designed monitoring protocols.

Stewardship in Australia?

Vickery *et al.* (2004) state that agri-environment schemes may represent the only currently available mechanism to reduce declines in farmland biodiversity over large areas. As such, the ES model may appear an appropriate model for achieving Australia's environmental goals.

However, agri-environment schemes operate at enormous cost and, in the European case, are potentially vulnerable to changes in EU funding and WTO regulation. There is also considerable discussion as to whether such schemes actually deliver the biodiversity benefits that they purport to (Kleijn and Sutherland 2003).

The applicability of the model to the unique environments of Australia is a matter for debate. It is nevertheless clear that many of the mechanisms of bird decline in agricultural landscapes could be addressed by the development of a highly targeted, well-designed, economically robust and nationally consistent scheme that addressed matrix management and large-scale habitat restoration as well as remnant protection and provided significant and ongoing support to facilitate land holder adoption.

References

Cocklin, C., Dibden, J. & Mautner, N. (2006) From market to multifunctionality? Land stewardship in Australia. *Geographic Journal* **172:** 197-205.

Donald, P.F., Pisano, G., Rayment, M.D. & Pain, D.J. (2002) The Common Agricultural Policy, EU enlargement and the conservation of Europe's farmland birds. *Agriculture, Ecosystems and Environment* **89:** 167-182.

Ford, H.A., Barrett, G.W., Saunders, D.A. & Recher, H.F. (2001) Why have birds in the woodlands of Southern Australia declined? *Biological Conservation* **97:** 71-88.

Gregory, R.D., Noble, D.G. & Custance, J. (2004) The state of play of farmland birds: population trends and conservation status of lowland farmland birds in the United Kingdom. *Ibis* **146:** 1-13.

Kleijn, D. & Sutherland, W.J. (2003) How effective are European agri-environment schemes in conserving and promoting biodiversity? *Journal of Applied Ecology* **40:** 947-969.

Vickery, J.A., Bradbury, R.B., Henderson, I.G., Eaton, M.A. & Grice, P.V. (2004) The role of agri-environment schemes and farm management practices in reversing the decline of farmland birds in England. *Biological Conservation* **119:** 19-39.

Sutherland, W.J. (2004) A blueprint for the countryside. *Ibis* **146:** 230-238.

Are there more biologically and economically effective ways to protect aquatic biota in agricultural landscapes?

B.R. Davies[1], J. Biggs [1], P.J. Williams [1], S. Maund [2], S. Thompson

[1] Pond Conservation c/o School of Life Sciences, Oxford Brookes University, Gipsy Lane, Headington, Oxford OX3 0BP, UK.
e-mail: brdavies@brookes.ac.uk
[2] Syngenta Crop Protection AG, 4002, Basel, Switzerland

Introduction

There is much policy and legislation pertaining to freshwater ecosystems in the UK, including drinking water standards, flood defence, abstraction restrictions and nature conservation legislation. Ideally these measures should cumulatively result in high quality freshwater ecosystems, rich in aquatic biodiversity. In reality, policy and legislation has concentrated on attaining water chemistry targets, and there is little evidence that these measures have translated into improved aquatic biodiversity on the ground. Indeed overall, the indication is that the UK's aquatic biodiversity has levelled off or declined in recent years.

The expansion and intensification of agriculture is seen as one of the major influences on the degraded state of much aquatic biodiversity worldwide, caused largely by a combination of the hydro-physical alteration and loss of waterbodies and increased sediment, nutrient and pesticide loadings in runoff (e.g. Allan et al., 1997; Cresser *et al*., 2000; Woltemade, 2000). These impacts have been widespread, partly due to the scale of agriculture which, in the UK dominates almost 80% of land cover in England and Wales (Defra, 2002; Brown *et al*., 2006).

UK Agri-Environment schemes and their protection of aquatic biota

Detrimental effects from agriculture are mitigated for through agri-environment measures, such as the UK's Environmental Stewardship scheme, which is designed to protect both terrestrial and freshwater habitats, the historic environment and promote public access through a range of tiered measures. The extensive scale of agriculture means that, in practice, it is these measures which should deliver the majority of broad-scale benefits for aquatic biodiversity in England and Wales. One of the most widely employed measures for the protection of waterbodies is the use of buffer strips. Although buffer strips have been very well investigated and it is broadly agreed that they remove agricultural pollutants, the widths required to do so have been much debated with over 25 m frequently being recommended. Such widths are much greater than those suggested under Environmental Stewardship, which offers 2 m to 6 m field margin buffers or over 10 m surrounding in-field ponds, implying that at least a 100% increase in buffer widths may be needed to ensure that they are effective. More broadly, evidence from several other countries has indicated that, buffer zones alone may not be sufficient, with declines in aquatic biodiversity being observed when the proportion of a waterbody's catchment under agriculture exceeds 30% to 50% or sometimes less (Wang *et al*., 1997; Fitzpatrick *et al*., 2001; Allan, 2004; Donohue *et al*., 2006).

Therefore, it is not surprising that recent evidence has, so far, often shown a lack of realisation of the desired benefits from agri-environment schemes, with research showing the actual enhancement of farmland biodiversity to be limited and in some cases negative (Whitfield, 2006). In eastern England the impacts of diffuse agricultural pollution have been identified as so severe that it has been suggested that they can only be addressed by a complete halt to farming in this area with the conversion of extensive areas of arable land to semi-natural uses (Clover, 2006). This implies that current solutions provided by agri-environment schemes are unlikely to be optimal and has led to a call for 'smart' solutions to ensure that agricultural production may be retained (Clover, 2006).

We have investigated one such 'smart' solution by examining where aquatic biodiversity lies within agricultural landscapes and how protection and mitigation measures may be redistributed to provide more effective protection for key waterbody types whilst allowing the continuation of agricultural production.

Smart solutions

New evidence shows that smaller waterbodies and in particular ponds support comparatively very high levels of aquatic biodiversity across agricultural landscapes (Williams *et al*., 2004; Davies, 2005; Davies *et al*., submitted). Although all waterbody types contribute to aquatic biodiversity, it is likely that the protection and creation of a range of smaller waterbodies may be a useful tool for securing aquatic biodiversity across a region. This is made possible by the characteristically small catchment areas of these smaller waterbodies (Davies *et a*l., submitted) enabling resources to be concentrated into relatively small pockets with extensive catchment deintensification, whilst retaining farming in adjacent areas outside of these catchments.

References

Allan, J.D.; Erickson, D.L. & Fay, J. (1997) The influence of catchment land use on stream integrity across multiple spatial scales. *Freshwater Biology* **37**: 149-161.

Allan, J.D. (2004) Landscapes and riverscapes: the influence of land use on stream ecosystems. *Annual Review of Ecology, Evolution and Systematics* **35**: 257-284.

Brown, C.D.; Turner, N.L.; Hollis, J.M.; Bellamy, P.H.; Biggs, J.; Williams, P.; Arnold, D.J.; Pepper, T. & Maund, S.J. (2006) Morphological and physico-chemical properties of British aquatic habitats potentially exposed to pesticides. *Agriculture, Ecosystems and Environment* **113**: 307-319.

Clover, C. (2006) *Farmland 'must go back to the Middle Ages'*. Retrieved on May 2nd 2006, from: www.telegraph.co.uk/news/main.jhtml.

Cresser, M.S.; Smart, R.; Billet, M.F.; Soulsby, C.; Neal, C.; Wade, A.; Langan, S. & Edwards, A.C. (2000) Modelling water chemistry for a major Scottish river from catchment attributes. *Journal of Applied Ecology* **37**: 171-184.

Davies, B.R. (2005) *Developing a Strategic Approach to the Protection of Aquatic Biodiversity*. Unpublished PhD thesis; Oxford Brookes University.

Davies, B.R.; Biggs, J.; Williams, P.J.; Lee, J.T. & Thompson, S. (submitted) A comparison of the catchment sizes of rivers, streams, ponds, ditches and lakes: implications for protecting aquatic biodiversity in an agricultural landscape. *Hydrobiologia*.

Defra (2002) *Second Consultation Paper on the Implementation of EC Water Framework Directive (2000/60/EC)*. Defra; London.

Donohue, I.; McGarrigle, M.L. & Mills, P. (2006) Linking catchment characteristics and water chemistry with the ecological status of Irish rivers. *Water Research* **40**: 91-98.

Fitzpatrick, F.A.; Scudder, B.C.; Lenz, B.N. & Sullivan, D.J. (2001) Effects of multi-scale environmental characteristics on agricultural stream biota in eastern Wisconsin. *Journal of the American Water Resources Association* **37**: 1289-1507.

Wang, L.Z.; Lyons, J.; Kanehl, P. & Gatti, R. (1997) Influences of watershed land use on habitat quality and biotic integrity in Wisconsin streams. *Fisheries* **22**: 6-12.

Whitfield, J. (2006) How green was my subsidy. *Nature* **439**: 908-909.

Williams, P.; Whitfield, M.; Biggs, J.; Bray, S.; Fox, G.; Nicolet, P. & Sear, D. (2004) Comparative biodiversity of rivers, streams, ditches and ponds in an agricultural landscape in Southern England. *Biological Conservation* **115**: 329-341.

Woltemade, C.J. (2000) Ability of restored wetlands to reduce nitrogen and phosphorus concentrations in agricultural drainage water. *Journal of Soil and Water Conservation* **55**: 303-309.

Landscape ecology at the service of the policy maker: evaluating the Swiss agri-environmental measures

F. Herzog, W. Richner , T. Walter

Agroscope Reckenholz-Tänikon Research Station ART, Zurich, Switzerland
e-mail: felix.herzog@art.admin.ch

Introduction

"IALE encourages landscape ecologists to transcend boundaries and to work together building theory and developing knowledge of landscape pattern and process, developing integrative tools, and making them applicable to real landscape situations and applying them to solve problems" (www.IALE.com). Evaluating the effects of policy measures is a formidable challenge for landscape ecologists. Their broad interdisciplinary knowledge is required to assess the effectiveness of policy measures and to distinguish their effects from other factors affecting environmental parameters. The communication of results and the involvement of stakeholders goes beyond mere scientific requirements (Figure 1).

In the early 1990's a comprehensive agri-environmental programme was launched in Switzerland, which was later (1999) transformed into a cross-compliance mechanism ("Proof of Ecological Performance" – PEP). In order to quality for direct payments, whole-farm nutrient budgets have to be balanced, measures for soil conservation, integrated crop protection and animal welfare have to be implemented. Moreover at least 7 % of a farm's land have to be managed as Ecological Compensation Areas (ECA).

Environmental objectives were formulated by the government and we were given the task to assess goal attainment and the actual effectiveness of policy measures.

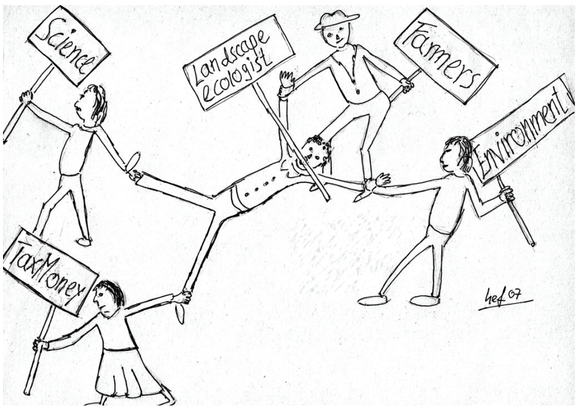


Figure 1. Nightmare of the landscape ecologist evaluating agri-environmental programmes. Reality proved to be less cruel because the stakeholders agreed on a joint interpretation of results.

Materials and methods

The methods comprised (i) monitoring of ground- and surface water quality; (ii) long-term monitoring of agricultural practices and of their effects on nitrate leaching, soil erosion and phosphorous run-off from grassland; (iii) scenario studies using nitrogen and phosphorous simulation models; and (iv) large-scale surveys of vascular plants, arthropods and birds on ECA. The research period covered 1995 – 2005.

Scientific findings

The main difficulty in evaluating the PEP's environmental effects was that many factors (e. g. climate, technical progress, socio-economic conditions of farmers) act both on farming practices and on the environmental parameters under investigation. Only long-term observations in conjunction modelling studies can single out the effect of policy measures.

Nitrogen and phosphorous emissions and immissions were substantially reduced in comparison to the reference period 1990-92 (Herzog and Richner, 2005; Prasuhn and Sieber, 2005). However, not all objectives were reached and there is still a considerable amount of excess nitrogen and phosphorous leading to pollution problems.

Biodiversity was increased on ECA as compared to intensively managed fields (Herzog and Walter, 2005; Aviron *et al.*, 2007). In the lowlands, PEP rules protect these sites from intensification whilst in mountain areas, ECA prevent them from abandonment. ECA largely failed to promote threatened species.

Communication and stakeholders

In addition to scientific publications, results were communicated to the authorities and to stakeholders. They contributed to the formulation of the new agricultural policy project for the period 2008-011. At this stage, the scientific findings were evaluated also from a political point of view. Farmers' representatives tend to secure their income, environmental NGOs emphasise the protection of natural resources, and regional representatives defend particular regional interests. The administration tries to balance the different stakeholder interests according to their political weight and ability to defend their stake.

What did we as scientists and landscape ecologists learn from this exercise?

1. Stakeholders may try to interfere already in the course of the project in order to influence the results (Figure 1). However, they finally agreed that objective, scientifically well founded results are most useful for everyone.
2. The requirements of science (e.g. sufficient sample size, sufficient time for data acquisition and analysis) need to be defended against ''*just-in-time*'' requirements for results by decision makers.
3. Whereas scientific findings are unambiguous, they need to be interpreted. We found it useful to integrate stakeholders in this process. They tried to steer the interpretation in order to strengthen their position. But once a common interpretation was reached, the results were generally accepted.
4. The communication of the results should be neutral and science oriented. Still it was not always possible to prevent misuse by the press and by specific pressure groups.

In conclusion, we found this a rewarding exercise - both scientifically and in terms of impact. We addressed four of six key issues (Wu and Hobbs, 2002) of landscape ecological research: interdisciplinarity, integration with applications, international collaboration, outreach and communication with the public and decision makers.

References

Aviron S., Jeanneret P., Schüpbach B. Herzog F. (2007) Effects of agri-environmental measures, site and landscape conditions on butterfly diversity of Swiss grasslands. *Agriculture, Ecosystems and Environment* (in press).

Herzog F. & Richner W. (eds.) (2005) Evaluation der Ökomassnahmen: Bereich Stickstoff und Phosphor Zurich, Agroscope FAL Reckenholz, Schriftenreihe der FAL 57, 132 pp.

Herzog F. & Walter T. (eds.) (2005) Évaluation des mesures écologiques : Domaine biodiversité. Zurich, Agroscope FAL Reckenholz, Les cahiers de la FAL 56. 208 pp.

Prasuhn V. & Sieber U. (2005) Changes in diffuse phosphorus and nitrogen inputs into surface waters in the Rhine watershed in Switzerland. *Aquatic Sciences* 67, 363–371.

Wu J. & Hobbs R. (2002) Key issues and research priorities in landscape ecology: An idiosyncratic synthesis. *Landscape Ecology* 17(4), 355–365.

The role of habitat networks in guiding integrated land-use planning in agricultural landscapes

M. Smith, J.W. Humphrey

Ecology Division, Forest Research Northern Research Station, Roslin, Midlothian UK.
e-mail: Mike.Smith@forestry.gsi.gov.uk

Introduction

The development of habitat networks is seen as an important mechanism for reversing the effects of fragmentation on biodiversity while delivering a range of other environmental benefits such as creating more opportunities for public access and recreational enjoyment of the countryside. In the Scottish lowlands, there is a desire to develop a more integrated approach to planning land-use change, which takes account of conservation objectives for the full suite of habitats and species associated with different types of land use.

Focal species modelling offers a potentially useful tool for developing different types of habitat networks and informing the targeting of agri-environment and forestry incentives Humphrey *et al*., 2005). Studies to date in Scotland have focused on the use of focal species modelling in developing forest habitat networks (Ray *et al*., 2004), but there is now a need to apply the approach to multi-network planning in more complex landscapes where there are a mix of different land-uses. In this paper we report on a test of the focal species modelling approach on the Isle of Tiree one of four case study areas in lowland Scotland with contrasting patterns of land use and conservation objectives.

<u>Study area description</u>

The Isle of Tiree, covering approximately 80 km^2 is situated some 50 km from the Western Scottish mainland. Topographically the island is low-lying with the highest point 140 m above sea level. Tiree has a unique climate; although benefiting from the Gulf Stream, precipitation at 1100mm/annum is much lower and temperatures are generally higher and more equable through the year than on the mainland. Extensive agriculture using the traditional crofting system is the main form of land-use on the island. This is based round small Townships with groups of smallholdings sharing common grazings. Here, through stakeholder groups, cattle grazing has been identified as the single most important conservation management tool and issue for habitats of conservation concern on the island. These are the Machair, unimproved coastal grasslands, and the *Carex nigra* dominated wet heaths that are found on thin peat further inland. The enclosed land historically was made up of small fields which were often further sub-divided by the crops grown on them, barley oats and potatoes being the most common but also with patches of hay meadow intermingled between the crops.

Land use change

Over that last 40 years land use has changed the balance on the enclosed in-bye land notably through the introduction of black bag silage and increased use of non-organic fertilisers. Tiree is an important area for breeding Corncrake (Cerex cerex) in Scotland and agri environmental schemes for the protection of this species has contributed to this land use change with close to 10% of agricultural land being under such schemes in 2005. This involves the late cutting of silage to allow for a second brood and the maintenance of *Iris pseudacorus* dominated mires, used as early cover for the birds. Over this same period cropping, growing of barley and oats mainly and hay meadows have declined significantly with only 20 ha under cropping in the whole island and hay cutting abandoned in all but the driest of summers.

There has been a resultant decline in species associated with cropping and hay meadows such as arable weeds and graniverous birds most notably the corn bunting (*Miliaria calandra)* which became extinct on the island in 2000 though is still present, but declining, on nearby islands. Winter cattle feed has now to be imported to the island from the mainland threatening the sustainabiltity cattle production and therefore the use of grazing as a conservation tool on the Machair and *Carex nigra* heaths. The Township of Barrapoll in the south west of the island has an area of approximately 750ha and changes in land use here reflect those over the whole island.

Over 50% of the 342Ha of present day permanent grassland in Barrapoll is in agri environmental schemes 85% of which is late cute silage the rest as early cover for birds. The 42 ha of former cropping fields has resulted in 10 of these 14 being converted to late cut silage under agri-environmental schemes for Corncrake, the remainder now being other forms of permanent grassland. Since 1962 20% of the 447ha common grazings within this township have been apportioned to individual crofts. This practice has gained momentum over the last 25 years where crofters enclosed the area of common land they had the grazing rights to. These apportioned areas have remained as Machair but the change in grazing regime results in less extensive grazing over smaller areas and a subsequent decline in habitat quality.

<u>Getting the balance right</u>

Corncrakes and corn bunting are both declining across much of Europe and where there are populations or potential populations the habitats that support them should be safeguarded. By using these as focal species as part of the development of integrated habitat networks a balance can be struck that can maintain the corncrake population but also allow for the return of the corn bunting. This would not only benefit the other species that utilise these habitats but allow for the sustainability of cattle grazing. Winter feed would again be produced on Tiree and so the quality of the Machair maintained for species such as the bee *Colletes floralis* (another focal species used in this case study) which is an indicator of Machair habitat quality

Acknowledgement

This work benefited greatly from the stakeholder involvement of Ross Lilley, David and Janet Bowler and their knowledge of the ecology and land-use history of the island.

References

Humphrey, J.W.; Watts, K., McCracken, D., Shepherd, N., Sing, L., Poulsom, E.G. and Ray, D., 2005. A review of approaches to developing lowland habitat networks in Scotland. ROAME No. FO2AA102/2. Commissioned Report. 104. Scottish Natural Heritage, Edinburgh.

Ray, D., Watts, K., Hope, J.C.E. and Humphrey, J.W., 2004. Developing forest habitat networks in southern Scotland. In: R. Smithers (Eds.), Landscape Ecology of Trees and Forests. Proceedings of the twelfth annual IALE (UK) conference, held at the Royal Agricultural College, Cirencester, 21-24 June 2004. IALE UK, Stoke on Trent, pp 216-223.

An up-to-date cost benefit analysis of English agri-environment schemes: their impact at the landscape scale and the cost of adequate monitoring

P.D. Carey, R.F. Pywell

Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon, UK.
e-mail pdca@ceh.ac.uk

Introduction

Four years ago in Darwin a summary of English agri-environment schemes and their effectiveness was presented to IALE (Carey et al 2004). Since then there has been a well mannered debate on the efficacy of schemes across Europe that in the end depended on whether you think the ‘glass is half empty or half full’.
The new Environmental Stewardship scheme in England has the slogan “Look after your land and be rewarded”. The scheme is split into two main parts in the ‘Entry Level Scheme’ (ELS) and the ‘Higher Level Scheme’ (HLS). The ELS is designed to attract 85% of all farmland. By December 2006, there were approximately 25000 agreements covering 3.5Mha (34%). The farmers are asked to reach a points target (30) for each hectare of land where the points are gained for carrying out different and basic management prescriptions for things such as the creation of wildflower strips in arable land, hedgerow management, and over-wintering stubbles for birds. The Higher Level Scheme is more like the old schemes where high quality land is targeted and the aim is to protect it and enhance if possible.
At Monks Wood we have been gathering data by experimentation on the efficacy of different management prescriptions that will be given to the farmers. By applying these results to the uptake figures for the new schemes we aim to predict the impact of the new schemes across the countryside. As this abstract is written the data on uptake for different prescriptions are not yet available.
Monitoring any project or programme against its objectives makes perfect sense. However, in the world of conservation and government policies it is seldom done adequately. Why is that? The simple answer is that it has not been budgeted for adequately. Recently the EU fifth framework project EASY devised and tested a monitoring programme for agri-environment schemes. We present how much the EASY methodology would cost to adequately assess change.

The Cost of Monitoring – a fictional example

The region of Allsplat (total area 20,000 km$^{2)}$ follows EU directives by designing a scheme to protect the treasured landscape and wildlife. Most of the wildlife exists in small areas of semi-natural habitat in amongst the intensive agriculture. Like England we assume there are two levels, one for ordinary land and one for rare species and habitats. The European Union requires Allsplat to monitor the success of the scheme but does not say how, or give any money to help do it (Carey 2001). The scheme paid out an average €80 per hectare of managed land. The simplest and cheapest objective to monitor was uptake of the scheme and to know how the farms were geographically located so a GIS was designed. It was found that 50% of all farms were in the scheme and that overall 10% of all land was under scheme prescriptions, at an annual cost of €16M. The uptake analysis and GIS cost €150K per year.

To monitor the effectiveness of the scheme requires: a baseline survey; and a monitoring scheme of farms in the scheme and outside of it that will detect change in landscape and wildlife that can be attributed to each of the prescriptions. A random sample of all agreements will not detect rare species (as shown by Kleijn et al 2006) because they are rare. We will show that for a rare weed that occurs on 5 farms the probability of detecting it is ≏ 8 x 10^{-5}. This is obviously not an adequate probability to say anything about the efficacy of a scheme. Targeted monitoring of various habitats in UK has shown that 200 plots can detect a suite of rare plant species (Walker et al 2006).

If the aim is to show that habitats are getting closer to the pristine condition of Priority Habitats power analysis is required to work out what sample size is required to achieve the desired level of change detection. Critchley et al 2002 showed a sample of 1000 sites was required. To this number of sites a control of 1000 should be added in fields not in the scheme following the protocol suggested by Kleijn *et al* (2006)

To detect rare species and detect whether habitats are moving towards a pristine state would require a sample of 2200. If each plot is visited twice in five years (the bare minimum to detect change) and the cost of each visit is €300 then the cost of just collecting the data will be €1.3M. Add to this the cost of project management, analysis and report writing, €0.5M and 5 years of uptake analysis and GIS, €0.75M then the total monitoring cost for the wildlife objectives would be ♎ €2.55M. Socio-economic and landscape monitoring would also be required e.g. as carried out by Carey et al 2003 cost €4K per farm. A sample of 500 would therefore cost €2M. Total payments for the scheme over 5 years in Allsplat would be 5x€16M = €80M. The monitoring budget is therefore 5.6% of the total payments to farmers, reasonable but expressed as a cost would annoy farmers and is probably outside the reach of most regional governments who have hospitals, schools etc. to pay for.

There are 100 or so real regions in Europe the size of the fictional one and so the cost of an adequate monitoring programme would be €455M over 5 years. Is there anybody out there who has ever heard of an ecological monitoring programme getting anything close to that from governments?

References

Carey, P.D. (2001). Schemes are monitored and effective in the UK. *Nature* **414**: 687.

Carey, P.D.; Short, S.; Morris, C.; Hunt, J.; Priscott, A.; Davis, M.; Finch, C.; Curry, N.; Little; W., Winter, M.; Parkin, A. & Firbank, L.G. (2003). The multi-disciplinary evaluation of a national agri-environment scheme. *Journal of Environmental management* **69**:71-91.

Carey, P.D.; Manchester, S.J. & Firbank, L.G. (2005) Performance of two agri-environment schemes in England: A Comparison of ecological and multi-discipliary evaluations. *Agriculture Ecosystems and Environment* **108**: 178-188.

Critchley, C.N.R.; Maskell, L.C.; Mitchley, J.; Adamson, H.F.; Burch,F.M.; Carey,P.D.; Firbank, L.G.; Fowbert, J.A.; Parkin, A.B.; Smart, S.M. & Sparks, T.H. (2002). *Review and recommendations of methodologies to be used for botanical monitoring of agri-environment schemes in England.* Final contract report to DEFRA, pp. 224.

Kleijn, D.;Baquero,, R.A.; Clough, Y.;Díaz,M.; De Esteban,J.; Fernández, Gabriel, Herzog, A. Holzschuh, R. Jöhl, E. Knop, A. Kruess, E. J. P. Marshall, I. Steffan-Dewenter,F.; Tscharntke, T.;Verhulst, J.; West, T.M.; Yela, J.L. (2006) Mixed biodiversity benefits of agri-environment schemes in five European countries. *Ecology Letters* **9**: 243–254.

Walker, K.J.; Critchley, C.N.R.; Sherwood, A.J.; Large, R.; Nuttall, P.; Hulmes, S.; Rose, R.& Mountford, J.O. (2006). An assessment of new agri-environment scheme options in England, UK. *Biological Conservation in press.*

Spatial Ecology Models and Conservation Targeting in the UK

R.D.J. Catchpole

Natural England, Science and Evidence Team, Bull Ring House, Northgate, Wakefield, West Yorkshire.
e-mail: roger.catchpole@naturalengland.org.uk

Introduction

Mechanisms for targeting conservation effort rely heavily on existing definitions of protected areas and species. Yet biodiversity has continued with observed declines in woodland birds (Eaton *et al.*, 2005), bumblebees (Kells and Goulson, 2003; Goulson *et al.*, 2006), vascular plants (Cheffings *et al.*, 2005), woodland plants (Kirby *et al.*, 2005), infertile grassland plants (Bunce *et al.*, 1999) and butterflies (Bergman, 2001; Fox *et al.* 2001; Swaay *et al.* 2006). As conservation moves into the 21st century, never has the need been greater to think about where future conservation resources might be spent. Decisions that may have previously been made on either an *ad hoc* or opportunistic basis need to be placed within a more clearly defined framework which supports judgements with an appropriate ecological evidence base. This is especially the case beyond protected areas where land use planning has generally failed to safeguard critical natural capital.

The application of landscape ecology thinking could offer significant benefits and help develop a new paradigm for conservation in which the ecological flows between protected areas and their wider landscape context are more clearly recognised and valued. This is not a choice between the conservation of sites vs. whole landscapes but rather the development of a more informed interpretation that goes beyond the urge to simply make patches bigger or increase physical linkage. The use of ecological models, that are able to utilise currently available information, offer some hope however. This paper will contrast the application of species-based and habitat-based models. It will highlight key differences, explore the practical value of the outputs and consider how this might change current patterns of targeting, using England as an example.

Comparisons

One example of a habitat-based approach can be found in least-cost distance modelling. This calculates the path of the lowest cost to movement between a series of focal patches. These costs can be calculated from a modified land cover layer (*e.g.* Land Cover Map 2000, ITE). The modification requires the attachment of estimates for the relative cost to movement across different land cover types. These can be derived from a series of expert judgements for a ‘generic focal species’ that might be associated with focal patches. Although the approach can be applied to empirical data for individual species movement, its value, as a conservation tool, lies in more general application. This can be done through the use of the Spatial Analyst toolkit in ArcMap 9.0 GIS (ESRI, 2004). The algorithm generates least-cost buffers around existing habitat patches which indicates where more permeable areas of landscape might still occur.

One example of a species-based approach can be found in the ZONATION reserve selection model (Moilanen and Kujala, 2006). This is a grid-based approach that supports the simultaneous comparison of distribution data from a range of different species. It sequentially removes the lowest scoring cells in such a way that the loss of biodiversity and connectivity is minimised. Both masked and unmasked outputs can be generated for comparison with other methods and priorities. Such masking allows ZONATION model outputs to be constrained by where conservation action is currently prioritised, *e.g.* statutory sites. Even though connectivity is evaluated through cell adjacency, it provides a structured way to evaluate species distribution data. Currently available UK datasets for invertebrates, lower plants and higher plants could be used within such an analysis.

Conclusions

The use of systematic and repeatable ecological analyses, that utilise currently available information, are critical in prioritising spending to deliver the greatest benefits for wildlife. There is a clear need to define what actions are appropriate in a spatially explicit manner so that land managers and policy makers can be clear about what is expected beyond protected areas. Although actions would need to be kept under review, some significant benefits could be delivered through the use of such approaches. Questions not only need to be raised about the assumed ecological benefits where current targeting fails to correspond to such areas but also about the performance of newly targeted areas in the future. This is the only option in a changing environment.

References

Bergman, K-O. (2001). Population dynamics and the importance of habitat management for conservation of the butterfly *Lopinga achine*. *Journal of Applied Ecology* **38:** 1303-1313.

Bunce, R.G.H., Smart, S.M., van der Poll, H.M., Watkins, J.W., Scott, W.A. (1999). Measuring change in British vegetation. *Ecofact* Volume 2. ITE, Merlewood.

Cheffings, C.M., Farrell, L. , Dines, T.D., Jones, R.A., Leach, S.J., McKean, D.R., Pearman, D.A., Preston, C.D., Rumsey, F.J., Taylor, I. (2005). The Vascular Plant Red Data List for Great Britain. Species Status 7: 1-116. Joint Nature Conservation Committee, Peterborough.

Eaton, M.A., Noble, D.G., Hearn, R.D., Grice, P.V., Gregory, R.D., Wotton, S., Ratcliffe, N., Hilton, G.M., Rehfisch, M.M., Crick, H.Q.P., Hughes, J. (2005). *The state of the UK's birds 2004*. BTO, Thetford.

ESRI (2004). ArcMap 9.0 Geographical Information System. ESRI Inc.

Fox, R., Warren, M.S., Harding, P.T., McLean, I.F.G., Asher, J., Roy, D., Brereton, T. (2001). *The State of Britain's Butterflies*. Butterfly Conservation, CEH and JNCC. Wareham, Dorset.

Goulson, D., Hanley, M., Darvill, B., Ellis, J. (2006). Biotope associations and the decline of bumblebees (*Bombus* spp.). *Journal of Insect Conservation* **10:** 95-103.

ITE (2000). Land Cover 2000, Institute of Terrestrial Ecology, Merlewood, United Kingdom.

Kells, A.R., Goulson, D. (2003). Preferred nesting sites of bumblebee queens (Hymenoptera: Apidae) in agro-ecosystems in the UK. *Biological Conservation* **109:** 165–174.

Kirby, K.J., Smart, S.M., Black, H.I.J., Bunce, R.G.H., Corney, P.M., Smithers, R.J. (2005). Long-term ecological change in British woodland (1971-2001). English Nature Research Report **653**. English Nature, Peterborough.

Moilanen, A., Kujala, H. (2006). *ZONATION: Spatial Conservation Planning Framework Software v. 1.0 User Manual.* Metapopulation Research Group, Helsinki, Finland.

Swaay, C., Warren, M., Loïs, G. (2006). Biotope use and trends of European butterflies. *Journal of Insect Conservation* **10:** 189-209.

Can agri-environmental schemes reduce habitat isolation and enhance biodiversity? The example of butterflies in Switzerland

S. Aviron, P. Jeanneret, B. Schüpbach, F. Herzog

Agroscope Reckenholz-Tänikon Research Station ART – Reckenholzstr. 191, CH-8046 Zurich, Switzerland.
e-mail: stephanie.aviron@art.admin.ch

Introduction

Agri-environmental schemes (AES) aim at integrating environmental concerns into agricultural policy and at protecting biodiversity. AES can be considered as a real landscape restoration experiment at a large scale (Herzog, 2005) and they allow testing, whether restoration measures can reduce habitat isolation and enhance landscape diversity for biodiversity. This study investigated the effect of AES measures at the field and landscape scales on butterfly diversity in Switzerland. The Swiss AES consists in the conversion of 7% of farmland into low-input habitats, the ecological compensation areas (ECA). We focused on the two main ECA types in the lowlands, i.e. ECA grasslands (90’000 ha) and ECA orchards (2.6 millions trees). We tested whether (i) butterfly diversity is higher on ECA than on conventional grasslands, (ii) butterfly diversity is enhanced by the network of ECA and by landscape diversity and (iii) the effects of ECA vary according to their landscape context.

Materials and methods

The study was conducted in two landscape units located on the Swiss ‘Plateau’. Landscape unit 1 is characterised by mixed grassland-arable farming, whilst landscape unit 2 is characterised by intensive grassland farming. Within each landscape unit, butterflies were recorded in ECA grasslands (N = 41), ECA orchards (N = 15) and conventional grasslands (N = 34) in 2004. The selected grasslands were rotational grasslands initially sown with a mixture of Italian ryegrass and clover. Explanatory variables were grouped into four sets of variables: (i) grassland type (ECA grassland, ECA orchard, conventional grassland), (ii) grassland quality (plant richness), (iii) landscape context of grasslands (amount of ECA, semi-natural habitats, conventional grasslands and crop fields in a 200 m circle radius; distance to the nearest ECA, semi-natural habitats, conventional grasslands and crop fields; habitat diversity in a 200 m radius) and (iv) space (geographical coordinates of sampled grasslands). For each landscape unit, the explanatory variables were tested on synthetic indices of butterfly diversity (species richness, abundance, Shannon diversity) using general linear models (GLM) and on butterfly assemblages by the means of redundancy analysis (RDA).

Results – discussion

<u>Butterfly diversity indices</u>

Amongst the four sets of explanatory variables, only the type of grassland had a significant effect on diversity indices. The species richness of butterflies in landscape unit 1 was in average higher in ECA grasslands and ECA orchards than in conventional grasslands, whilst butterfly abundance was higher in ECA grasslands than in conventional grasslands in both landscape units. This suggests a positive effect of extensification measures at the field scale on butterfly communities, at least in one study area. The Shannon index was not influenced by any of the tested variables.

<u>Species assemblages</u>

In both landscape units, ECA grasslands had different sets of butterfly species as compared to ECA orchards and conventional grasslands (RDA, P < 0.05) (Figure 1). At the landscape scale, butterfly assemblages were influenced by the distance of grasslands to other ECA grasslands (landscape unit 2) and/or to natural herbaceous and woody habitats (both landscape units) (RDA, *P*<0.05). This indicates that ECA, together with existing natural habitats, contributed to reduce the spatial isolation of butterfly habitats. Butterfly assemblages were not affected by habitat diversity in the surrounding landscape (RDA, *P*>0.05).

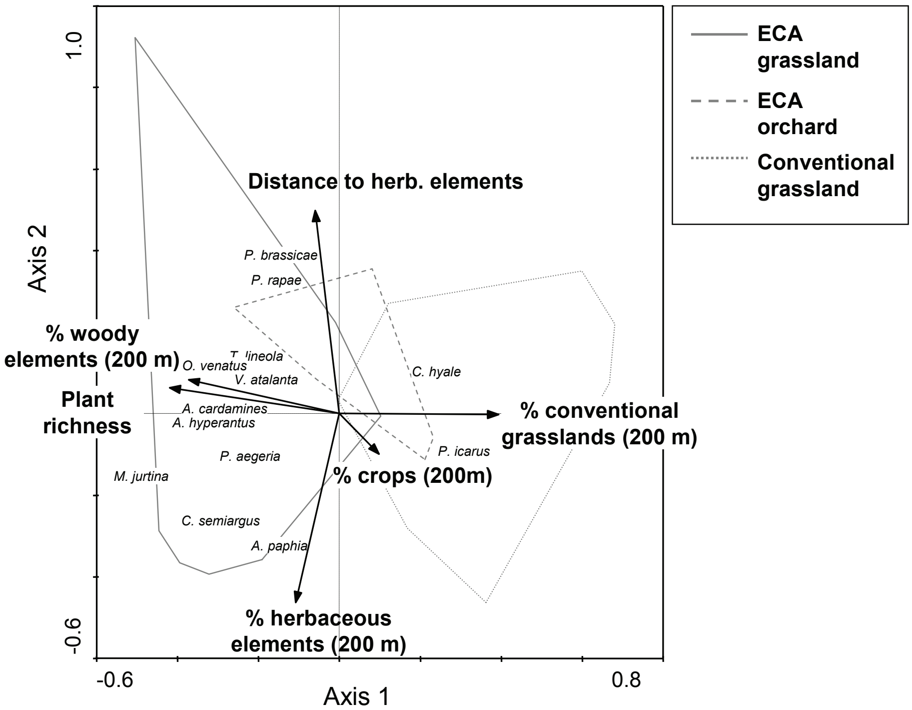


Figure 1. Ordination diagram from redundancy analysis of butterfly assemblages constrained by grassland type (samples: polygons around each type), plant species richness (arrow) and landscape context (arrows) in landscape unit 1.

Conclusions

Although AES focus on the implementation of good farming practices at the field scale, our study suggests that they might bring some environmental benefits by restoring the agricultural matrix (Aviron *et al.*, in press; Donald and Evans, 2006). For butterflies, habitat isolation can be reduced by connecting AES grasslands and existing natural habitats.

References

Aviron, S.; Jeanneret, P.; Schüpbach, B. & Herzog, F. (in press) Effects of agri-environmental measures, site and landscape conditions on butterfly diversity of Swiss grassland. *Agriculture, Ecosystems and Environment*

Donald, P.F. & Evans, A.D. (2006) Habitat connectivity and matrix restoration: the wider implication of agri-environment schemes. *Journal of Applied Ecology* **43:** 209-218.

Herzog, F. (2005) Agri-environmental schemes as landscape experiments. *Agriculture, Ecosystems and Environment* **108**: 175-177.

1.4 Open Session 5: Sustainability and agriculture

Silvoarable Agroforestry for Europe: environmental and economic performance

J.H.N. Palma[1], A.R. Graves[2], P.J. Burgess[2], Y. Reisner[3], F. Herzog[1]

[1] Ecological Controlling Research Group, Agroscope FAL Reckenholz, Zurich, Switzerland, e-mail: joao.palma@art.admin.ch
[2] Institute of Water and Environment, Cranfield University, Silsoe, UK,
[3] Swiss College of Agriculture, Zollikofen, Switzerland

Introduction

Many European landscapes suffer from intensive agricultural management which affects environmental quality (e.g. water quality and landscape biodiversity). Silvoarable Agroforestry (SAF) integrates use of trees and arable crops in the same field. It potentially offers a range of environmental and economic benefits in comparison with conventional arable cropping. A modeling approach was used to compare the environmental and economic benefits of SAF with arable and forestry systems at a landscape and continental scale.

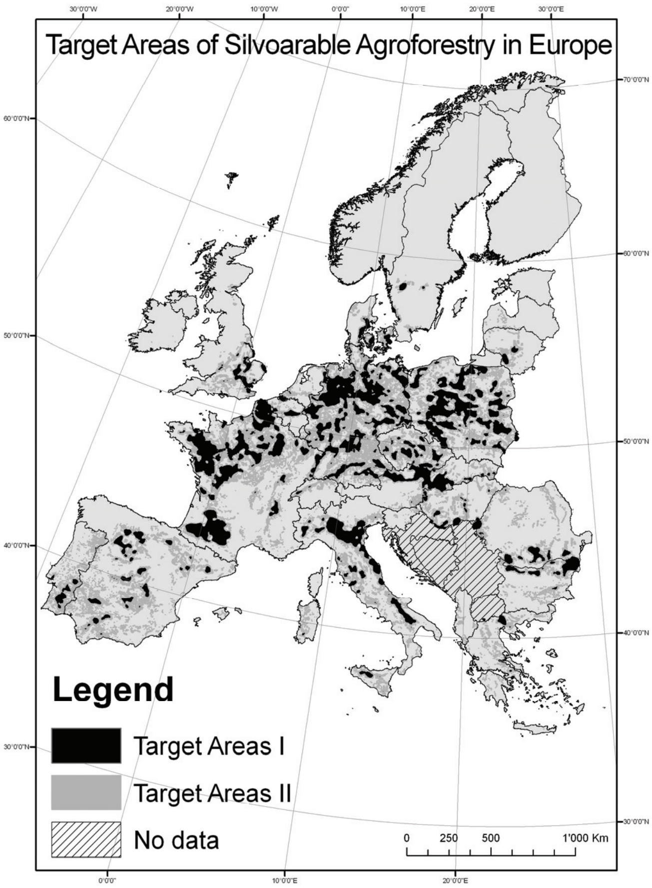
Methods

At the landscape scale, biophysical and economic data were collected for a stratified random sample of 19 Landscape Test Sites (LTS) in the Mediterranean and Atlantic regions of Europe. Five tree species, holm oak (*Quercus ilex* subsp. *ilex* L.), stone pine (*Pinus pinea* L.), hybrid walnut (*Juglans* sp), wild cherry (*Prunus avium* L.) and poplar (*Populus* spp) were modeled with combinations of up to five crops; wheat (*Triticum durum* Desf.), sunflower (*Helianthus annuus* L.), oilseed rape (*Brassica napus* L.), grain maize and silage maize (*Zea mays* L.). The environmental assessment focused on soil erosion, nitrogen leaching, carbon sequestration and landscape diversity following the methodology suggested by Palma et al. (2006a). The economic assessment focused on the farm's infinite net present value over the tree rotation period (Graves et al., 2006). At each LTS, different agroforestry scenarios were modeled and compared to status quo arable production.

At the continental scale, data on soil, climate, topography, land cover and tree growth were used to identify target regions for SAF, with the aim of finding areas where SAF could reduce the risk of soil erosion, contribute to groundwater protection, and increase landscape diversity.

Results and Conclusions

At landscape scale SAF had a positive impact on the four environmental indicators in comparison with the status quo, but economic benefits varied according to tree species and region. The extent of the environmental impact depends on the severity of the problems and the SAF management options for each location. Benefits were predicted to be highest when SAF was implemented on large areas (i.e. 50% of the farm) and on high quality land, where current agricultural practices were intensive and associated with high levels of soil erosion and nitrogen leaching (see details in Palma et al., 2006b). Economic predictions for the post-2005 Common Agricultural Policy payments suggested that SAF with walnut and poplar in France could provide a profitable alternative to arable systems. In Spain, it appeared that holm oak and stone pine could be integrated into arable systems without substantially reducing arable production for many years. Since these trees are of ecological and landscape importance, rather than productive importance, additional support in the form of an agri-environment payment could be justified (see details in Graves et al., 2006).



At a continental scale target regions were found to make up about 40% of the total arable area of the European Union (Figure 1). Of these, 7% were found to be at risk from soil erosion (erosion rate > 5 t ha^{-1} a^{-1}), 34% were in nitrate vulnerable zones, and 59% were low diversity arable landscapes (see details in Reisner et al., 2006).

Figure 1. Target regions for silvoarable agroforestry in Europe for *Juglans* spp., *Prunus avium*, *Populus* spp., *Pinus pinea*, and *Quercus ilex*. Possible areas for agroforestry on arable land in Europe, where at least one of the five selected tree species can potentially grow, and where at least one environmental problem exists (soil erosion, nitrate leaching, landscape diversity). Target Areas I: well defined areas; Target Areas II: scattered areas. Based on Reisner et al (2006).

References

Graves, A., P. Burgess, J. Palma, F. Herzog, G. Moreno, M. Bertomeu, C. Dupraz, F. Liagre, K. Keesman, & van der Werf, W. (2006) The development and application of bio-economic modelling for silvoarable systems in Europe. *Ecological Engineering* in press.

Palma, J., A. Graves, P.J. Burgess, K. Keesman, H. van Keulen, M. Mayus, Y. Reisner, & Herzog, F. (2006a) Methodological approach for the assessment of environmental effects of agroforestry at the landscape scale. *Ecological Engineering* in press.

Palma, J., A. Graves, R. Bunce, P. Burgess, R. De Filippi, K. Keesman, H. van Keulen, M. Mayus, Y. Reisner, F. Liagre, G. Moreno, & Herzog, F. (2006b) Modelling environmental benefits of silvoarable agroforestry in Europe. *Agriculture Ecosystems & Environment* in press: doi:10.1016/j.agee.2006.07.021.

Reisner, Y., R. De Filippi, J. Palma & Herzog, F. (2006) Target regions for silvoarable agroforestry in Europe. *Ecological Engineering* in press.

Shifting cultivation or agroforestry? The dilemma of selecting a livelihood model for the forest dwellers and preserving landscape ecology in north-east Himalayas

M. Choudhury

Centre for Himalayan Studies, North Bengal University, P.O. North Bengal University, Siliguri, Pin Code 734013, District Darjeeling, West Bengal, India
e-mail: maitreyee_c@hotmail.com

Introduction

There is an ever-growing debate between the advocates of shifting cultivation and the proponents of agroforestry. According to some, shifting cultivation is agriculture on forestland, and according to some others it is forestry on agricultural land (Kerkhoff, 2006). A case of such dilemma has been observed in India's northeast. Shifting cultivation, in spite of being a time-tested age-old practice in the region, is now under the scanner of environmental scientists. A section of bio-scientists working in the region are in favour of suitable agroforestry model as an alternative to shifting cultivation by traditional slash-and-burn method. However, this is often argued that "shifting cultivation is not to be confused with slash-and-burn, since slash-and-burn is a mere land clearing method, whereas shifting cultivation involves complete landscape management by customary institutions including the management of forests as fallows and village forests" (International Centre for Integrated Mountain Development, ICIMOD, 2006). The advocates of shifting cultivation are also of the opinion that shifting cultivators help biodiversity conservation since they use a large variety of plants and animal products in their everyday life and thus maintain these species, contrary to the belief that they destroy biodiversity. The practice of shifting cultivation is believed to be beneficial for certain species of wild biodiversity particularly the elephants that require open space. The practice of land rotation creates patches and corridor for the easy movement of elephant herds and other larger species of wild animals in northeast India, thereby maintaining wild biodiversity. According to the ICIMOD, in a way shifting cultivation itself is a traditional agroforestry practice that can be improved and adapted to modern needs, rather than replacing it with alternatives.

Shifting cultivation or agroforestry?

India's north-east, particularly the state of Arunachal Pradesh in the Eastern Himalayas is densely forested. On an average, at any given point of time, more than 60 percent of the geographical area of the state remains under forest cover though the percentage varies from place to place due to shifting cultivation. Shifting cultivation is a prevalent agricultural system in the state and affects an area of about 16,000 sq. km out of a total geographical area of 83,743 sq. km (Choudhury & Haridasan, 1993). The state is home to more than a hundred tribes, the majority of who are forest dwellers and practice shifting cultivation for centuries. They strongly rely on indigenous knowledge and oral tradition to maintain a balance between their livelihood practices and environment (Borang & Borkotoki, 2002). Till very recently, the abundant land and forests were thought to be sufficient to sustain the indigenous inhabitants of the state. However, of late, some telltale signs of environment degradation are appearing in certain areas that have put the practice of shifting cultivation in question. The increase in population, though not alarming, has temped the forest dwellers to reduce the gap between successive cycles of cultivation. The advocates of shifting cultivation are of opinion that it is not so much the practice of shifting cultivation, which is in question; rather it is the length of cycle that matters. Violating the indigenous norms of maintaining a gap of at least ten years between two consecutive periods of cultivation, many tribal groups are returning back to the forest clearings within three to six years (Sood, *et al*, 2002) that leave hardly any time to regenerate forest and regain the soil nutrients lost during the period of cultivation. Whatever the case may be, the gradual depletion of forest cover of the state is worrying the environment scientists in the country. With a density of population of only 16 persons per sq. km. (2001), the situation is hopefully not beyond repair. To preserve the landscape ecology in this thinly populated state, a section of environment scientists are of opinion that, the indigenous tribes should be trained to start agroforestry in place of shifting cultivation. Considering the fact that there are several models of agroforestry, it is important to select a model best suited for local needs, which may again vary according to the terrain condition, soil cover, altitude and climate.

Agroforestry models

The International Centre for Research in Agroforestry (ICRAF) has developed methodology for designing agroforestry models on the basis of regional productivity, sustainability and adoptability. Following ICRAF guidelines several models have been developed for the region by local as well as international agencies. The most talked about models of agroforestry in the region are the multi-tier Agro-silvi-horti-pastoral model developed by the Indian Council of Agricultural Research (ICAR) and the Sloping Agricultural Land Technolology (SALT) model developed by the Mindanao Baptist Rural Life Centre in the Philippines (Upadhyaya, *et al*, 2002). The present paper makes an attempt to assess the dimensions of dilemma between two schools in favour and against shifting cultivation, and viability as well as acceptability aspects of the agroforestry models prescribed for the area.

References

Borang, A. & Borkotoki, A. (2002) Indigenous people's knowledge and alien culture in Arunachal Pradesh, in R.C. Sundriyal, T. Singh & G.N. Sinha (Eds). *Arunachal Pradesh: Environmental Planning and Sustainable Development*, G.B. Pant Institute of Himalayan Environment and Development, Almora, India, pp. 537-548.

Choudhury, S.S. & Haridasan, K. (1993) Water conservation vis-à-vis forestry in Arunachal Pradesh, *Arunachal Forest News*, Itanagar, India, **11(1):** pp. 4-17.

Kerkhoff, E. (2006) A Dialogue on What Policy Makers Can Learn from Farmers, International Centre for Integrated Mountain Development, (ICIMOD), Kathmandu, Nepal.

Sood, K. K; Singh, B. & Rethy, P. (2002) Shifting cultivation in Arunachal Pradesh – causes and control, in R.C. Sundriyal, T. Singh & G.N. Sinha (Eds). *Arunachal Pradesh: Environmental Planning and Sustainable Development*, G.B. Pant Institute of Himalayan Environment and Development, Almora, India, pp. 161-165.

Upadhyaya, K; Arunachalam, A. & Khan, M.L. (2002) Designing proper agroforestry models for Arunachal Pradesh: scope and challenges, in R.C. Sundriyal, T. Singh & G.N. Sinha (Eds). *Arunachal Pradesh: Environmental Planning and Sustainable Development*, G.B. Pant Institute of Himalayan Environment and Development, Almora, India, pp. 349-353.

Large-scale biomass production and potential effects on farmland habitats and related biodiversity

B.S. Elbersen[1], P.D. Carey[2]

[1] Alterra, P.O.Box 47, 6700 AA Wageningen, The Netherlands,
e-mail: berien.elbersen@wur.nl
[2] Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon,
Cambridgeshire PE262XH UK,

Introduction

In this paper the pressures from land use changes resulting from a politically induced increased demand for biomass for bioenergy generation are assessed and translated into potential effects on biodiversity.

The decision of the European Council in March 2007 set a binding overall goal for 20% renewable energy sources and a minimum binding target share of 10% biofuels in the total transport fuel consumption by 2020 Currently, only around 4 % (69 MtOE) of the EU's total primary energy consumption is met from biomass.

The study conducted for the EEA[1] still based on the less ambitious targets of 5.75% share of biofuels in total fuel consumption and 21% share of renewable energy in total energy consumption by 2020 show that this would require an approximate 10% share of the present Utilised agricultural area (UAA) in the EU-25 for targeted biomass crop production. It is clear that the most recent more ambitious targets of 10% biofuels will even increase the pressure on agricultural land further to a possible share of up to 18% of the UAA in EU-25.

In order to assess the potential effect on farmland biodiversity in the EU it is important to understand how much land is required, but also what land use changes are induced and where these changes are mostly likely to take place.

Potential land use changes and effects on biodiversity

Trying to assess the effects of any change in land-use on biodiversity and the environment as a whole is extremely difficult because of imperfect knowledge. It is unclear how organisms are distributed in the landscape, how they function, and how management practices on the land affect them. But the effects of intensive agriculture on biodiversity are conclusive and there is little doubt that further intensification of agriculture will occur in the coming decades especially in the new EU countries. Economics along with the productive capability of the land will determine which changes in land-use will occur first to accommodate the needs of biomass production. But overall it is clear that biomass production is most likely to be taken up first in those regions where land is released from agriculture and on set aside land. The impacts on biodiversity of changing some extensive land-uses to intensive arable or biomass production would be catastrophic but from an economic and technical point of view these are less likely to occur.

However, a distinction needs to be made between extensive farmland categories that are suited for potentially suited for biomass production such as ancient extensive grasslands like the Dehesas/Montados and species rich hay meadows of the mountains and the extensive grasslands that are more recent and have occurred due to land abandonment. This second

[1] This paper is based on a study conducted for the European Environment Agency on the potential effects of a wider demand for biomass in agriculture on European farmland habitats and biodiversity. Elbersen. B.; Andersen. E; R. Bakker. R. Bunce. P.Carey. W. Elbersen. M. van Eupen. A. Guldemond. A. Kool. B.Meuleman. G.J. Noij & J. Roos Klein-Lankhorst (forthcoming). Large-scale biomass production and agricultural land use – potential effects on farmland habitats and related biodiversity. Technical report. EEA study contract EEA/EAS/03/004

group are also valuable in biodiversity terms and if converted to intensive arable would lose a great deal of environmental quality.

It is estimated that for most of the EU15 countries the negative biodiversity/environmental impacts will affect a rather small portion of the land. The negative impacts will be higher in Italy, Spain and Portugal. In Italy's case this is mainly due to the large conversion of permanent crops to intensive arable agriculture and the large demand for bioenergy and therefore biomass. In Spain there are predicted losses of extensive grasslands which have a high biodiversity value and there is also a large demand. Portugal, stands out as being particularly badly affected under the storylines. If no considerable efforts are being made to protect the environment in Portugal when biomass cropping is introduced it will be catastrophic for farmland biodiversity.

The effects of biomass production on the new EU countries are not quantifiable using the methods employed for the old EU countries but it is almost certain that biomass production will cause negative impacts. However, they might not be greater than the impacts that general intensification of agriculture in those countries will have (autonomous development?).

There is little scientific information on the impacts of biomass crops on biodiversity, but what can be inferred is that both short rotation coppice (SRC) and perennial biomass grasses will provide shelter for animals although little food for them. Growing SRC or the energy grasses on arable land will be very beneficial to earthworms and soil health generally because it is a limited or no till systems. However, if biomass crops replace permanent grassland there will be no benefits and probably negative effects on the soil and loss of soil carbon.

The areas where High Nature Value (HNV) farmland is most at risk of being converted to biomass crops is mapped by combining suitability information and HNV farmland concentrations. The maps show that HNV and high suitability for ligno-cellulose production are negatively correlated. This would be encouraging except that it has been postulated that areas of high suitability are also areas of greatest agricultural production and are likely to remain in their current land-use and it is areas of medium suitability and the better end of the low suitability class that are more likely to be converted. These maps clearly show that large areas of Spain, Portugal, Italy and Greece in the south have in theory large areas of HNV with medium suitability for ligno-cellulose crops. In practice much of the areas in Greece and the mountainous areas will be unsuitable because of the terrain. However, HNV in parts of Italy and Portugal (extensive arable, extensive grasslands, permanent crops) may be at threat. The low suitability areas are less at risk because they would be more difficult to convert to ligno-cellulose cropping and would produce low yields. In the north of Europe western Ireland, Wales, North Western England and Scotland have patches of medium suitability land with a high density of HNV farming land but most of it is protected.

The Baltic States, Poland, Romania and Bulgaria all have a large proportion of HNV (equivalent) in medium and high suitability categories and in these countries designations are not as stringent as in UK and therefore are more at risk of conversion to ligno-cellulose crops with a large impact on biodiversity. The area required for biomass crops in these countries is relatively small and the conversion rate will be low unless carbon credit trading is undertaken between member states.

Greenhouse planning criteria based on landscape ecology: a case study in the South of Spain

A. Matarán Ruiz, and L.M. Valenzuela Montes,

Department of Urban and Spatial Planning, University of Granada,
Edificio Politécnico, Laboratorio de Urbanística y Ordenación del Territorio, Campus Universitario de Fuente Nueva, Granada. Spain.
e-mail: mataran@ugr.es.

Introduction: planning problems concerning greenhouses

Greenhouses are producing important territorial impacts and environmental externalities related to unplanned land occupation and to the production of pollutants and discharges (Matarán, 2005). Nevertheless, the extraordinary spatial expansion of greenhouses along the last thirty years in the south east of Spain is leading to the saturation of the agricultural landscapes of coastal plains (Matarán, Aguilera, and Valenzuela, 2006).

From the point of view of the environment, planning documents are obsolete both in their methods and in their focus (Priemus, Rodenburg, and Nijkamp 2004). Agriculture is considered as a secondary activity in most of the documents. However, there are very few planning references to this important economic activity. In the case of local planning, the urban focus is predominant, so agriculture land is always the rest of the territory that has not got any other classification such as urban, urbanizable and protected. Furthermore, in the case of regional planning, we have to add the lack of coordination and out of date landscape and environmental analyses.

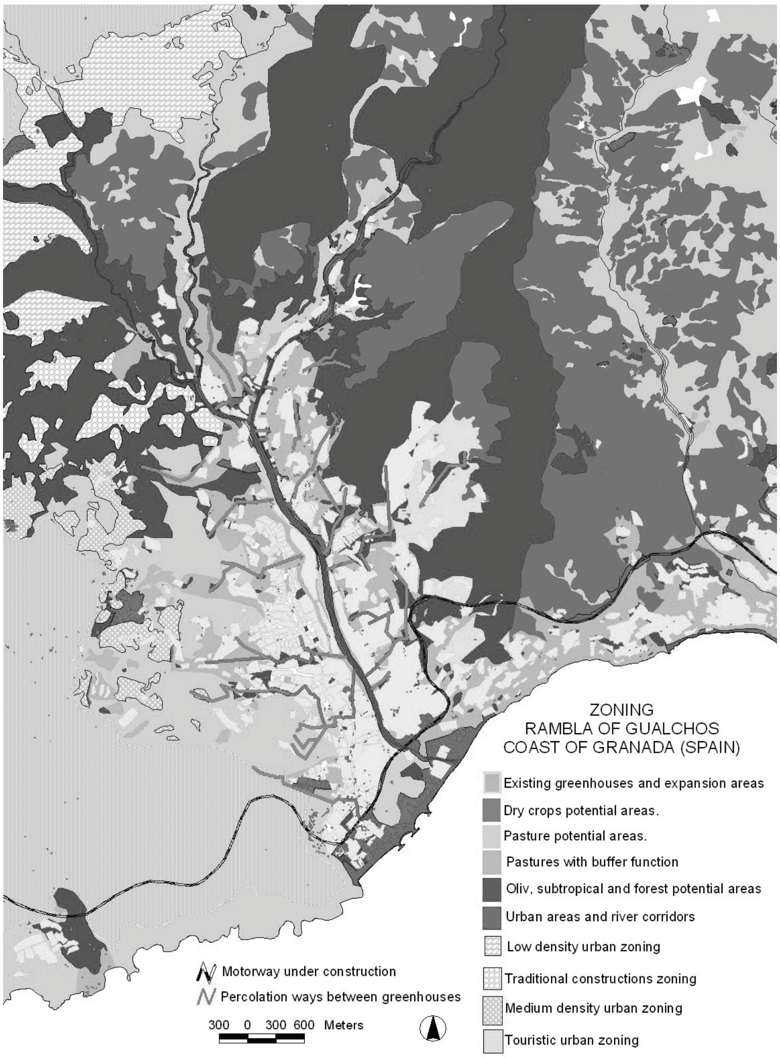
However, in this particular case, diverse historical, political, economic and environmental circumstances have led to a situation where natural resources are still considered to have high quantitative and qualitative territorial values (Matarán and Valenzuela, 2006). So, we are still in time to produce another scenario overcoming the current trends and producing planning and management measures taking into account new criteria based on the multifunctionality of agricultural landscapes, as well as focusing on ecological corridors and other landscape functions such as source, sink or buffer. The final objective of the proposed measures is to generate a more efficient agricultural landscape in a Mediterranean context.

Planning criteria

We are proposing here some planning criteria as a response to those problems detected in the planning documents. The following criteria are based on landscape ecology and on the multifunctionality of coastal landscapes. The presented cartography includes a spatial representation of these criteria in an area that is saturated by greenhouses (the Rambla of Gualchos in the Coast of Granada –South of Spain-):

Criterion 1. A re-interpretation of the Mediterranean mosaic. Including a proposal of tree based landscapes in two different categories: Dry crops like almond trees (light coloured) and olive trees, subtropicals and forest trees (dark coloured).

Criterion 2. A re-consideration of pasture land. Including the promotion of vegetation succession in two different categories: Pasture land with a buffer function (dark coloured) and residual pasture land (light coloured).



Criterion 3. A re-generation of diffusion nets. Including the promotion of connectivity functions in two different categories: Natural net, mainly rivers in this scale (dark coloured) the net of percolation ways between man made landscapes (light coloured).
Criterion 4. A re-organization of greenhouse zoning. Including the integration of other criteria in this area.
Criterion 5. A re-alocation of urban zoning. Including also the integration of the other criteria in the area and generating four categories of density and urban design.

Figure 1. Zoning proposal in the Rambla of Gualchos.

References

Matarán Ruiz, A. (2005). La valoración ambiental-territorial de las agriculturas de regadío en el litoral Mediterráneo: el caso de Granada. PhD Thesis. University of Granada.

Matarán, A. and Valenzuela, L.M. (2006). Regional planning in Granada, south-east Spain taking account the network of natural values. In R.G.H. Bunce and R.H.G. Jongman (Eds) 2006. Landscape Ecology in the Mediterranean: inside and outside approaches. Proceedings of the European IALE Conference 29 March – 2 April 2005 Faro, Portugal. IALE Publication Series 3, pp. 95 – 109.

Matarán, A.; Aguilera, F. and Valenzuela, L.M. (2006). Modelling future landscapes: greenhouse expansion in the Mediterranean coast. In Meyer, B.C. (Ed.), 2006. Sustainable Land Use in Intensively Used Agricultural Regions. Landscape Europe. Alterra Report No.1338, Wageningen.

Priemus, H. Rodenburg, C.A. and Nijkamp, P. (2004). Multifunctional urban land use. Built Environment, 30, 4.

Multifunctionality of landscapes – rural development, landscape functions and their impact on biodiversity

N. Guiomar, J. P. Fernandes

CEEM, Universidade de Évora, Rua Romão Ramalho, Évora, Portugal
e-mail: nunogracinhas@hotmail.com

Introduction

Rural Landscapes constitute a particular good example of the integration through space and time of multiple natural, social and economical functions. This integration is materialized in a set of land use systems and social structures adapted to the particular natural constraints and resources in the frame of the available technologies. Each structure tries to find the best combined solution to the feasibility equation, involving the balance of labour and other investments with the different products and alternative sources in order to maximize the desired landscape functions. Under functions, the use and the response of a landscape to human needs is understood. Multifunctionality consists in the integration of different functions in a given spatial and/or temporal unit at a given scale. All landscapes are multifunctional but their degree of multifunctionality can vary strongly with different environmental potentials and resources. This paper aims at analysing the way in which the present land users of this landscape equate their land use options and adapt to the different landscape functions and social constraints (e.g. tradition, subsidies). The viability of the resulting system compared with development scenarios is evaluated, as well as alternative income sources such as the payment for environmental services.

Development of a conceptual framework

Over the past decades many of the traditional multifunctional Mediterranean landscapes with their typical complexes of agro-, silvo- and pastoral components have changed completely. Nowadays only relativelly few still exist. Their complex farming systems provide at the same time a multitude of other functions than just agricultural production, such as support for recreation, amenity, cultural identity, preservation of natural resources and environmental quality (Pinto-Correia & Vos, 2004). De Groot (1992) classifies landscape functions related to land use as production functions, which are related to the ability of a landscape to ensure a functional balance as regulation functions and the functions related to the ability to produce non material goods as information functions. These different functions and the corresponding land use demands determine, at each moment and site, a particular solution of land use intensity and typology and degree of landscape and resources stress.

There is a relationship between cultural-historical and biodiversity aspects of landscape structures. Both intensive and extensive land use are expressed in the landscape: the structure of the land, the size of the parcels and their area and the diversity of natural and semi natural vegetation that is present. The spatial arrangement of land use at each moment and in each location is the local integration of multiscalar decision and constraining factors of economical, social and biophysical nature (Jongman, 2004). Land use intensification and the resulting pressure on resources and regulation functions have determined the spatial segregation of land use types, the functional specialisation and the degradation of the quality and functionality of many landscape, process that is particularly perceptible in marginal rural areas. This process is closely associated with the regression of traditional land use systems, extensification and land abandonment due to human migration and the generalisation of land use types associated to very low management efforts.

This situation is well illustrated by the particular situation of the depressed Portuguese Mediterranean rural areas, where in the last 70 years land use has evolved from an intensive use of the resources, either through agriculture or forestry and many times in a close integration between agriculture and forest, to a situation of concentration of intensive agricultural practice on good land, contrasted by an extensification and abandonment of poorer or remote areas. The resulting increase in the forestry sector, both in Mountain areas and on the plains, takes advantage of supporting policies. Many these plantations are poorly or unmanaged forests which are prone to disease or fire.

In the frame of the European project “LACOPE-Landscape Development, Biodiversity and co-operative Livestock Systems in Europe” the relations between extensive grazing and biodiversity has been analysed as well as the contribute of given forms of grazing to the promotion of biological quality and other landscape functions (Kaule & Fernandes, 2006). The particular situation of Portuguese mediterranean agricultural systems, where land use systems show a very high liability and a high susceptibility to disturbance, determine an urgent need for integrated studies to assess the contribution of each land use system to the different landscape functions, as well as assessing their economical and social viability (Fernandes & Guiomar, 2006).

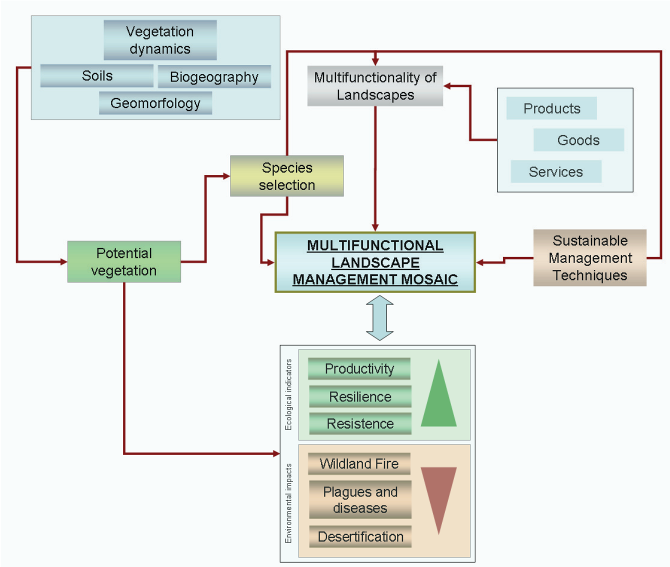


Figure 1. Multifunctional Landscape Management Mosaic

References

de Groot, R. S. (1992) *Functions of Nature: evaluation of nature in environmental planning, management and decision-making*. Wolters Noordhoff BV, Groningen, The Neth.

Fernandes, J. P.; & Guiomar, N. (2006) *Scenario approach – unpublished WP 12 final report Project LACOPE-Landscape Development, Biodiversity and co-operative Livestock Systems in Europe. Contract EVK2-CT-2002-00150*, Stuttgart.

Jongman, R. (2004) Landscape linkages and biodiversity in European landscapes. R. Jongman R. (Eds). *The New Dimensions of the European Landscape*, Wageningen EU Frontis Series, Springer.

Kaule, G.; & Fernandes, J. P. (2006) Atlantic heath land rough grazing systems- Portuguese section – unpublished report Project *LACOPE-Landscape Development, Biodiversity and co-operative Livestock Systems in Europe. Contract EVK2-CT-2002-00150*, Stuttgart.

Pinto-Correia, T.; & Vos, W. (2004) Multifunctionality in Mediterranean landscapes – past and future. R. Jongman R. (Eds). *The New Dimensions of the European Landscape*, Wageningen EU Frontis Series, Springer.

Kaule, G.; & Fernandes, J. P. (2006) Atlantic heath land rough grazing systems- Portuguese section – unpublished report Project *LACOPE-Landscape Development, Biodiversity and co-operative Livestock Systems in Europe. Contract EVK2-CT-2002-00150*, Stuttgart.

Pinto-Correia, T.; & Vos, W. (2004) Multifunctionality in Mediterranean landscapes – past and future. R. Jongman R. (Eds). *The New Dimensions of the European Landscape*, Wageningen EU Frontis Series, Springer.

Landscape configuration, vegetation condition and ecosystem services in cotton agro-ecosystems in southern Queensland, Australia

A.P.N. House[1], N.A. Schellhorn[2], S.D. Brown[1], F.J.J.A. Bianchi[2]

[1] CSIRO Sustainable Ecosystems, 306 Carmody Road, St Lucia, Qld, Australia.
email: alan.house@csiro.au
[2] CSIRO Entomology, 120 Meiers Road, Indooroopilly, Qld, Australia

Introduction

Cotton (both dryland and irrigated) is one of Australia's most intensive agricultural crops. One of the challenges for sustainable cotton enterprises is to optimise the production of goods and services from all parts of the landscape. Most cotton farms support a wide range of habitats suitable for native wildlife through the patches of native vegetation (woodlands and grasslands) and other farming systems (cropping and grazing) that may benefit the environment and sustainability of cotton production. The maintenance of habitat heterogeneityin agricultural landscapes is the key to sustaining biodiversity (Benton *et al.* 2003), and there are links between levels of biodiversity and ecosystem function (Díaz & Cabido 2001). However the means to manage for the maintenance of biodiversity and the ecosystem services it provides on cotton properties and at larger catchment scales is poorly understood.

Project components

<u>Vegetation condition and ecosystem services</u>

The ecological condition of vegetation may be as important to landscape function as spatial arrangement (Debuse *et al.* 2006). Our project will assesses vegetation condition by looking at surrogates of function – evidence of stand replacement, levels of ground cover, structural complexity, diversity and abundance of key arthropod groups (ants, beetles, spiders) – and analyse these in respect of landscape context (i.e. patch size, isolation, shape, connectance). These spatial analyses will inform subsequent analyses of predator-prey/parasitoids-host complexes and vertebrate habitat use.

<u>Source:sink dynamics and bio-control</u>

Colonisation of cotton and grain crops by predator-prey/parasitoid-host complexes is influenced by the surrounding landscapes (Tscharntke & Brandl 2004). Crops and non-crop habitat (i.e. native vegetation and weeds, and the condition of the vegetation) can be both sources and sinks for pests and natural enemies (Tscharntke *et al.* 2005). However, little is known of how the degree of synchrony between sources and sinks, and spatial characteristics of these habitats influences (i) the timing and numerical response of colonization by pests and natural enemies, (ii), species accumulation over time and (iii) trophic interactions. This project addresses these issues using empirical and modelling approaches. Experiments will quantify insect colonisation in crops and non-crop habitats, identify habitats that function as sources and sinks of pests and natural enemies, and monitor the population dynamics of pests and natural enemies in crop and non-crop habitats. Modelling will focus on how the spatial arrangement and synchrony of sinks and sources of pests and natural enemies impacts insect dispersal, trophic interactions, and population dynamics.

<u>Birds in cotton landscapes</u>

Birds can play important roles in pest control in agricultural landscapes (Jones *et al.* 2005). We know that birds have been impacted by agricultural development through loss of habitat, habitat fragmentation and habitat simplification (Radford *et al.* 2005). Our interest is in the residual habitat value for birds of native and non-native vegetation elements in cotton-dominated landscapes, and the potential pest control services that birds provide.

Contrasting landscapes

We will test the influence of landscape configuration on ecological and pest control services in two contrasting landscapes. Cotton is a component of both and occupies similar proportions of the landscape, but there are major differences in the proportions of irrigated cropping, non-irrigated cropping and native vegetation, and in the spatial arrangement of native vegetation patches (Table 1).

Table 1. Proportions of land use types and key landscape metrics in 2 contrasting cotton landscapes in southern Queensland, Australia. Measures based on 5 km radii; landscape metrics calculated using FRAGSTATS (McGarigal *et al.* 2002).

	landscape 1	landscape 2
irrigated cropping	26.1	30.4
non-irrigated cropping	55.5	27.4
native vegetation	15.4	39.3
for native vegetation:		
largest patch index	7.8	39.1
no. patches	16	4
splitting index	148.2	6.6

By examining the relationships between spatial pattern, ecological condition of vegetation, and the provision of ecosystem services to both production and conservation, we will provide scientific knowledge to inform regional resource management plans and support the refinement of best management practice in cotton systems.

References

Benton, T.G., Vickery, J.A. and Wilson, J.D. (2003) Farmland biodiversity: is habitat heterogeneity the key? Trends in Ecology and Evolution 18: 182-188.

Debuse, V.J., King, J. and House, A.P.N. (2006) Effect of fragmentation, habitat loss and within–patch habitat characteristics on ant assemblages in semi–arid woodlands of eastern Australia. Landscape Ecology.

Díaz, S. and Cabido, M. (2001) Vive la différence: plant functional diversity matters to ecosystem processes. Trends in Ecology and Evolution 16: 646-655.

Jones, G.A., Sieving, K.E. and Jacobson, S.K. (2005) Avian Diversity and Functional Insectivory on North-Central Florida Farmlands. Conservation Biology 19: 1234-1245.

McGarigal, K., Cushman, S.A., Neel, M.C. and Ene, E. (2002) FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps, <www.umass.edu/landeco/research/fragstats/fragstats.html >.

Radford, J.Q., Bennett, A.F. and Cheers, G.J. (2005) Landscape-level thresholds of habitat cover for woodland-dependent birds. Biological Conservation 124: 317-337.

Tscharntke, T. and Brandl, R. (2004) Plant-insect interactions in fragmented landscapes. Annual Review of Entomology 49: 405-430.

Tscharntke, T., Rand, T.A. and Bianchi, F.J.J.A. (2005) The landscape context of trophic interactions: insect spillover across the crop-noncrop interface. Annales Zoologici Fennici 42: 421-432.

Provision of non-commodities in agricultural production at farm and landscape level in the MEA-Scope case study area Mugello (Italy)

S. Uthes[1], C. Sattler[1], A. Ciancaglini[2], G. Piani[2] and G. Lombardi[2]

[1] Leibniz-Centre for Agricultural Landscape Research, ZALF, Institute for Socio-Economics, D-Müncheberg, Germany.
e-mail: uthes@zalf.de
[2] Università di Firenze, Dipartimento di Economia Agraria e delle Risorse Territoriali, DEART, I-Firenze, Italy.

Within the framework of the FFP 6 EU project MEA-Scope, we investigate ex-ante the effects of different policy options on the economic, ecological and social functions of agriculture in seven European case study regions by using and combining micro-level bio-economic and biophysical modelling techniques (Piorr *et al.,* 2006).
In this contribution, we apply the bio-economic linear programming model MODAM to the Mugello territory in Northern Tuscany, Italy (1127 km^2) to model the provision of agricultural land-use related non-commodities. The Mugello territory is characterised by small, in terms of economic size, mixed crop-livestock farms mostly engaged in the total cow-calf line mixed farming. The beef sector is made of traditional farms with forage crops or grassland for grazing. Mountain pastures and permanent grasslands dominate the land-use; followed by fodder crops such as alfalfa and forage sorghum. Important arable crops are grain maize, barley and durum wheat. The actual multifunctional role of agriculture in Mugello encompasses issues including the landscape and the hydro-ecological asset conservation and the high quality local products, including the organic ones, as expressions of the specific territory communicating values that are deeply-rooted in local history, custom and a wholesome environment. In this paper, we will particularly focus on the environmental functions in Mugello, namely water quality, soil conservation and biodiversity, which have been specified by following indicators (cp. table 1)

Table 1. Environmental targets and indicators in the Mugello territory (MEA-Scope)

Function	Indicator
Biodiversity	Habitat potential for amphibians (Amph)
Biodiversity	Habitat potential for wild flora species (Flora)
Biodiversity	Habitat potential for field hares (Hare)
Soil conservation	Risk of water erosion (WaEro)
Water quality	Risk of nitrate entries into groundwater (NO3)
Water quality	Risk of pesticide entries into ground- and surface waters (Pest)

To explore the relation between these indicators and agricultural land-use, we have carried out a detailed computer-based survey to collect information on region- and site-specific cropping practices and livestock systems. “Site-specific” means, that as the Mugello territory is very heterogeneous with respect to geology, geomorphology, soils and elevation, management and yield potential of the cropping practices were adapted to four main landscape units: the Sieve River valley bottom, the hilly parts between the main axis valley and the mountainous region both north and south of Sieve river, the mountain area south of the river, between the Mugello valley and Florence valley, and the proper Apennines area in the north/north-west of the territory. Altogether, two production systems, organic and conventional, 192 cropping practices, and 12 livestock systems have been identified and ecologically evaluated. The ecological evaluation in MODAM is based on a fuzzy-logic-impact-assessment-method (Sattler *et al.,* 2006) generating goal attainment values that express the suitability of cropping practices with respect to the environmental indicators listed in table 1.

We combined the information on the agricultural management with FADN-information on farm capacities (land, labour, etc.) and geo-referred cadastral data to create “virtual” that is, model farm types that could be allocated in a raster grid of the region (Ungaro *et al.,* 2006). Input/output prices as well as information on different past and future policy framework conditions, including 2nd pillar instruments were also added to the model. Possible future policy options were identified with regional stakeholders, modellers, and representatives of the European Commission leading to three main scenarios to be analysed: (i) a baseline as a continuation of the status quo (BASELINE), (ii) an introduction of a single-area-payment to replace the current single-farm-payment (SAP) and (iii) a free-market scenario (NOSUBS).
By optimizing the production plan of the virtual farm types in the three scenarios, we were able to compare changes in land-use and economic performance of the farm types as well as environmental impacts. For example, we could observe that the overall environmental threat increases during the scenarios and varies considerably between conventional and organic farming (figure 1).

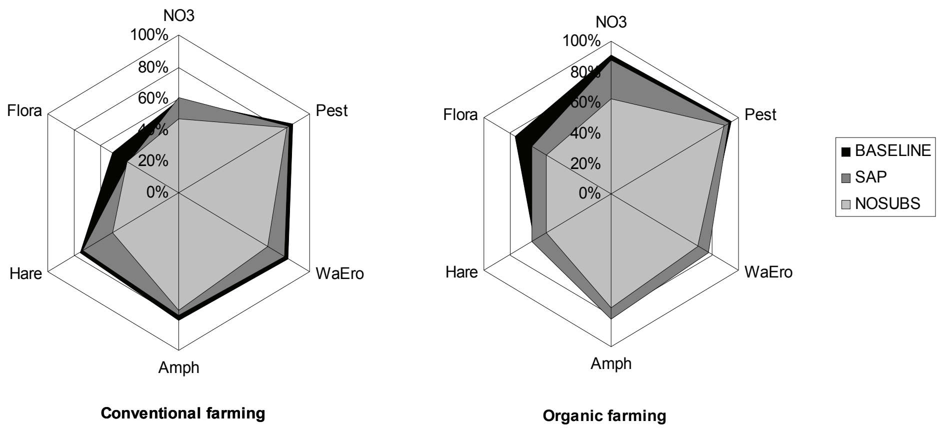


Figure 1. Average index of goal attainment in % for six environmental indicators in Mugello, comparison between conventional and organic farming (MEA-Scope); 100 % indicating a good and 0 % a poor ecological performance

We will present our results in the form of graphs and GIS maps, such as the average environmental risk in each scenario, differences in environmental risk between production systems (as shown in figure 1) or farm types, trade-off functions between economic performance and environmental impacts etc.

References

Piorr, A.; Müller, K.; Happe, K.; Uthes, S. & Sattler, C. (2006) Agricultural management issues of implementing multifunctionality: commodity and non-commodity production in the approach of the MEA-Scope project. Mander et al.(Eds). Multifunctional land use meeting future demands for landscape goods and services. New York, pp. 167-182.

Sattler, C.; Schuler, J. & Zander, P. (2006) Determination of trade-off-functions to analyse the provision of agricultural non-commodities. – International Journal of Agricultural Resources, Governance and Ecology **5:** 309-325.

Ungaro, F.; Venuti, L. & Ciancaglini, A. (2006) Up-scaling approach for the Mugello Area I: soil quality. MEA-Scope internal report, unpublished.

1.5 Open session 6 Biodiversity, management, policy and stakeholders

Identification of Conservation Opportunities: a study case of management and conservation of biodiversity in rural landscapes based on field research in the Central Andes of Colombia

F. H. Lozano-Zambrano, J. E. Mendoza , E. Jiménez, P. Caycedo-Rosales, W. Vargas

Alexander von Humboldt Institute, Cra. 7 #35-20 Bogotá Colombia.
e-mail: fhlozano@humboldt.org.co

The mountain forests are one of the most endangered ecosystems in the World due mainly to the high degradation rates and habitat loss. This kind of forests has different kinds of associated values such as, harboring high biological diversity, high proportion of endemism, water sources, and biotic relationships (e.g. altitudinal migrations of species looking for shelter and food), and resources for human communities, for instance, timber, charcoal, medicinal plants, water sources for urban places, among others. In Colombia, the mountain forests have around of 33.288.000 ha, 4.770.000 ha out of this amount of forest, is protected areas and the rest are rural landscapes for livestock or agriculture. In Colombia, the spreading productive system is livestock with more than 12.000.000 ha. In this way, is pretty important go further and increasing the knowledge about structure and composition of biotic communities in this kind of rural landscapes. We addressed four questions as the basis to establish potential conservation strategies at local scale: What is the species composition in fragmented landscapes? What is the turnover among different landscape elements? Are rural landscapes harboring interesting species for conservation purposes such as endemic or endangered species?

We worked with three target groups using rapid characterizations of birds, ants and plants (trees and shrubs). This study was conducted in sub-Andean forests (1700 – 2100 m) in the western slope of the Central mountain range in the Colombian Andes, specifically in the Barbas river watershed, Municipalities of Filandia and Pereira, Colombia. We selected a landscape window of 2500 ha with grasslands matrix, and recorded samples of our target groups in six kinds of landscape elements, each one with different number of replicates. Thus, eight big forest patches; five small forest fragments (3 – 6 ha), eight streams with forest cover, five patches of forestry plantations (exotic species), and eight replicates in the landscape matrix of grasslands. We made alpha, beta and gamma analysis for all three target groups, and we are proposing a “conservation Index” to establish priority in landscape elements which could represent higher conservation opportunities for all three biological groups.

We found 94 ant species, 409 plant species (trees and shrubs, 74 spp. under threaten category), and 156 bird species (4 globally endangered and 37 negatively affected by habitat fragmentation). Alpha diversity is high for all three groups, especially in forest patches and streams. For all three groups the species richness decreases within the gradient from forest to productive systems. Regarding turnover (beta diversity), it was high for plants, while for birds and ants has middle values. For birds we found 16 species were present in one of the bigger forest fragments (Barbas river Canyon) which were not present in the other one (Bremen forest preserve), and vice versa 20 bird species which were present in Bremen forest preserve were not in Barbas river canyon forest patch. We also found differences in the species abundances between these forest fragments.

Finally, we used three criterions (species richness, number of endangered and endemic species) to build a “conservation index”. This index is based on the creation of three ranges using percentiles (high, middle and low). The results for each biological group and for all groups together are mapping. As we expecting, our “conservation Index” showed higher values for forest patches. We suggest that activities such as maintenance and restoration of this forest patches (through natural succession or ecological restoration) to increase size, reintroduction of native species, and increase structural connectivity among patches using linear landscape elements for instance hedgerows and biological corridors, for the elements with higher values of the conservation index will ensure species conservation in our studied landscapes.

This information is the first step in a conservation strategy for this landscape having in consideration not only the necessities for biological conservation, but also social, economical, and cultural interests for the inhabitants.

Investigation of the impact of herbivores on a Mongolian steppe vegetation and the implications for conservation

M. A. van Staalduinen, M. J. A. Werger

Plant ecology and biodiversity, Utrecht University, Utrecht, The Netherlands.
e-mail: maria.vanstaalduinen@uam.es

The large and relatively intact steppes of Mongolia have been a pastureland for thousands of years and support large populations of wild ungulates and livestock. These steppes are of great global importance.

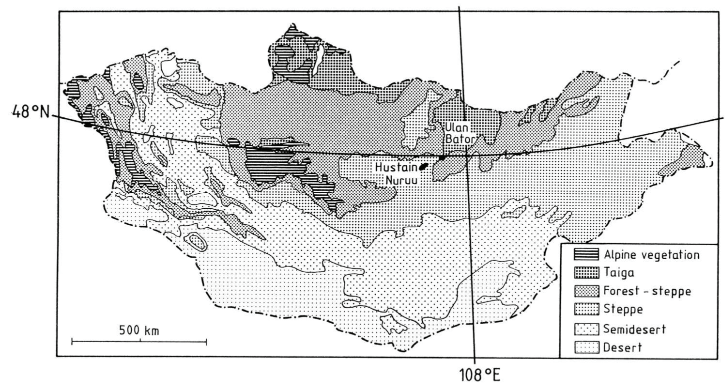


Fig.1 Vegetation zones of Mongolia (after WallisdeVries, 1996) with the location of Hustai National Park and the capital Ulaan Baatar.

In Mongolia the vegetation zonation (Fig.1) corresponds rather well with a gradient of decreasing precipitation from the north to the south (Van Staalduinen, 2005). The forest steppe zone lays in the zone with an annual precipitation between 300 and 400 mm, and consists of a mosaic of patches of forest and grassland. Further south, in the zone with a precipitation between 200-300 mm, trees become rare and grasses dominate the vegetation. This is the region of the typical steppe, or grass steppe, with vast areas of grasslands. The *Stipa* steppe (Cymbario-Stipetum krylovii, Hilbig, 1995) is a characteristic community of this region.

Nowadays overgrazing is a serious threat to the sustainability of the grasslands in Mongolia, of which a significant proportion already is degraded. The high pressure on the steppe is ascribed to the dramatic increase in the population and livestock over the past century. From 1918-1990 the population of the country increased almost three-fold (Kharin *et al.*, 1999), and the number of livestock, consisting of sheep, horses, cows or yaks, goats and camels, increased 2.3 times (Kharin *et al.,* 1999). These animals all had to live from the same plant resources as before, since the country did not, or hardly, import any fodder, while the biomass productivity of the steppe is very low (about 125 g m^{-2} y^{-1}, Van Staalduinen, 2005).

The overgrazing resulted in a decrease of the vegetation cover, productivity and plant species diversity in many degraded locations (Kharin *et al.*, 1999). The original dominant *Stipa* grasses were replaced by other grasses like *Leymus chinensis*, *Cleistogenes squarrosa* and ruderal plant species (Hilbig 1995), or by the sedge *Carex duriuscula*. In heavy degraded areas the grasses have disappeared altogether and are replaced by *Artemisia* species. Sometimes the vegetation cover has completely disappeared and the bare soil is left susceptible for wind erosion, leading to desertification.

In order to be able to develop a sustainable pasture management, a better understanding is needed of the role of herbivory in the sustainability of the ecosystem. To this end we conducted a field study in central Mongolia in the forest steppe region, on a research site in Hustain National Park (Fig. 1), a national park located at about 100 km from Ulaan Baatar. The takh (*Equus przewalskii*) which is the last surviving ancestor of the modern domestic horse, has been successfully reintroduced in the park. In 2005 a population of 158 takh has established and lives freely in the Park.

We investigated the impact of different types of herbivores, a large and a small, on the steppe vegetation (Van Staalduinen & Werger 2007; Van Staalduinen *at al* 2007). An exclosure experiment was set up on the *Stipa* steppe, in which we examined the effects of 3 years of exclusion of takh and Siberian marmots on plant species abundance, plant biomass and plant N-concentration (Van Staalduinen et. al 2007). We investigated whether shifts in plant species dominance occur with increased grazing, and if this can be explained by differences in growth responses to clipping. We tried to establish a link between the plant species dynamics in the Mongolian steppe and physiologically based plant characteristics. In a greenhouse experiment we compared the potential for compensatory growth of *Leymus chinensis* and *Stipa krylovii*, two co-occurring grass species of the steppe, using a recently developed technique of growth analysis. Compensatory growth was much stronger for the rhizomatous *Leymus chinensis* than for the caespitose *Stipa krylovii*, and *Leymus* showed a significant increase in its relative growth rate (RGR) after clipping, while for *Stipa* RGR was negatively affected (Van Staalduinen and Anten, 2005). Apparently *Leymus* is more tolerant to clipping (and by extrapolation to grazing) than *Stipa* and this could explain the shift in dominance from *Stipa* to *Leymus* when grazing pressure increases in the Mongolian steppe.

The carrying capacity of the steppe areas, i.e. the maximum number of herbivores which can be supported in an area, is an important issue for pasture management. When estimating the carrying capacity the effect of compensatory growth should be accounted for. Our results showed that compensatory mechanisms contribute enormously to the productivity of plants after clipping.

Knowledge about the carrying capacity and forage quality of the steppe vegetation was important for the reintroduction of the takh into Hustain National Park. The takh is seen as a flagship species for the conservation of the park, whose general objectives are: the restoration and conservation of the biodiversity (Bouman, 1998), development of a research and training centre, development of eco-tourism, and improvement of pasture management in the buffer zone around the park.

References

Bouman, I. (1998) The reintroduction of Przewalski horses in the Hustain Nuruu mountain forest steppe reserve in Mongolia. An integrated conservation development project. Netherlands Commission for International Nature Protection. Mededelingen 32.

Hilbig, W. (1995) The vegetation of Mongolia. SPB Academic publishers, Amsterdam, The Netherlands.

Kharin, N.; Tateishi, R. & Harahsheh, H. (1999) Degradation of the drylands of Asia. Center for environmental remote sensing (CEReS), Chiba University, Japan.

Van Staalduinen, M. A. (2005) The impact of herbivores in a Mongolian forest steppe. PhD-thesis. Utrecht University, Utrecht, the Netherlands.

Van Staalduinen, M.A. & Anten, N.P.R. (2005) Difference in the capacity for compensatory growth of two co-occurring grass species in relation to water availability. Oecologia 146:190-199.

Van Staalduinen, M.A. & Werger, M.J.A. (2007) Marmot disturbances in a Mongolian steppe vegetation. Journal of Arid Environments 69: 344-351.

Van Staalduinen, M.A.; During, H.J. & Werger, M.J.A. (2007) Impact of grazing regime on a Mongolian forest steppe. Applied Vegetation Science (in press).

Wallisdevries, M.F.; Manibazar, N. & Dugerlham, S. (1996) The vegetation of the forest-steppe region of Hustain Nuruu, Mongolia. Vegetatio 122:111-127.

Analysis of recent ecosystem transformation processes in two sectors of the buffer zone of Colombia's Pisba National Natural Park (1955 - 2001)

N.A. Ciontescu Camargo

Pontificia Universidad Javeriana. Department of Environmental and Rural Studies
e-mail: nciontescu@gmail.com

Introduction

National Natural Parks also host human communities that perform certain production activities that may be transforming their natural landscapes. This research was aimed at analyzing how anthropic activities performed in the buffer zones of the Pisba PNN have influenced the space/time variations in the patterns of the landscape of the ecosystems present in the park.

Results and discussion

The research found that the shrubby scrubland unit (Figure 1) is the natural unit bearing the densest relative coverage. Nevertheless, anthropically originated units such as grasslands, crop grasslands and shrubby grasslands also bear very dense relative coverage rates.

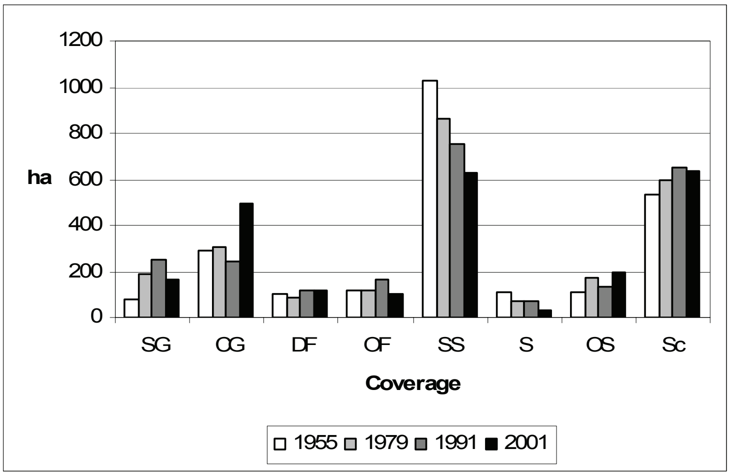
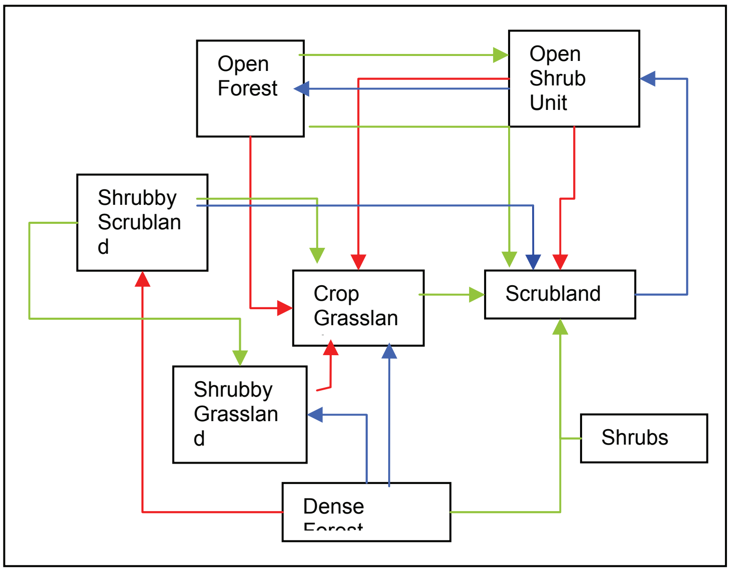


Figure 1. Dynamics of coverage changes for all periods (SG: Shrubby grassland; CG: Crop grassland; DF: Dense forest; OF: Open forest; SS: Shrubby Scrubland; S: Scrubland; OS: Open shrub; Sc: Scrubland)

Figure 2 shows the transformations of the various coverage units between the first and the last period covered by the study. Natural units of dense forest, open forest and shrubbery appeared highly transformed, while anthropically-originated units of scrublands and crop grasslands gained a broader area during the past 46 years.



Low (0-10%) Medium (10-20%) High (20-100%)

Figure 2. Flow chart of the main coverage changes during 1955-2001

Transformation processes have led to the development of agricultural and livestock activities carried out basically by the local peasant communities. Human activities linked to the slashing and burning of natural vegetation in an effort to broaden the agricultural and livestock frontier have been a determining factor in the transformation of these highland plateau zones. The shrubby scrubland unit has suffered the highest transformation rate. The systems used to grow potatoes, lima beans, wheat and peas, and intensive and extensive livestock-related activities have been responsible for the prevalence and increase of crop grassland agro-ecosystems.

The rotation of agricultural and livestock activities around various coverage units generates an increase in the number of patches of various vegetation mosaics in varying succession states. According to Hofstede (2000), this is one of the main characteristics of the current highland plateaus intervened by man.

According to Forman (1995), the consequences of fragmenting vegetation coverage units such as these ones may include: increased isolation of patches, an increased number of generalist species, greater number of habitats, an increased number of borderline species, an increased number of exotic species and a higher extinction rate.

Other studies suggest that the transformation processes have occurred since pre-Colombian and colonial times. Nevertheless, the current uses to which the territory is subject have led to a constant acceleration in the transformation of the vegetation layer, resulting in some remnant patches of forest and highland plateau vegetation.

References

Forman, R.T.T. (1995). Land Mosaics: the ecology of landscapes and regions. Cambridge University.

Hofstede, R. (2002). Los paramos andinos: su diversidad, sus habitantes, sus problemas y sus perspectivas. Un breve diagnostico regional del estado de conservación de los páramos. Congreso Mundial de Páramos.

Conservation priorities for threatened Yatsu valley landscapes in central Japan: Evaluation based on ecological value and vulnerability

K. Takahashi[1], K. Hara[2] and K. Short [2]

[1] Tokyo University of Information Sciences, 1200-2 Yato-cho, Wakaba-ku, ChibaJapan.
e-mail: takahashi_ybbmail@yahoo.co.jp
[2] Tokyo University of Information Sciences, 1200-2 Yato-cho, Wakaba-ku, Chiba, Japan.

Introduction

To successfully balance development with preservation of biodiversity, a full and accurate understanding of local topography and land use patterns, as well as zoning plans based on this understanding, is required. Landscape ecology can be an effective tool for simplifying and improving accuracy in this process (Forman & Godron 1986). Prior studies (Blankson & Green 1991, Bunce 1996) have classified the natural environment by landscape types to develop indicators for evaluating environmental value. In this research, landscape ecology is employed to evaluate conservation priorities for threatened 'Yatsu' valley traditional agricultural landscapes (Fujihara *et al*. 2005) in the southern Kanto region of central Japan. Evaluation was based on both ecological value and vulnerability to development.

Study Area

The research was implemented in the city of Sakura, located in northern Chiba Prefecture, about 40 kilometres northeast of Tokyo. The city is served by the Keisei and JR railway lines, and is thus well within commuting distance of Tokyo. As a result, development of suburban housing and associated commercial infrastructure is proceeding at a rapid pace, thereby threatening traditional agricultural landscapes (Hara, 2000).

Methods

Landsat TM data and DEM were employed to classify landscape types, and five basic types were identified and mapped:

- Marsh Landscape: Low-lying (less then 1 meter above sea level) marshland, comprising Inba Marsh and its associated canals.
- Urban Landscape: Areas currently used as or designated for residential, commercial or industrial development.
- Upland Agricultural Landscape: Farmland on top of relatively level uplands (20-30 meters above sea level), used for non-irrigated vegetable fields, and fruit and chestnut orchards.
- Floodplain Agricultural Landscape: Low-lying areas comprising the original floodplain and marshland that were reclaimed historically. Mostly planted in irrigated rice paddies.
- Yatsu Valley Agricultural Landscape: Narrow, branching valleys that cut deep into the surrounding slopes. Valley bottoms traditionally planted in irrigated paddy.

In addition, 13 ecotopes, the most basic unit of which landscapes are comprised, were identified and mapped against the distribution of the five landscape types. To evaluate the ecological importance of each landscape type, the distributions of natural water seeps, as well as that of two birds of prey, common buzzard (*Buteo buteo*) and gray-faced buzzard-eagle (*Butastur indicus*), and five frog species were employed.

Results and Discussion

The results clearly showed that all these distributions concentrate in the Yatsu valley landscape. Figure 1 evaluate individual Yatsu valleys, 17 valleys were identified and assigned an overall ecological rating. In addition, vulnerability to future development was estimated for each valley as a function of the distance from the nearest train station (Figure 2). The results of the research were used to prioritise valleys for conservation. The Azeta Yatsu valley, for example, was ranked as the highest priority. Hopefully, these results will be of use to government agencies involved in development and conservation planning in Sakura City and in other structurally similar areas.

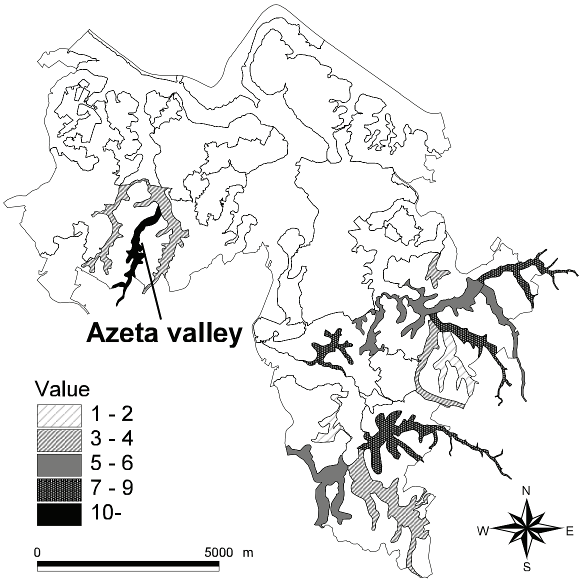


Figure 1. Evaluation of overall ecological value for 17 Yatsu valley landscapes in Sakura City

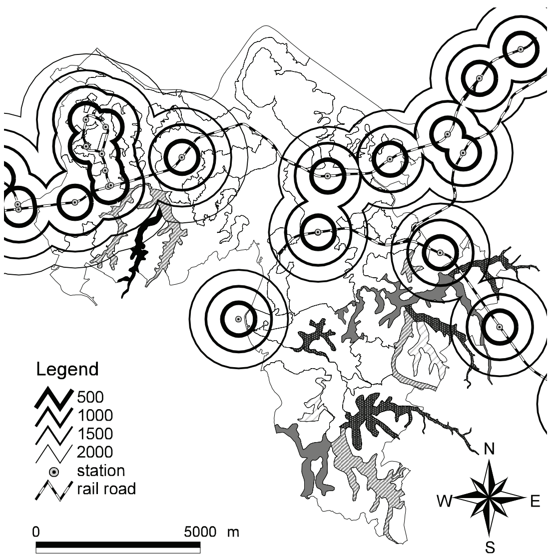


Figure 2. Distance from nearest train station (0.5-2.0 Km)

References

Blankson, E. J. & B.H. Green. (1991) Use of landscape classification as an essential prerequisite to landscape evaluation. *Landscape and Urban Planning* **Volume:** 21: 149-162.

Bunce R. G. H. (1996) ITE Merlewood Land classification of Great Britain. *Journal of Biogeography* **Volume:** 23: 625-634.

Forman, R. T. T. & M. Godron. (1986) *Landscape Ecology.* John Wiley & Sons Inc, New York. pp. 619.

Fujihara, M., K. Hara, & K. Short. (2005) Changes in landscape structure of "yatsu" valleys: a typical Japanese urban fringe landscape. *Landscape and Urban Planning.* **70**: 261-270.

Hara, K. (2000) Landscape of Sakura-City. *Natural Environment of Sakura City (ed Sakura Natural Environment Survey Group)*. Shinzansha, Tokyo, pp. +7pp Sakura City. (In Japanese)

The rural policy as a tool for the natural resource management

D. Franco

Ministero dell'Ambiente e della Tutela del Territorio e del Mare, C. Colombo 44, Roma, Italy.
e-mail: daniel.franco@tfambiente.it

Introduction

The European rural regions (OECD criteria) represent the 92% of EU25 landscape, producing the 45% of the Gross Value Added and providing of the 53% of the employment. Agricultural and forestry sectors account for the 8.3% of the employment and the 4.4% of the GDP, covering the 77% of the land use, which is for the 12-13% designated as Natura 2000 and for the 10-30% designated as High Nature Value Farming Systems. Rural regions had undergone a critical period in the last decades. The underlying approach adopted for rural areas is the sustainable development, that is the engine of the EU policies on the basis of the Göteborg - Lisbon strategies for a "European model" of development, where the employment and development growth capacity has to be triggered by a best knowledge and sustainable use of natural resources. The application of these strategies throughout multi-annual policies undergoes to a monitoring and evaluation process that should allow an on-going comparison between policies expectations, results and innovative knowledge.

The adaptive process to fit the expectations and the results: does it work?

In general the rural development policy (related to the compulsory integration and subsidiarity with other EU, National and regional policies) appears to be a good strategic approach in achieving a sustainable development. Policy programming tools seem actually to cope with competitiveness, employment and natural resources sustainable management, giving to the "externalities" a new marketable perspective and transforming the environment in a competitive boost. The related economic instruments (schemes of measures) seem to be progressively able to ensure the strategies aims, mostly coupled with a (annually!) review system that should optimise the local fit to the policy. All these from the economic, administrative and financial point of view; but two elements appear to limit this effectiveness.

The first is the bureaucratic viscosity in the strategies sharing and application at the management level (in between EU and rural communities' awareness); the LEADER axis in the 2007-13 Rural Dev. Fund should contributes to correct this problem encouraging the bottom up approach.

The second, and more general, is the lack of information feedback of the best knowledge to the policy input, a central principle of the "European model" of sustainability that waken the policy adaptive process implementation. This is related to the difficulties of science to inform policy and management, to interact each other to jointly inform the policy and management decision, and to the delay in the upgrade of policy and management output. These information feedback difficulties, (very human) are coupled to: (i) the complexity of the rural landscape, that intrinsically brings uncertainty that has to be communicated to the policy makers and managers, to allow them to progressively adjust the solutions adopted; (ii) the fact that disturbance (human and not), openness and heterogeneity are intrinsic features of rural landscape, and that composition, structure and functions of a single rural ecosystem are contingent on its history and spatial context. Then the complexity and uncertainty of this system is coupled with the complexity of the policy measures used to implement the rural sustainable development.

Research and feedback needs

Monitoring the environmental effect of policies and management solutions is essential to cope with the high variability of rural systems, and on ground data are necessary to verify expectation and to cope with uncertainty: this awareness is actually unclear in the ongoing monitoring schemes. The actual lack of science-policy-management feedback and its consequence has been already pointed out in the assessment of agro-environmental measures effects on the environmental policy objectives: uptake figures do not give factual information about the environmental results of their implementation, and do not give efficient information to review the schemes to cope with the policy objectives. On the landscape preservation and structural transformation side, similar consideration may be drawn: natural resources' policy strategies and programs decoupled with spatial planning are not necessarily correspondent to the policy objectives (e.g. Madsen, 2002). Considering that uncertainty is a core concept of the nowadays non-equilibrium ecology, and most ecological knowledge comes from managed systems far from a human free equilibrium climax, a first solution could be to enforce the information feedback between theory and application by means of a direct engagement of the scientific world with society, to promote *upgraded awareness* in the policy makers to correctly drive the bureaucratic engine. Examples exist to feed this exchange, which account for the intrinsic characteristic of the system and/or the embedded social values, by means of participatory processes or considering the valuation of shared societal values (e.g. Nassauer & Corry, 2004; Hughes, 2005; Bastian et al. 2006).

Conclusions

Some key points can be considered in the future landscape ecology contribution to the process: 1) scientific bodies should encourage the participative approach with the local actors and stakeholders before and during the programmes implementation; 2) the best knowledge available should contribute to a clearer definition of environmental objectives at the landscape scale pursued by single and mix of measures in each program; 3) a long term scientific on the ground evaluation of environmental measures impacts has urgently to be embedded in the programming structure, and a better evaluation at the landscape scale would be possible by geo-referencing the measures application, allowing synergies with risk assessment and natural resources management and planning; 4) environmental services can represent a new market for rural enterprises' income, but local research it is urgent to bid them inside the schemes as shared public benefits, linking them to other emerging markets such as bioenergies for their implication on climate change carbon market and on renewable energy policies.

References

Bastian O; Krönert R. & Lipski Z. 2006. Landscape diagnosis on different space and time scales – a challenge for landscape planning. *Landscape Ecology.* **21**: 359-374

Hughes, F. M. R; Colston A; Owen Mountford. J. 2005. Restoring riparian ecosystems: the challenge of accommodating variability and designing restoration trajectories. *Ecology and Society* **10**: 12. *[online]* URL: http://www.ecologyandsociety.org/vol10/iss1/art12

Madsen L.M, 2002. The Danish afforestation programme and spatial planning: new challenges. *Landscape and Urban Planning.* **58**: 241-254.

Nassauer J.I; Corry R.C. 2004. Using normative scenarios in landscape ecology. *Landscape Ecology.* **19**: 343-356.

A computer aided, modular, spatial support tool for the systemic land-use management toward environment conservation and socio-economic development

M.F. Falcetta[1], F. Attorre[2], C. Corugati [3]

[1] PROGES - Planning and Development Consulting, Via Appennini, 46 Roma, Italy,
e-mail: marco.falcetta@progesconsulting.org
[2] Department of Plant Biology – Sapienza University of Rome, P.le A. Moro 5, Roma, Italy.
[3] Platypus S.r.l.Via Pedroni, 13 - 20161 Milano, Italy

Introduction

These days there is an internationally generalised concurrence on the merits of tackling planning and management of environmental conservation and development in an "Integrated", "Holistic", "Comprehensive", etc way. Still, such a convergence in principle is far from being effectively paralleled at the actual implementation level. The process toward a consistently systemic action in ecological sustainability and human well being pursuits is still very immature and cannot yet rely on standards and internationally accepted systemic procedural/methodological mechanisms. During the last decade, the Italian Development Cooperation has being promoting and supporting truly systemic objective planning and management decision making. In pursuing such a challenge, a general-purpose DSS software shell has developed which can be customised to implement Decision Support System (DSS) systemic applications for Specific territorial and thematic contexts such as Lake Turkana area -Kenia, Madre de Dios District – Peruvian Amazon, Bay of Guanabara – Brazil and Galapagos Archipelago - Ecuador. DSS has been developed to help the understanding and assessment of the relationships between the ecosystem components and their related management issues; this in order to enable policy maker to take informed decisions and monitor effectively their performances.

DSS description

Why use a DSS

- Facilitates the organization and effectiveness of the data gathering process.
- Stores all relevant data and information in coherent databases (GIS and tabular).
- Provides a conceptual framework for the analysis of information for both monitoring and management.
- Allows specific management actions to be selected from a list of options, or to be identified as "new options" to be added to such list.
- Allows to set target values for selected indicators for the prescribed management actions.
- Facilitates efficient monitoring of the prescribed management actions .
- Provides efficient presentation tools to its users.
-

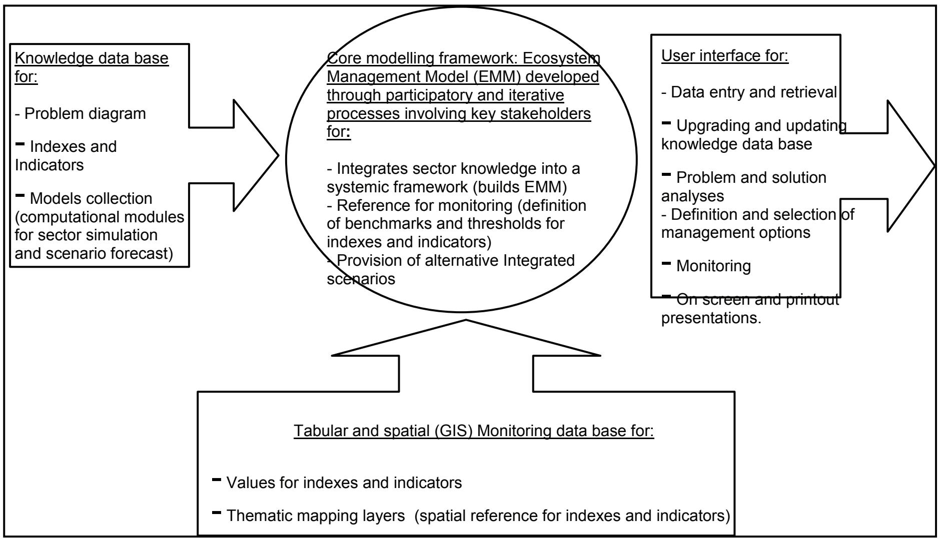
DSS core modelling framework: the Ecosystem Management Model (EMM)

- Is developed through participatory and iterative processes involving key stakeholders.
- Defines basic structural components and key functions of the involved ecosystems.
- Identifies key management issues and their cause-effect relationships in the framework of relevant ecosystem components and functions.
- Defines a set of specific and quantitative indicators within Drivers-Pressures-Impacts-States-Responses framework. Allows the integration of the identified management issues and indicators into the relevant areas.
- Assists in monitoring the performances of management actions and/or policies by evaluating their effects against a number of selected references, baselines and benchmarks.
-

<u>Base attributes for each index and indicators (benchmarks)</u>

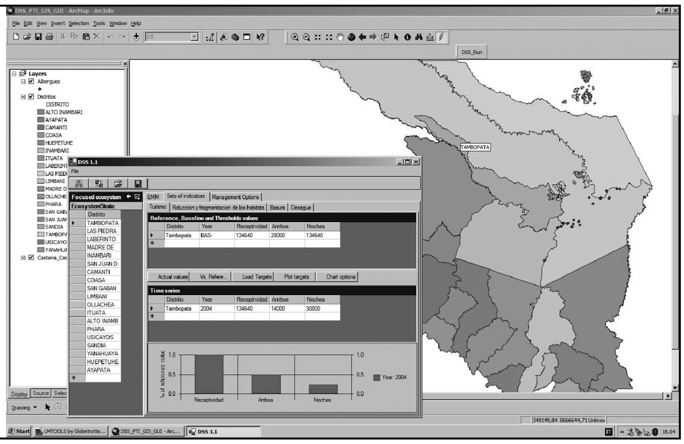
- Baseline - is the value at the time the SSDSS is put to use by the decision makers.
- Reference - is the ideal value which corresponds to the optimal or equilibrium state .
- Thresholds - are values (upper and lower with respect to the baseline) marking the level above/beyond which an action must be taken.
- Targets - are goals of a prescribed management action.
-

Architectural framework of the DSS



DSS functionalities

- Socio-economic and environmental monitoring: analysis of current status and trends of the selected indicators within the DPSIR model.
- Management actions: management actions can either be selected from a list of options prompted by the DSS, or identified by the user and added as “new options” to such list.
-Monitoring of



The effects of the attitude concept, public education campaigns, social discourse and socio-demographic factors on water conservation behaviors in residential landscapes

B.J. Andersen

Environmental Science Program, University of Idaho, Moscow, Idaho, USA.
e-mail: bjander@uidaho.edu

Since the early decades of the 20th century, the study of attitudes has been a predominant theme in contemporary social psychology (Eagly and Chaiken, 2005). Attitudes consist of psychological tendencies to evaluate a specific object, whether that object is a person, thing, or concept and may be either enduring or temporary; either implicit or explicit; and simple and unitary, dual or multiple in their nature. Therefore, the attitude concept is a common tool utilized in attempting to understand human behavior. My literature review examines this concept in relation to what we know about pro-environmental behaviors in residential landscapes. One interesting gap in existing research, building on the Theory of Reasoned Action and Theory of Planned Behavior work of Ajzen and Fishbein (2005) and others, involves the lack of examination of the inconsistencies that occur when people fail to carry out their intentions.

Recent evaluations of energy conservation, water conservation and recycling behaviors show that the overall theory of attitudes influencing actions is useful. However, using evidence from studies of residential landscape water consumption behavior and energy conservation behavior (Stets and Biga, 2003), I show that local environmental education campaigns, discussions with friends and family, and socio-demographic variables also shape environmental behaviors (Campbell et al., 2004). For example, the Eco Team Program approach studied in several Dutch cities by Staats et al. (2004), found evidence for the informal advice of neighbors, friends, and family having a positive influence on the adoption of proenvironmental behaviors. However, overcoming habitual behaviors, i.e., those not preceeded by overt, conscious intention, requires the aim to act differently and a commitment to try and sustain a new action. Campbell et al. (2004) studied individual household water consumption in Phoenix, Arizona (USA), assessing the effectiveness (through actual individual water consumption records, rather than self-reports) of different policy intervention techniques: devices/engineering solutions (low flow showerheads), people (having seniors go to senior households to help install water-saving devices), prices, and rules. Prices and rules were more certain in reducing water consumption than were people or devices.

Municipal officials trying to convince residents to implement water conservation practices in their domestic landscapes should concentrate on policies that will provide them with opportunities to implement public education, promote social discourse, and focus on people typically not practicing pro-environmental behaviors as well as addressing the pro-environmental attitudes and values of people already practicing water conservation (Schultz, 2000). Values appear to be a fruitful avenue to explore because of data supporting them as a basis for environmental attitudes (Schultz and Zelezny, 1999). Connected to this, Schultz and Zelezny (1999) found self-enhancement to be associated with self-benefit and self-transcence to be related with a broader cognitive representation of self, rather than proenvironmental attitudes and behaviors being linked with altruism, egoism, and prosocial behaviors. Analysis of this aspect of the social/human dimension of landscape challenges landscape ecologists to integrate social science with biophysical science for a broader landscape perspective.

References

Ajzen, Izak and Fishbein, Martin. 2005. The Influence of Attitudes on Behavior. Pp.173-221 in Albarracín, Dolores, Johnson, Blair T., and Zanna, Mark P. (eds.). *The Handbook of Attitudes*. Mahwah, NJ: Lawrence Erlbaun Associates.

Campbell, Heather E., Johnson, Ryan M., and Larson, Elizabeth Hunt. 2004. Prices, Devices, People, or Rules: The Relative Effectiveness of Policy Instruments in Water Conservation. *Review of Policy Research* 21(5):637-662.

Eagly, Alice H. and Chaiken, Shelly. 2005. Attitude Research in the 21st century: The Current State of Knowledge. Pp.743-767 in Albarracín, Dolores, Johnson, Blair T., and Zanna, Mark P. (eds.). *The Handbook of Attitudes*. Mahwah, NJ: Lawrence Erlbaun Associates.

Schultz, P. Wesley and Zelezny, Lynn. 1999. Values as Predictors of Environmental Attitudes: Evidence for Consistency Across 14 Countries. *Journal of Environmental Psychology* 19:255-265.

Schultz, P. Wesley. 2000. Empathizing with Nature: The Effects of Perspective Taking on Concern for Environmental Issues. *Journal of Social Issues* 56(3):391-406.

Staats, Henk, Harland, Paul, and Wilke, Henk A. 2004. Effecting Durable Change: A Team Approach to Improve Environmental Behavior in the Household. *Environment and Behavior* 36(3):341-367.

Stets, Jan and Biga, Chris F. 2003. Bringing Identity Theory into Environmental Sociology. *Sociological Theory* 21(4):398-423.

Catchment management in lowland England: an integrated, multifunctional approach

C. Stoate

The Game Conservancy Trust, Allerton Project, Loddington, Leics. UK
e-mail: cstoate@gct.org.uk

Introduction

The requirements of the Water Framework Directive (WFD) for improved chemical and ecological status of watercourses are an important driver for land management and research at the catchment scale. Associated wildlife and landscape, including their use by local people are additional social and economic drivers for a new approach to catchment management. This paper is based on the 67,000 hectare Eye Brook catchment, a tributary of the River Welland in the English East Midlands. The catchment comprises arable and livestock farming on clay soils, ancient semi-natural woodland, and Eyebrook Reservoir (a trout fishery). Since 1992, the Allerton Project research and demonstration farm business in the centre of the catchment has been the focus for research into farmland ecology, the relationship between soil management and water quality and ecology, and practical management measures for environmental improvement, including EU and UK government and industry funded projects in collaboration with numerous research partners. Loss of soil and nutrients, especially phosphorus (P), from land to water is a major concern because of costs of water treatment and environmental consequences such as eutrophication. This paper provides a summary of this research in the context of the changing agricultural and economic climate.

Stream ecology

An electro-fishing survey of brown trout in the Eye Brook revealed low numbers at all ten sites, and very low numbers of young fish at all but one site. Breeding success is low because of sedimentation of gravel spawning habitat resulting from soil erosion associated with surface runoff from arable land. The physical, chemical and biological processes associated with transport of soil and nutrients from arable land to the stream are investigated by the Phosphorus from Agriculture: Riverine Impacts Study (PARIS) which is based mainly on a low input grass sub-catchment and an arable sub-catchment at Loddington. Median particulate P concentrations are ten times higher in the arable catchment than in the low input grass catchment, and in both, highest concentrations are associated with storm events. Allerton Project monitoring revealed that field drains also contribute P to water, exceeding concentrations likely to cause eutrophication on 60 – 100% of sampling occasions. Septic tank discharges result in further elevation of soluble reactive P in some headwater streams. The effect of this is diluted in winter but can be substantial under low summer flows. Diatom and macro-invertebrate communities show a response to increasing P.

In-field mitigation

Two erosion plot based studies at Loddington assess the loss of sediment and nutrients from fields via surface runoff. The Soil and Water Protection (SOWAP) project compares minimum tillage with ploughing in Belgium and Hungary as well as at the Loddington site. Loss of soil and nutrients to water are generally lower under minimum tillage than under plough and soil organic matter, earthworm density and soil microbial biomass are also higher under minimum tillage. Minimum tillage could have multiple environmental benefits, as well as mitigating against diffuse water pollution. Crop establishment costs can be lower under minimum tillage, with potential benefits for the farmer, but this is sometimes offset by increased herbicide costs. The Mitigation Of Soil and Phosphorus loss (MOPS) project compares the mitigation potential of cultivation direction and in-field barriers ('beetle banks'), as well cultivation type. Cultivation direction has the overriding influence on runoff and nutrient loss.

Field edge mitigation

UK farmers prefer to avoid in-field measures to meet environmental objectives and the Allerton Project has a long history of developing field edge measures for environmental improvement. Perennial grass buffer strips are adopted at Loddington to provide wildlife habitat, over-wintering habitat for beneficial predatory invertebrates, and to reduce surface runoff entering watercourses. In one case, ditches and field drains are diverted into series of pools within a wide buffer strip in a small food plain. P concentrations are 40 – 50% lower at the outlet than at the inlet of these pool sequences. Although small and eutrophic, these pools provide a valuable habitat for several aquatic invertebrates, including fifteen Odonata species and seven nationally scarce beetle species. The associated vegetation also supports five species of Orthoptera and breeding bird species such as whitethroat (*Sylvia communis)* and reed bunting (*Emberiza schoeniclus*), and wintering snipe (*Gallinago gallinago*), jack snipe (*Lymnocryptes minimus*) and water rail (*Rallus aquaticus*). Continuing research is investigating the potential of smaller scale field edge features for nutrient management and wildlife conservation, including nutrient behaviour, macro-invertebrate communities, and birds in ephemeral ditches.

The social dimension

The project also introduces a social dimension. While regulation and economics are important influences on catchment management, cultural influences also play a role. Values attached to landscape provide an example. Knowledge of local history increases local people's cultural identity, sense of place, and 'ownership' of environmental problems and opportunities. This is addressed through a four year project which engages local people in exploration of the cultural and natural heritage at the catchment scale.

Integration and multifunctionality

This paper describes how hard science, as applied locally by national and international institutions, can combine with cultural values of local people to build a sustainable approach to catchment management. The integration of a number of research themes is essential to a comprehensive understanding of catchment issues. The examples of grass field margins, minimum tillage and buffer strip pools illustrate how this approach can bring multifunctional benefits which can be cost effective and attractive to stakeholders. Meeting multiple objectives simultaneously can therefore involve cost sharing. Such an approach is most likely to succeed in meeting policy objectives such as those of the WFD, as well as those of local people.

Acknowledgements

The research described here is in collaboration with the universities of Cranfield, Harper Adams, Lancaster and Leicester, and ADAS, Centre for Ecology and Hydrology, the Ponds Conservation Trust and RSPB, with funding from Defra, the EU, Environment Agency, HART and the Lottery Heritage Fund.

Integrated river basin management plan: public involvement and stakeholder participation

Z. Gulbinas

Nature Heritage Fund/Vilnius Pedagogical University, A. Juozapaviciaus 9, Vilnius, Lithuania.
e-mail: zenonas@gamta.lt

Introduction

In year 2003 PIN-Matra project "Management and Restoration of Natura 2000 sites through an Integrated River Basin Management Plan of the Dovine River", financed by the Netherlands Ministry of Agriculture, Nature and Food Quality, was started in Lithuania. The overall purpose of the project was to produce a Management and Restoration Plan for the Dovine River Basin (total area 588.7 km^2).

Approach

In 2002 the Zuvintas Lake and adjacent areas (Almalvas wetlands, fen meadows, drained peatlands and buffer zones) were designated as a biosphere reserve. As these territories are on the list of SCI, Lithuania is obliged to maintain its favourable conservation status. This implies that the eutrophication has to stop and relevant management and restoration activities have to be carried out.

Both the obligation to maintain the favourable conservation status of the Zuvintas Lake, adjacent wet grasslands and bogs (based on the Habitats Directive) and the obligation to restore the reference situation of the Dovine river (according to the WFD) make the area an excellent pilot for integrating of the protection and restoration of nature values of European significance into integrated river basin management. The project provided the bases for the long term protection of the Zuvintas Lake, the re-naturalisation of the Dovine River and the restoration of drained wetlands.

The project helped to improve the capacity and organisational build up of involved Lithuanian governmental organisations in the implementation of Natura 2000 and the WFD. Training was provided for local and central staff on the implementation of the WFD and the Natura 2000. Dissemination of the lessons learned to other regions in Lithuania took place. Involvement of local stakeholders in decision making and the awareness and knowledge of the local population on biodiversity protection and sustainable water management and the role of relevant EU legislation has been increased (Zingstra *et. al.,* 2006).

Activities and results

Seminars and trainings

The project carried out a series of workshops and trainings:

1. Seminar on introduction of the project activities and EU requirements.
2. Seminar on the status of the Natura 2000 habitats and species in the Dovine River Basin.
3. Seminar on defining and assessing Favourable Conservation Status of Natura 2000 species and habitats.
4. Seminar on monitoring of biological quality elements for assessing WFD typology and ecological status of inland surface water bodies.
5. Peatland Restoration Workshop with focus on the Amalvas and Žuvintas fen complexes.

Dissemination of project activities and results

An information leaflet introducing the project idea and tasks, presenting implementation organizations, presenting information about the Dovine river basin was prepared and published, and distributed for the national, regional and local stakeholders. At the end of the project a “Door-to-door” newsletter was prepared and published where main results and outcomes of the project with recommendations were presented. This publication was oriented mainly to regional and local stakeholders and to the people living in Dovine basin.

The web site for Žuvintas Biosphere Reserve was created and domain www.zuvintas.lt was registered. Project home page and Extranet were developed inside the Žuvintas biosphere reserve web site.

Information about the project activities and project results were published in local and national newspapers. In May 2006 the Lithuanian National TV broadcasted a documentary about the Žuvintas Lake and the PIN-Matra Project.

Activities in the region

Municipal schools were visited to educate and teach school teachers and students in the Dovine Basin in knowledge about the importance of biological diversity and nature protection. 8 meetings in three municipalities were organized and about 630 pupils and 90 teachers took part in the meetings. For different levels of the pupils lectures were presented on subjects like: “Why are wetlands useful for us?”, “What are the watersheds? Survey the Dovine watershed”, “What are the habitats of Natura 2000? Why is it necessary to safe and restore?”, “Wetlands habitats and their state in the Dovine watershed”, “Forests, meadows and water habitats and their variety in the Dovine watershed”. For the primary classes’ pupil after a lesson about wetlands practical period “I draw a wetland” was organized. For the teachers special discussion at the round table “Natura 2000 habitats, their protection and restoration: ecological education and local community view” was arranged.

The main results and outcomes of the project were presented during the regional conference organized for regional and local stakeholders. Representatives and responsible specialists from different institutions such as counties, municipalities, Environmental Protection Departments, forest enterprises, localities and protected areas administrations acting within the basin took part in this conference.

Final conference

Project implementation process, main results and outcomes, also project evaluation and recommendations prepared by project were presented during the Final conference. Around 60 participants took part in the conference: members of the project Steering Committee, responsible officers from the Ministry of Environment, officers from Environmental Protection Agency and State Service for Protected Areas, foreign and local experts of the project, guests discussed the main project issues.

Acknowledgments: Support from the Dutch Government through PIN-Matra programme (project No. 2003/040) is greatly acknowledged.

References

Zingstra, H (final edit); Gulbinas, Z; Kitnaes, K. & Querner, E. (2006) *Integrated Water and Biodiversity Management in the Dovine River Basin, Lithuania.* Wageningen International, the Netherlands.

1.6 Open Session 8: Landscape and Nature Perception

From re-discovering to dealing with nature. The Netherlands as an example.

S. Kost

University of Kassel, Department of Architecture, Urban Planning, Landscape Planning, Institute for Empirical Research of Planning Issues, Georg-Forster-Str. 7, Kassel, Germany, e-mail: s.kost@uni-kassel.de

Introduction

In the 1980s there started in The Netherlands a kind of rediscovering of nature connected with a change in how nature is seen and evaluated by experts and people. In regions where so-called new nature was constructed new forms of economy and cooperative planning have start to develop. More and more people were involved in the discussion as how to preserve and develop nature. New nature became a symbol for the change in politics and planning in general.

New ways to handle landscape

Transformation processes either in the meaning of and handling of nature depends on the accumulation of problems and events. A beginning is seen to be visible in different fields, such as water management, spatial planning or ecology. In these fields experimental forms of planning and projects have been developed, which combine different aspects, for example ecology and economy, ecology and aesthetics, housing and landscape conservation etc. Step by step a process of invention and innovation in handling nature is taking place, with the elements of a new paradigm are becoming visible.

Making Landscape

Two key issues are important in the development of landscapes in The Netherlands:

The shortage of land leads to the production of new land for agriculture and settlement. The knowledge of land engineering and land-management corresponds with an „everything goes mentality“- everything is thinkable anywhere. This has been true up to now: one can produce any kind of landscape as an economic resource anywhere.

The renaissance of nature in the middle of industrialized and technical designed territories is made clear: the nature, which was believed to be lost, develops spontaneously and in an unplanned way. The concept „new nature“ refers to this process of self-creating landscape and renewed discourse on nature as a potential of the economic development of regions. New nature has become a marketing strategy for several economic branches and political institutions. Thus nature has become an integral part of regional socio-economic development and planning.

Dealing with nature

If one concentrates on the active participants of this process one sees how the status of power of different groups is changing and a new pattern of strategies has been developed: The issue of new nature opens new forms of cooperation with former conflicting parts: economic and ecologic interests, business and nature conservation are finding new coalitions in an instrumental sense.

Companies are becoming sponsors for nature-protecting projects and demonstrating an image which conforms to natural processes; in sponsoring projects of new nature they convince the local government that their business will not destroy the natural environment. One outstanding example is the re-naturalization of the Maas, where the river will be more natural in the future by changing its course. The exploitation of the gravel is the basis of economic surplus. Another example is the planning of new nature means of making the planning of new houses more attractive and developing new recreational areas. New nature is becoming a symbol of any kind of innovative action.

In general, in different economic fields and geographic regions, one can show that the idea of new nature has already been helpful in constituting new alliances of active participants, innovative coalitions of development and a creative correlation of economic interests and nature conservation. The presentation will show this on the basis of a number of case studies and interviews with experts and citizens in different parts of the Netherlands.

Do people experience landscapes as they state they do? Stated and observed landscape preference assessment on site.

M. Sevenant, M. Antrop

Ghent University, Department of Geography - Krijgslaan 281, S8, Ghent, Belgium.
e-mail: marjanne.sevenant@ugent.be

Introduction

Research on landscape preference should consider a series of preferences for landscapes as elicited (1) in general and verbal terms, (2) in most landscape preference studies, i.e. using visualisation, and (3) in concrete behaviour in daily life (de Groot and van den Born, 2003). The present study attempted to compare stated and observed landscape preferences. The research questions concern the agreement between what respondents express as their landscape preferences and the observations and judgements they make in the specific landscapes, and how these relate to their environmental beliefs.

Research approach and method

<u>Questionnaire</u>

A questionnaire on site was carried out during field excursions in France and Belgium, on different days with similar weather conditions during April-May 2006. Respondents (n=108) were recruited within different students' groups who followed a similar course on landscape science. In the first part of the questionnaire, they were asked about their general landscape preference in an open-ended question. Their environmental beliefs were assessed using the original 12-item version of the New Environmental Paradigm scale on 5-point scales, with high codes corresponding to high ecocentrism (Dunlap and Van Liere, 1978). The second part dealt with valuation of 11 concretely experienced landscape vistas *in situ*. Respondents were asked to describe, in decreasing order of importance, three aspects why they did (not) like the landscape (e.g. Galindo and Rodríguez, 2000) and to rate the vista on 'beauty', giving a score between 0 and 10 (e.g. Kaplan and Kaplan, 1989; van den Berg et al.,1998).

<u>Analysis</u>

The 4 open-ended questions on stated and observed landscape preference were first text-analyzed using WinMAX software. Per question, all text segments were assigned a (sub)code in a hierarchical code system, covering the aspects of landscape evaluation as summed up by the respondents. The 19 most frequent (sub)codes in all 4 questions (see table 1) were then transformed into dichotomous variables, with the values depending on whether the respective aspect being mentioned or not in the answer per question. This yielded 19 dichotomous variables for each of the 4 open-ended questions, ready for further quantitative analysis.

Results

Nine of 19 most frequent aspects that were mentioned in stated general landscape preference also show up in landscape observations on site (see table 1, italic font style). The average score on 'beauty' differ with the occurrence or otherwise of only 3 of the 19 aspects of stated landscape preference (t-tests or Mann-Whitney U tests, $p<0.05$). These are: diversity, relief, and human influence s.l. The average score given by the respondents on 'beauty' of the landscape on site is not significantly related to the average score on New Environmental Paradigm (Spearman's rho correlations).

Table 1. Agreement of most frequently mentioned aspects between stated and observed landscape preference (italic font style: significant agreement; (**): p<0.001; (*): p<0.05).

Stated general landscape preference (n= frequency of mentioned aspect)	Observations of landscape preference *in situ*					
	First aspect		Second aspect		Third aspect	
	Mc Nemar	Kappa	Mc Nemar	Kappa	Mc Nemar	Kappa
Agriculture (n=1)	.000	-.018	.000	-.018	.000	.060
Buildings (n=17)	.000	.037	.000	.104	.002	.160
Closed landscape (n=0)	(not calculated as n=0)					
Coherence (n=20)	.011	.058	*.115*	.274 (*)	.012	.201
Colours (n=16)	*.503*	.335 (**)	.041	.417	*1.000*	.120
Contrast (n=1)	.004	.168	*.219*	-.016	*.375*	-.015
Diversity (n=25)	*.065*	.198 (*)	*.851*	.291 (*)	*.324*	.123
Human influence s.l. (n=10)	.041	.239	.008	.045	*.629*	.174
Infrastructures (n=4)	.035	.065	.000	.039	.000	.112
Landscape structure (n=16)	.000	.191	.000	.106	.003	.089
Nature s.l. (n=38)	.001	.262	.000	.182	.000	.077
Open landscape (n=14)	*.267*	.371 (**)	*.210*	.197 (*)	*.057*	.241 (*)
Quietness (n=57)	.000	-.043	.000	.173	.000	-.003
Relief (n=2)	.000	.000	.000	.012	.000	.029
Vast (n=25)	.024	.260	*1.00*	.050	.020	-.035
Vegetation (n=27)	.004	.180	.012	.163	*.081*	.140
View (n=18)	.014	.175	*.080*	.116	*.678*	.281 (*)
Water (n=15)	*.362*	.006	*.265*	.061	*.824*	.267 (*)
Weather (n=26)	.000	.038	.000	.216	.000	.056

Conclusion

From this study it appears that people do not always pay attention to the same aspects in the landscape as the elements they state to be important for evaluation when not being exposed to a specific landscape. Similarly, their environmental beliefs are not significantly related to the landscape judgements on ‘beauty’ they make on site.

References

de Groot, W.T. & van den Born, R.J.G. (2002) Visions of nature and landscape type preferences: an exploration in The Netherlands. *Landscape and Urban Planning*. **3**: 1-19.

Dunlap, R.E. & Van Liere, K.D. The 'New Environmental Paradigm': a proposed measuring instrument and preliminary results. *Journal of Environmental Education*. **9**: 10-19.

Galindo Galindo, M.P. & Corraliza Rodríguez, J.A. (2000) Environmental aesthetics and psychological wellbeing: relationships between preference judgements for urban landscapes and other relevant affective responses. *Psychology in Spain*. **4**: 13-27.

Kaplan, R. & Kaplan S. (1989) *The experience of nature: a psychological perspective*, Cambridge University Press, Cambridge .

van den Berg, A.E.; Vlek, C.A.J. & Coeterier, J.F. (1998) Group differences in the aesthetic evaluation of nature development plans: a multilevel approach. *Journal of Environmental Psychology*. **18**: 141-157.

Integrating geographic information into scenic assessment of a catchment basin

S. Yamashita [1] and N. Nakamura [2]

[1] Department of Civil and Urban Design Engineering, Kyushu Sangyo University, 2-3-1 Matsukadai, Higashi-ku, Fukuoka, Japan.
e-mail: samp@ip.kyusan-u.ac.jp
[2] Center for Landscape Research, Kyushu Sangyo University, 2-3-1 Matsukadai, Higashi-ku, Fukuoka, Japan.

Introduction

Suburban areas, or middle landscapes, can serve as ideal human habitats and demonstrate how human-environment synergy can be sustained (Marx, 1964). Middle landscapes tend to vary in type and are susceptible to either urban or natural encroachment (Tuan, 1998), which makes assessment and management of aesthetic quality quite difficult.

There are two different types of approaches to landscape quality assessment: the ecologist's approach and the engineer-architect's approach. The former, landscape ecology, emphasizes exploring causes and effects of the spatial heterogeneity of a region whereas the latter, landscape architecture/engineering, focuses on investigating perceptual features of the region for design and its management. Landscape ecology often uses and analyzes aerial photographs and satellite images. Landscape architecture/engineering establishes a designated viewpoint on the ground representing ordinary, "down-to-earth" experiences of landscapes. Landscape ecology addresses a wide-ranging area of the region whereas landscape architecture/engineering emphasizes a relatively small locale encompassing the viewpoints.

Combining these contrast approaches enables environmental planners and managers to address the geographic information relevant to ordinary perceptions and aesthetic assessments of landscapes. It also allows us to appreciate the aesthetic attributes of the region and examine places beyond the vicinity of the designated viewpoint. The combination of these two approaches may thus contribute to identifying elusive middle landscapes and assessing them aesthetically in the geographic context of the region.

This study will identify the middle landscapes in a catchment basin of a Japanese river and obtain information relevant to the assessment and management of the basin by integrating GIS information of the basin into an aesthetic assessment of the river landscape. The study explores the roles the middle landscape plays in the perception and evaluation of landscapes.

Procedure

The selected catchment basin is of the Mikasa River, which runs from upstream, natural areas to downstream, intensely-urbanized/densely-populated areas.

To integrate geographic information into perceptual/aesthetic data, a digital surface model of the catchment area was created using aerial photographs which were classified according to land use. Panoramic video images were taken both upstream and downstream from all the 66 bridges along the mainstream of the river. View-shed areas within the frame of each of the panorama images were generated for the 3-D individual land use areas. The composition of each panorama image was analyzed in terms of water surface, vegetation, man-made structure and sky. Forty-one college students evaluated and rated the images using the Scenic Beauty Estimation procedure to standardize the perceptual assessment data thus obtained.

Results

Three types of middle landscape were identified by factor analysis and cluster analysis: 1) a perspective of distant mountains and forests with anthropogenic structures in the foreground (mountain-forest type); 2) view consisting of rice paddy fields, farmlands, natural areas and/or vacant land (country-nature type); and 3) view of water surface with commercial facilities (developed waterfront type). A "naturalness" factor, which is relevant to vegetation and man-made structure and is independent of the three types, was also identified; views were characterized by this factor as well.

The mountain-forest type was observed upstream from the viewpoints at the bridges over the middle reaches of the river. The viewpoints of the country-forest type were located within the upstream areas, and its directions of view were confined to downstream. The developed waterfront type was located in the mid-to-lower reaches and viewed in the directions of both up- and downstream. The views in the lower reaches tended to be characterized by the "naturalness" factor.

The mountain-forest type middle landscape and the country-nature type tended to be rated high in preference whereas the developed waterfront type tended to be less preferred. The factor score for the mountain-forest type had a significant correlation with the evaluation of the river landscapes (Table 1). The "naturalness" factor score was slightly correlated with the landscape evaluation (Table 1); the projected area of man-made structure in an image was significantly correlated with preference (r=-.32, p<.01); however, the relationship between the area of vegetation and preference was not significant due to vegetation's complex effects of obstructing visual penetration and covering man-made structure.

Conclusions

The findings indicated that the visibility of middle landscapes, particularly the perspective of distant mountains and forests, has a positive impact on the view from the river, even if they have conspicuous anthropogenic structures in the foreground. Conversely, the combination of commercial facilities with water tends to be rated relatively low.

It is clear that the perspective in the upstream direction from the mid-stream areas of the river is most important. Keeping buildings low in this direction is thus essential in the planning and management of the catchment area. From middle- to downstream areas, the combination of man-made structure, vegetation and water surface needs to be improved by taking the ambivalence toward vegetation into account.

Table 1. Correlation coefficients between factor scores and evaluation (SBE).

Mountain-forest	Country-nature	Developed waterfront	Naturalness
0.408**	0.087	0.086	0.186^{+}

**: p<.01, +: p<0.1

References

Marx, L. (1964) *The Machine in the Garden: Technology and the Pastoral Ideal in America.* Oxford University Press, New York.

Tuan, Y.-F. (1998) *Escapism.* Johns Hopkins University Press, Baltimore and London.

1.7 Posters

Improved Decision-Making for Food Security, Income and Environmental Services through Modeling Cropping Systems and Optimizing Land Use Options: A Case Study of Taita Hills, Kenya

D. W. Odede-Oremo, MSc

e-mail: dwodede@gmail.com

Regional GIS Office, Juba Southern Sudan, United Nations Mission in Sudan

Climate changes and rapid population growth cause increasing pressure on the East African highlands. The results of the pressure are manifold: intensified agriculture, decreasing amount of forestland, loss of biodiversity, intensified land degradation and soil erosion. These consequences introduce high demands on land use and land use planning in these areas. The Taita hills are one of the highland areas in East Africa which has gone through significant changes in land use over the past decade. Being part of the Eastern Arc, Taita Hills is very valuable and rich in biodiversity and has many endemic mammal, bird, and butterfly species. The hills were once forested with cloud forest, but today, only few larger patches of indigenous forests are left. These forest patches are not only valuable for the endemic animal and vegetation species, but also for local people because of their importance as sacred forests. Parts of these forest remnants are sacred or traditionally protected. The forests have suffered substantial loss and degradation since the early 1960s.

The current land use practices in Taita Hills exhibit inefficient patterns that are of a major concern for sustainable rural development. The biotopes in Taita Hills have suffered from quantitative as well as qualitative decline primarily as a result expansion of land under agricultural use. Currently, there is growing need to implement on-farm biodiversity and soil conservation strategies and re-forest the biotope. Faced with decreasing farm sizes due to constant land sub-division, the local farmers' constantly make adaptations to their farming practices to meet the basic house-hold food economy demand. While it is prudent that farmers' minimize environmental impacts of their decisions, their decisions on choice of enterprises is constrained by poverty, limited access to technologies, lack of stable markets and weak institutional capacity to respond to environmental and market shocks.

For each parcel of land, the farmers choose a type of use from which they expect to derive the most benefit considering a variety of issues: (i) their personal objectives and constraints, (ii) the given set of biophysical parameters, and (iii) the institutional, cultural, and legal attributes of the land parcel. As these issues vary in space and time, so does land use choices, resulting in a spatio-temporal mosaic in land use types. Little is known about the long-term ecological and economic consequence of such changes in land use hence, making sustainable rural land-use policy formulation a daunting task. For instance, changing the plot size of one crop and re-allocating to another has practical implication on land management and soil erosion as the change in crop type may affect soil water infiltration, run-off, evapo-transpiration and plant-water budget.

The objectives of the proposed doctoral study are to: (i) develop cropping strategies that can improve cash income and nutritional quality using optimizing models, (ii) evaluate the implications of the change in crop enterprise choice on soil erosion and biomass production, (iii) assess the costs of agricultural land use changes and compare them with the ecological benefits from expected vegetation changes and reduced fragmentation of (semi-) natural terrestrial biotopes, and (iv) develop a land use conflict resolution process that uses a Geographic Information System (GIS) based decision support system to optimize land use allocation in Taita Hills.

The multifunctional character of the landscape in areas of intensive agriculture: towards a sustainable planning strategy

J. Ruiz, G. Domon

Department of Landscape and Environmental Design, University of Montréal, C.P. 6128, succ. Centre-ville, Montréal, Québec, CANADA.
e-mail: julie.ruiz@umontreal.ca

Introduction

Many functions of landscapes were greatly altered over the last decades following the transformations occurring in agriculture. In areas suitable for agriculture, trends towards the homogenization of landscapes were coupled with a decrease in the number of farms, creating a risk of devitalization for rural zones. Thus, the restoration of various landscape functions, particularly the environmental functions, is urgent. In addition, issues related to quality of life, because of the growing demands of urbanites towards landscapes, will have to be considered. In that context, an interdisciplinary research project was conducted for three years within a southern Québec agricultural watershed (1200 km²). The main objective of the project was to identify landscape structures that would allow for both the reintroduction of past functions, as well as being responsive to new functions (residential, amenities, etc.). This project posited that the multifunctional character of landscapes could be maintained or reintroduced solely if farmers, non-farmers and communities would receive benefits.

Methodological strategy

First, an ecological classification of the study area allowed us to select three types of landscape patterns representative of areas of intensive agriculture in Quebec. Within these three landscape contexts, the research project was developed in three parts. The objective of the first part was to find landscape structures and patterns likely to promote the presence of insects beneficial to agriculture, in order to decrease the use of insecticides by farmers. Aphid populations present in corn fields were sampled, and using multivariate statistics (redundancy analysis), these insect data were analyzed jointly with landscape characteristics. The second part was to focus on the landscape structures valued by farmers and non-farmers. A total of 46 semi-directed interviews were thus conducted among resident populations of the three different landscape contexts. These data were analyzed qualitatively. The third part was to measure the influence of agricultural patterns on water quality during the last five years. Finally, the development of landscape scenarios (presented visually and using maps) integrated the results of the three parts of the project.

Results and discussion

The results suggest the existence of landscape structures that are beneficial to both individuals and communities, and that are able to support multiple functions (environmental, aesthetics, amenities, etc.). The importance of forested areas, the size of agricultural fields, and the types of crops were among such landscape structures and patterns. From the point of view of landscape design in areas of intensive agriculture, these results also suggest the necessity of developing new practices, no longer solely oriented towards protection measures, but also capable of allowing the coexistence of the different functions of landscapes, including those associated with aspects of the quality of life of residing populations.

Understanding graziers' decision-making in the Great Barrier Reef catchment to improve environmental, social & economic objectives

I. Bohnet

CSIRO Sustainable Ecosystems – Tropical Forest Research Centre, PO Box 780, Atherton 4883, Queensland, Australia. e-mail: iris.bohnet@csiro.au

Grazing lands cover over 75% of the Great Barrier Reef (GBR) catchment. The major livestock production—beef—contributes over $3,000M to the national economy annually and employs approximately 9000 people (Productivity Commission, 2003). These grazing lands also contribute a substantial proportion of the sediments and nutrients that drain into the GBR lagoon (Brodie *et al.,* 2003). Recent research shows that the quantity of sediments and nutrients lost from these grazing lands is strongly dependent upon grazing management practices (Roth *et al.,* 2003). This has led to growing public concern about the environmental performance of the beef industry and increasing pressures on graziers to change their management practices to decrease off-property impacts.

It is believed that improvements in the quality of water draining into the GBR lagoon may be more easily achieved if science-based improved grazing management practices can demonstrate improved economic and environmental performance for graziers, leading to "win-win" outcomes for all concerned (Gordon and Nelson, 2007). However, graziers' decision-making is largely based on experiences and the perception of potential outcomes from changes in management actions. He or she will select the management actions that provide, in his/her opinion, the highest chance of attaining their personal objectives. The various combinations of management actions from which a grazier might choose are almost endless. Therefore, this research suggests that it is important to understand graziers' mental models (Abel *et al.,* 1998) to develop schemes, e.g. educational programs, demonstration sites, financial incentives, tax rebates, that can be taken up by graziers and assist them to achieve a multitude of objectives.

Results from nine in-depth interviews with graziers and land assessments of their properties in the Bowen-Broken, a small sub-catchment of the GBR catchment, support the importance of identifying graziers' mental models. The interviews provide insights into a range of decision-drivers that have led to degraded grazing lands, indicating that the number of schemes currently available to graziers only attracts a small number of graziers, and therefore, additional schemes, that are tailored to address the constraints graziers face, and regulatory measures, may be required to achieve the desired outcomes.

References

Abel, N.; Ross, H. & Walker, P. (1998). *Mental Models in Rangeland Research, Communication and Management.* Rangeland Journal 20(1), 77-91.

Brodie, J.; McKergow, L.A.; Prosser, I.P.; Furnas, M.; Hughes A.O. & Hunter H. (2003). *Sources of sediment and nutrient exports to the Great barrier Reef World Heritage Area.* Australian Centre for Marine and Tropical Freshwater.

Gordon, I. J. & Nelson, B. (2007). *Reef Safe Beef: Environmentally sensitive livestock management for the grazing lands of the Great Barrier Reef catchments.*

Productivity Commission (2003) *Industries, Land Use and Water Quality in the Great Barrier Reef Catchment.* Research Report, Canberra, Australia.

Roth, C.H.; I.P. Prosser; Post, D.A.; Gross, J.E. & Webb, M.J. (2003). *Reducing Sediment Export from the Burdekin Catchment.* CSIRO Land & Water, NAP3.224, Burdekin Dry Tropics Board, Townsville, Australia.

Do woods help biological control of cereal aphids by hoverflies?

F. Arrignon [1], A. Ouin [2], B. Bouyjou[2], M. Deconchat, [2], C. Monteil[2], J.P. Sarthou[2]

[1] UPRES EA 1293 ECODIV, Université de Rouen, Bât. IRESE A, place Emile Blondel, Mont Saint Aignan.
e-mail: ouin@ensat.fr
[2] UMR DYNAFOR, INRA / INP-ENSAT, Avenue de l'Aagrobiopôle, BP 32607, F-31326 Castanet Tolosan

Introduction

As an aphidophagous, *Episyrphus balteatus* (De Geer, *1776*) is an auxiliary species for agriculture, particularly at the end of winter-beginning of spring; its densities may be influenced by the amount of natural habitat in landscape. Our hypotheses were that i) *E. balteatus* overwintering success and spring abundances are higher in woody landscape (providing shelter and feeding) than in a less wooded landscape.

Methods

Spring abundance and winter survival were studied in the same two landscapes differing by wood density. The field studies of the spring abundances held in 2003, 2004 and 2005 in 14 wheat parcels spread in two landscapes of south western France. Aphids, syrphids eggs and larvae were counted. A multi-agent model of winter survival was developed, on CORMAS plateform to predicts the abundance of hoverfly at the end of the winter, according to winter temperature, landscape composition and structure, and individual behavior (Arrignon et al. 2007).

Results

Winter survival was higher in woody than in less woody landscapes, the importance of flowered hedge bank or meadows was also pointed out. While in 2003 simulated winter survival corresponded to high early abundance in wheat, in 2004 and 2005 early abundance in wheat did not differed between landscapes (Figure 1).

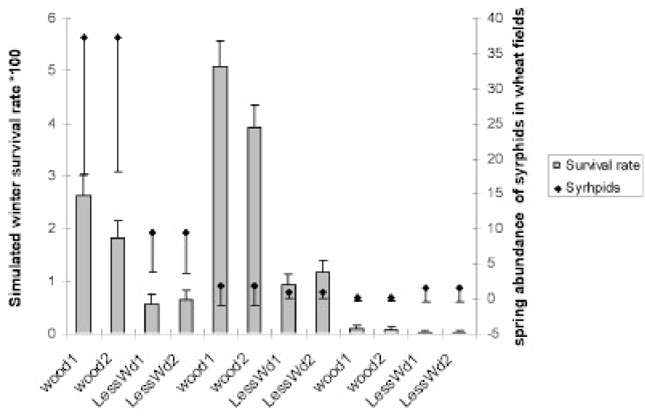


Figure 1. **S**imulated survival at the end of the winter (mean and SD) and hoverfly (eggs and larvae) wheat field abundance (mean and SD) in the following early spring (4 first samplings), in 4 landscapes: woody1, woody2, LessWoody1, LessWoody2 (wood cover: 25%, 17%, 3.6% and 1.8%) in 2003, 2004, 2005.

References

Arrignon, F., Deconchat, M., Sarthou, J.P., Balent, G., & Monteil, C. (2007) Modelling the overwintering strategy of a benficial insect in a heterogeneous landscape using a multi-agent system. Ecological Modelling, accepted.

Five centuries of landscape change in Colombia: a conservation perspective

A. Etter

Depto. Ecología y Territorio, Facultad Estudios Ambientales y Rurales, Universidad Javeriana, Tr 4 Nr 42-00 Piso 8, Bogotá, Colombia.
e-mail: aetter@javeriana.edu.co

Introduction

The spatial extent and the patterns of ecosystem and landscape transformation we observe today are the consequence of historic settlement patterns dating back hundreds or thousands of years (Foley *et al.*, 2005), and with varying cultural, socioeconomic and political contexts (Wardell *et al.*, 2003; Lunt and Spooner, 2005). Analyzing and reconstructing land use change and the historical landscape patterns can help advance the understanding of the dynamics and persistence of present-day landscapes and ecosystems, and therefore contribute to their conservation. However, longer term historical analyzes are still very scarce. This paper presents a spatially explicit historic approach to analyze the human transformation of broad Colombian ecosystems at a national scale, identifying areas and ecosystems with higher transformation impacts.

Methods

I applied a historic spatial approach to reconstruct the landscape change since 1500, based on historic demographic, settlements, economic and land use data, biophysical data, and present day and reconstructed ecosystem maps, applying GIS analysis. The analysis is based on meaningful historic periods and their land use change drivers.

Results

Overall rates of landscape clearing are estimated to have increased from around 10,000 to 280,000 ha per year during the last 500 years. There are large contrasts in the rates, spatial extent and patterns of transformation of different ecosystems. The largest impacts are on Tropical Dry and Sub-humid forests, and the high-Andean forests. However, during the last 100 years Humid Tropical Lowland and the sub-Andean forests show the highest rates of change. Cattle grazing progressively became a major driver of land clearing and transformation in Colombia. Due to historic events some areas show processes of land abandonment, regrowth and eventual re-clearing decades or centuries later. Regions with longer and more intense disturbance regimes should show stronger and larger impacts on native ecosystems and species. The study provides an insight into the environmental history of Colombia, inviting the formulation and testing of new hypotheses about the impacts of human land use on ecosystems in a longer time frame.

References

Foley, J.A., DeFries, R., Asner, G.P., Barford, C., Bonan, G., Carpenter, S.R., Chapin, F.S., Coe, M.T., Daily, G.C., Gibbs, H.K., Helkowski, J.H., Holloway, T., Howard, E.A., Kucharik, C.J., Monfreda, C., Patz, J.A., Prentice, I.C., Ramankutty, N. and Snyder, P.K., 2005. Global consequences of land use. *Science*, **309** (5734): 570-574.

Lunt, I.D. and Spooner, P.G., 2005. Using historical ecology to understand patterns of biodiversity in fragmented agricultural landscapes. *Journal of Biogeography*, **32** (11): 1859-1875.

Wardell, D.A., Reenberg, A. and Tottrup, C., 2003. Historical footprints in contemporary land use systems: forest cover changes in savannah woodlands in the Sudano-Sahelian zone. *Global Environmental Change*, **13** (4): 235-254.

Environmental analysis and diagnosis of recreational zones in protected areas of Madrid (Spain)

C. Rozas, B. Martín, N. Roblas, C. Muñoz & L. Jiménez

Centro de Investigaciones Ambientales de la Comunidad de Madrid "Fernando González Bernáldez" C/ San Sebastián 71. Soto del Real MADRID.
e-mail: bmartinc@bio.ucm.es

There has been a noteworthy increase in the recreational use of protected natural areas over the last few years. With the aim in mind of minimising the impacts caused by the numerous visitors, a series of recreational areas has been set up in order to concentrate them therein.

On locating a recreational area it is important to evaluate the possible impacts by visitors in order to avoid sensitive areas with high ecological or landscape values. Furthermore, these areas must also have a certain degree of naturalness and of landscape and environmental quality if they are to satisfy the expectations and news of visitors and they are to be used as a resource for the development of environmental education activities.

The objectives of this study involve analysing the recreational areas of the Madrid Regional Autonomy, evaluating their degree of naturalness, their state of conservation and the possible impacts deriving from the recreational activity in the surrounding area. The study focuses on areas situated along riverbanks or streams within a Protected Natural Area. The methodology is based upon the analysis of the quality of the riparian vegetation and the state of conservation thereof and involves the application of the QBR riverbank quality index (Munné *et al*; 1998), and an estimation of the impacts caused by the recreational use in the area itself (Gómez-Limón *et al*, 1996).

The results obtained show that the quality of the riparian ecosystems is significantly lower in the recreational areas than in the control sites. According to the QBR index, 45% of the sampling sites present a level from acceptable to optimum in the recreational areas, compared with 90% in the control sites.

Over 70 % of the recreational areas studied are in a poor state of conservation, according to the impact assessment index. The factors with most influence are the width of the main pathway and the percentage of ground with no cover, both of these being indicators of a high number of visitors.

In exploratory studies, no correlations have been detected between both indices, and it would therefore be of interest to study the factors influencing the variation of the QBR inside and outside the recreational areas.

Easy evaluation of the abundance of carnivores through habitat use map, in a Brazilian savanna region

M.C. Lyra-Jorge, M.C. Ribeiro, V.R. Pivello

Instituto de Biociências – Universidade de São Paulo.
e-mail:carolina_ecologia@hotmail.com

Introduction

São Paulo is the most urbanized state in Brazil; therefore a few fragments of natural ecosystems remain. Land cover in the study area (UTM 200000–7620000; 240000–7590000, SAD69 Brazil 23S) comprises patches of savanna and semideciduous forest surrounded by a matrix of sugar-cane and Eucalyptus monocultures. Despite the intense agricultural use, large mammals are still found in that region. To establish conservation strategies focusing on these animals it is necessary to understand how they respond to land cover variation and to landscape structural patterns. In this study, we intended to register the carnivorous mammal species which are using the mosaic of native vegetation patches and Eucalyptus plantations.

Methods

We registered species occurrences using 23 camera traps placed in fragments of typical native savanna (CSS), dense savanna (CAO), semideciduous forest (NSF), and Eucalyptus plantation (EP). We located sample points on a land cover map generated from a Landsat-TM5 satellite image and calculated landscape indices – percentage of remaining habitat (PLAND), edge density (ED), and habitat patch shape (SHAPE) – in areas defined by 250 m, 500 m, 1,000 m and 2,000 m of radii around each sample point. ANOVA was undertaken to verify habitat effect on species occurrence but no significant habitat effect was found ($F=2.84$; $p>0.05$). We created a carnivorous habitat use map through a model generated by stepwise regression analyses and data on species richness, occurrence, habitat type, and landscape indices.

Results

The best regression model for species occurrence considered the parameters: radius=250m; $0.04219*PLAND_{(CAO)} + 0.01174*PLAND_{(CSS)} + 5.04857*SHP_{(EP)} – 0.26911*ED_{(EP)}$ ($R^2=0.88$; $p<0.01$). The map showed that Eucalyptus plantations and fragments of dense savanna are intensively used by mammals such as *Puma concolor, Chrysocyon brachyurus, Leopardus pardalis, Eira Barbara*. The results indicate that some non-native agrosystems - as, in this case, the eucalyptus plantation - may also have a high conservation value for large and medium carnivores, as they perform as permeable matrices and probably offer environmental resources to the animals, such as refuge or simply an access route.

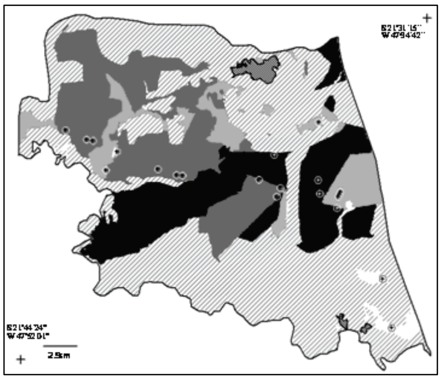


Figure 1: Habitat use in Mogi-Guaçú river basin according to the occurence of carnivours mammals. (Darker areas represent high intensity of use, as the bright areas represent less intense use; dashed areas were not analysed; dashed enclosed areas are uban zones. Each point represents the camera trap and a 250m buffer.

Financial support: FAPESP, CNPq, NGC.

Relationships between the naturalness of the landscape and the nature conservation status of a particular habitat in it

E. Illyés, Z. Botta-Dukát, F. Horváth, Zs. Molnár, J. Bölöni, I. Pándi

Institute of Ecology and Botany of HAS – 2163, Vácrátót, Alkotmány 2-4., Hungary
e-mail: illyese@botanika.hu

Introduction

Loss of area and fragmentation are the two main endangering factors of natural habitats and landscapes (Millennium Ecosystem Assessment 2005). Conservation efforts often attempt to maintain (semi)natural landscapes as a whole with the biggest possible unfragmented area (Margules & Pressey 2000). This approach seems to be successful on landscape level, but is it suitable for the conservation of particular habitats in the landscape? We assessed the correlation between the overall naturalness of the landscape and the nature conservation status of a particular habitat in it to answer this question.

Method

We worked with the database of the Landscape Ecological Habitat Mapping Program of Hungary (MÉTA) for this study, which contains data on 86 (semi)natural habitats based on actual field survey. Hexagons of 35 hectares covering whole Hungary are the basic units of the database. List of (semi-natural) habitats and their area, naturalness based conservation value and 16 other attributes are stored in the database for all hexagons. We choose forest steppe meadow as our modell habitat, therefore we performed our analysis on the 3969 hexagons where forest steppe meadow occured.

We defined nature conservation status of the chosen habitat by the area of the habitat in the hexagon and its naturalness based conservation value derived from the database. The naturalness of the landscape was defined in two spatial levels, by the overall area of (semi)natural habitats within the same hexagon and by the overall area of (semi)natural habitats in landscape section containing app. 100 hexagons (we had 340 such sections).

We used Spearman's rank correlation to explore the relationships in these two spatial scales. We worked with the Statistica program package.

Results and conclusion

We found that there was a significantly positive relationship ($p<0,01$) between the overall area of (semi-)natural vegetation and the area of the forest steppe meadows on both spatial scales, although the relationship between them was low ($r=0,433$ and $r=0,437$). The naturalness based conservation status of the habitat was significantly correlated ($p<0,01$) with the overall area of natural and semi-natural vegetation on the finer scale, but the relationship was even weaker ($r=0,205$). It seems that a more natural landscape somewhat contributes to the higher conservation status of the habitats in it, however this effect is rather weak and may not be driving factor in the future maintenance of the habitats.

References

Margules, C.R. & Pressey, R. (2000) Systematioc conservation planning. *Nature* **405:** 243-253.

Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-being: Biodiversity Synthesis*. World Resources Institute, Washington, DC.

Adjacency analysis: a method to evaluate landscape conservation status

L. Zavattero[1], D. Smiraglia[2], M. Marchetti[1] & C. Blasi[2]

[1] Department S.T.A.T. – University of Molise, Contrada Fonte Lappone, Pesche (IS) Italy.
e-mail: l.zavattero@tiscali.it
[2] Dept of Plant Biology – University of Rome " La Sapienza", P.le Aldo Moro 5, Rome – Italy.

The replacement of traditional agricultural, silvicultural and pastoral practices by more intensive exploitation has strong impact: structural simplification, changes in spatial diversity and boundaries, and modification of matter and energy flows between patches. To characterize and quantify the landscape heterogeneity level in space and time the patch boundary analysis could be more explanatory in a multitemporal study because it gives information on how a landscape has changed and not only on how much. So, the spatial arrangement of land use types across a given landscape can be explained by using the nature of the different contact types (Acosta *et al.* 2003). Depending on the spatial distribution of the patches and the shared perimeter between different land cover types is possible to assess the landscape conservation status.

The aim of this study is to describe the dynamics of the landscape through patch boundaries dynamics, taking into account the nature of the spatial contacts between adjacent land cover types and using the spatial distribution of land units as reference model.

We considered recent historical changes (1954-2000) in the landscape of Lepini Range (Central Italy) focusing on the boundaries between patches for the characterization of spatial organization. A spatial delimitation in "land unit" of the study area is better suited for assessing landscapes, thus it is possible to study ecological processes in an ecosystem classification framework. In this paper we apply the method for classifying and mapping land units at different scales developed by Blasi *et al.* (2000). The method integrates the basic physical aspects of the landscape and is particularly useful for multipurpose applications. In this case, the emphasis is focused on the boundaries analysis in environmental homogeneous units (to Potential Natural Vegetation units). The term "boundary" refers to two different neighbouring land use types having a common or shared perimeter. We take into account 5 kinds of contacts between land cover types: 1) artificial surface/agricultural land, 2) artificial surface/natural areas, 3) agricultural land/natural areas, 4) between natural areas not dynamically related: that is between coenoses which do not represent successional stages (forests/grassland), 5) between natural areas dynamically related: that is between cenoses which represent successional stages (forest/shrubland or shrubland/grassland).

The results show a reduction in the number of contacts agricultural lands/natural areas and an increase of contacts artificial surfaces/agricultural lands and artificial surfaces/natural areas. Generally, this involves a retrieval of forest cover in abandoned mountains with a decrease of agricultural lands and natural areas such as shrublands and grasslands and, to the opposite, a more intensive exploitation of flat areas. In particular, in the analysed land units, we noticed in the Mediterranean Region a decrease of adjacency grasslands /shrublands and an increase shrublands/forests. In the Temperate Region land units instead there is a decrease grasslands/shrublands and also shrublands/forests and, to the opposite, an increase forests/grasslands.

References

Acosta, A; Blasi, C; Carranza, M.L. & Ricotta C. (2003) Quantifying ecological mosaic with a new topoecological index. *Phytocoenologia* 33(3): 40-51.

Blasi, C; Carranza, M.L; Frondoni, R. & Rosati, L. (2000) Ecosystem classification and mapping: a proposal for Italian Landscape. *Applied Vegetation Science* 3: 233-242.

Estimating the effect of protected lands on the development and conservation of their surroundings

R.I. McDonald[1], C. Yuan-Farrell[2], C. Fievet[3], M. Moeller[4], P. Kareiva[2], D. Foster[1], T.Gragson[3], A. Kinzig[4], L. Kuby[5], C. Redman[5]

[1]Graduate School of Design, 48 Quincy Street, Harvard University, Cambridge, MA USA.
e-mail: rmcdonald@gsd.harvard.edu.
[2]The Nature Conservancy, Seattle, WA, USA [3]Department of Anthropology, University of Georgia, Athens, GA, USA [4]School of Life Sciences, Arizona State University, Phoenix, AZ, USA [5]International Institute for Sustainability, Arizona State University, Phoenix, AZ, USA

The fate of private lands is widely seen as key to the fate of biodiversity in much of the world. Organizations that work to protect biodiversity on private lands often hope that conservation actions on one piece of land will leverage the actions of surrounding landowners. However, few researchers have examined whether protected lands do in fact encourage land conservation nearby or how protected lands affect development in the surrounding landscape. Using spatiotemporal datasets on land cover and land protection for three sites (western North Carolina, central Massachusetts, and central Arizona- see Figure 1), we examined whether the existence of a protected area correlates with an increased rate of nearby land conservation or a decreased rate of nearby land development. At all sites, newly protected conservation areas tended to cluster close to pre-existing protected areas. This may imply that the geography of contemporary conservation actions is influenced by past decisions on land protection, often made for reasons far removed from concerns about biodiversity. On the other hand, we found no evidence that proximity to protected areas correlates with a reduced rate of nearby land development. Indeed, on two of our three sites the development rate was significantly greater in regions with more protected land. This suggests that each conservation action should be justified and valued largely for what is protected on the targeted land, without much hope of broader conservation leverage effects.

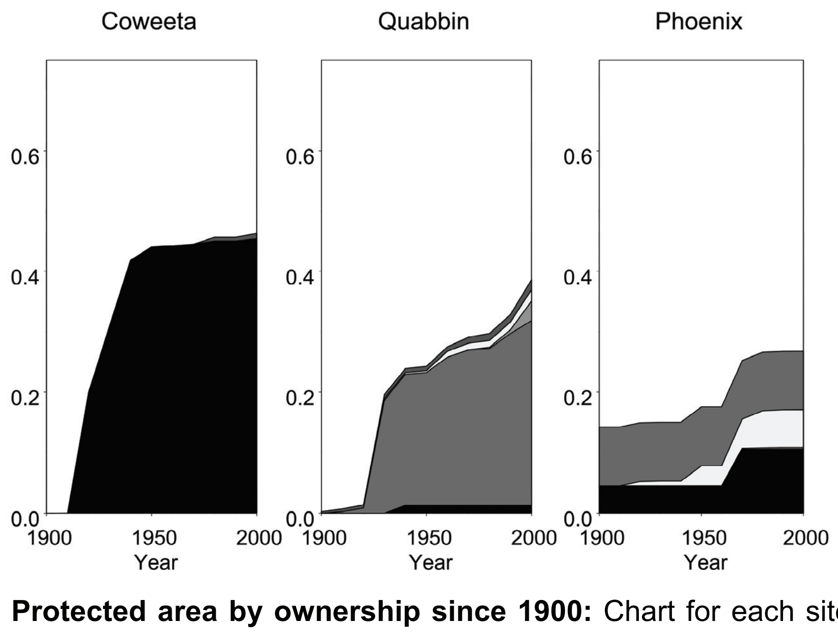


Figure 1. Protected area by ownership since 1900: Chart for each site, showing the proportion of land protected by different groups: federal (black), fee-simple NGO (dark grey), owned by state (grey), easement NGO (light grey), and municipal/county (white). Coweeta is dominated by federal ownership, Quabbin by state ownership, and Phoenix by a mix of federal, state, and municipal ownership.

Identification of sites for mitigation banks using multiple ecological and social criteria

N.Hope, M.C. Fessey, N. Bailey, S. Thompson

Spatial Ecology and Landuse Unit (SELU), School of Life Sciences, Oxford Brookes University, Headington, Oxford UK.
e-mail: nhope@brookes.ac.uk

Introduction to mitigation banking

In order to address key landscape planning concerns such as; habitat loss and fragmentation, accessible greenspace, and potential climate change demands, mitigation banking is proposed. This approach to compensatory mitigation operates by developers offsetting adverse effects and habitat loss from developments by the purchase of credits in a land 'bank' with a pre-determined nature conservation value (Treweek 2000). This allows larger scale and higher quality habitat creation and management to be achieved, than current systems, through accumulation and targeting of funds (Wende et al. 2005). Mitigation banks must become part of the green infrastructure resource. Therefore, their location and constituent habitats need to be planned from a multifunctional perspective.

Multifunctional landscape assessment

Four linked assessment modules; ecological networks, enhancement of landscape character, recreation and amenity provision and natural resource protection, will be used to address landscape planning concerns. The results from two modules; ecological networks and recreation and amenity provision are explored here using the Milton Keynes and South Midlands (MKSM) Growth Area as a case study.

Ecological networks and recreation and amenity modules

Using generic focal species (Watts et al. 2005), ten scenarios were developed for woodland, grassland and wetland. The ecological network model then used resistance surfaces to measure functional landscape connectivity. Existing ecological networks were identified, followed by determination of optimum locations for further habitat creation. Categorisation of greenspace using a typology based on national planning guidance formed the recreation and amenity baseline. Allocation of resistance values subsequently allowed people's accessibility zones to be mapped accurately. Using national accessibility standards identified zones were analysed to determine current level of provision and potential expansion areas. Compilation of the two modules allowed areas with potentially multiple functions to be identified.

Results

Comparison of habitat expansion areas with biodiversity targets (Bedfordshire and Luton Wildlife Working Group 2000) reveal expansion zones to have the potential to exceed targets for woodland by 44320 ha, grassland by 4240 ha and wetland by 840 ha. Existing recreation and amenity greenspace does not currently meet either Local Nature Reserve or 20 ha site standards. Recreation expansion zones have the potential to rectify this shortfall with 110 sites over 20ha (4770 ha) identified. Compilation of the two modules indicates habitat creation areas can provide multiple functions with 5740ha woodland, 720ha grassland and 50ha wetland featuring in both modules.

References

Bedfordshire and Luton Wildlife Working Group (2000). Bedfordshire and Luton BAP. Luton.
Treweek, J. (2000). "Royal Commission on Environmental Pollution." (online).
Watts, K., M. Griffiths, et al. (2005). Towards a Woodland Habitat Network for Wales. Report 686, Countryside Council for Wales and Forestry Commission.

A conceptual model for restoration site selection based on a review of reserve selection procedures

J. Imanishi, A. Imanishi, Y. Natuhara, Y. Morimoto

Graduate School of Global Environmental Studies, Kyoto University, Yoshida-Honmachi Sakyo-Ku, Kyoto, Japan.
e-mail: imanishi@kais.kyoto-u.ac.jp

Introduction

The Law for the Promotion of Nature Restoration of Japan, which aims at recovering the ecosystems and other natural environments that have been degraded or destroyed in the past, was enforced in January 2003. However, procedures for nature restoration at national and regional scales are still unclear. The purpose of this study is to propose a conceptual model for restoration site selection based on a review of literature on procedures for selecting nature reserves to conserve biodiversity in a nation and a region.

We, herein, define ecological restoration as the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (SERI 2004). Although activities of ecological restoration partly overlap with conservation by reserves, it is difficult to find restoration opportunity using usual reserve selection procedures for the ecosystems that have already been altered. Thus, it is needed to integrate restoration site selection into reserve selection procedures in conservation planning.

A conceptual model for national biodiversity conservation planning of Japan

The three attributes, i.e. composition, structure and function, seem well recognized as elements of ecosystems in current conservation biology. A conceptual model, which separately assesses the three elements, was proposed as one of the practicable procedures based on the availability of necessary information.

The information on ecosystem composition for national biodiversity conservation planning is available as distribution data of endangered species in coarse geographical units and as maps of vegetation communities in 1:50,000. The concentrated areas of endangered species are identified as primary reserves in a “reactive” manner. Then, abiotic environmental units are analyzed in relation to the distribution of vegetation communities as a surrogate for species diversity with a similar procedure of Imanishi *et al.* (2005) to find gaps in present conservation networks and to find possible restoration sites in a “proactive” manner.

An aspect of ecosystem structure is analyzed in landscape pattern at regional to watershed levels using medium resolution satellite imagery. Habitat models for species, which rely large area, “area-demanding umbrella species,” and which use multiple types of habitats, e.g. amphibians, are utilized for the assessment.

A feature of ecosystem function is assessed by distribution of artificial structures such as dams and levees at watershed level. It is a prerequisite for the restoration of interface ecosystems between land and water, which usually maintain high biodiversity.

References

Imanishi, J, Shimabayashi, Y & Morimoto, Y. (2005) A new analytical method for wildlife habitat conservation planning on a city scale using the classification of physically homogeneous areas. *Landscape and Ecological Engineering* **1(2):** 157-168.

Society for Ecological Restoration International Science & Policy Working Group (2004) *The SER International Primer on Ecological Restoration.* Society for Ecological Restoration International, Tucson, USA. available online at www.ser.org.

Preservation of sand scenery and native plants conservation in the coastal dunes, the landmark of Tottori, Japan

D. Nagamatsu, S. Tominaga

Department of Regional Environment, Tottori University, Tottori, Japan.
e-mail: daina@rstu.jp

Introduction

The Tottori Sand Dunes are typical costal dunes in Japan. They are the largest dune park in the Japanese National Parks and the most famous tourist attraction for this region. But the dunes were regarded as a nuisance for local people for centuries. They planted pine trees and tried to develop the dunes into farmland. After WWII, the dunes were therefore reduced in area. The remaining dunes were converted into grassland (Shimizu & Shibata 1991). The dunes then declined in their value as a miniature desert. Local government and citizens are now focusing their efforts on trying to preserve sand scenery by weeding for the past 15 years. Vegetation in the dunes has changed gradually due to environmental change and alien plant removal by human beings. But vegetation change in the dunes has not been yet objectively examined. So the changes in plant communities and the effect of exotic removal have been investigated.

We measured distribution of plant community using a GPS receiver and studied species composition and abundance of the community in the dunes (c.a. 130 ha). To estimate past vegetation, we used scientific reports (e.g. Shimizu & Shibata 1991) over 40 years. We made a detailed vegetation map and analyzed community structure by GIS software.

Results and Discussion

Based on vegetation maps from 1967, 1979, 1991 and 2006, *Carex kobomugi* and *Ischaemum anthephoroides*, the native plants of the dunes dominated over 40 years. Although no alien plant communities were recorded until 1967, *Digitaraia ciliaris* and other alien communities became distributed widely between 1979 and 1991. It is suggested that plant communities of the dunes were once widespread in the 1960's to the 1990's and then declined until the present. Alien weed communities were clearly decreased by recent weeding but have not been eliminated. Now native plants occupy most of the dunes, the balance of the sand scenery and native plant communities is the main subject for discussion in the dunes.

Reference

Shimizu, H. & Shibata, M. (1991) Expansion of grassland in Tottori Sand Dunes. The research committee of the Tottori Sand Dunes (Ed). *Science Report of the Tottori Sand Dunes, San-in Kaigan National Park,* Tottori Prefecture, Tottori, pp. 14-24 (in Japanese).

Landscape structural analysis at human scale in a Mediterranean nature park

L. Hadar[1], Z. Henkin[2], I. Noy-Meir[3] and H. Muklada[1]

[1]Ramat Hanadiv Nature Park, P.O.B. 325 Zichron Ya'acov, Israel.
e-mail: liat@ramathanadiv.org.il
[2]Beef Cattle section, Newe-Ya'ar Research Center, Department of Natural Resources, Agricultural Research Organization, P.O. Box 1021, Ramat Yishay, Israel.
[3]Institute of Plant Sciences, Faculty of Agricultural, Food and Environmental Quality Sciences, the Hebrew University of Jerusalem, Rehovot, Israel.

Introduction

Vegetation description at the landscape level often focuses on the botanical elements, such as communities, dominant species and species diversity. However, for management and planning objectives, vegetation units must also be defined on the basis of their structural qualities and with relation to the human scale. Structural criteria relate to basic human needs, such as transparency, accessibility, shade and micro-climate, air and open space. When combined with visual and aesthetic values, they define the extent to which different areas are attractive for human activity (Jacobs, 1993).

Methods

An inter-disciplinary approach to landscape vegetation description was developed and tested in northern Israeli rangelands (Henkin *et al.*, 2007) and then applied to a well managed nature park in the Mediterranean region of Israel. The landscape was described using a set of 'architectural' criteria, by mapping the dimensions, basic shapes, and distribution of gaps between individual plants, to distinguish between areas with different management regimes. The shapes of the trees and the bushes were drawn in situ in order to characterize the various structural profiles of the vegetation.

Application

The Ramat Hanadiv Nature Park is managed as an open space for nature, landscape, public activity, research and education. The park's animal populations are an integral part of the landscape and much effort is invested in their monitoring. An application of the proposed method to the scale of the park will also produce a 'structural vegetation map' to which animal data could be related in a more reliable way.

As the drawing of structural profiles is an intuitive, easy and a 'user friendly' technique, an application of the above method to be used by teachers and high school students was tested and is now widely used in the park.

References

Henkin, Z; Hadar, L & Noy-Meir, I. (2007) Human-scale structural heterogeneity induced by grazing in a Mediterranean woodland landscape. *Landscape Ecology (in press).*

Jacobs, A. (1993) *Great Streets.* M.I.T. Press, Boston.

Impact of agriculture on water erosion and new organization of landscape

I. Šimonides[1], T. Hrnčiarová[2]

[1] Horticulture and Landscape Engineering Faculty, Slovak University of Agriculture in Nitra, Hospodárska 7, Nitra, Slovak Republic,
e-mail: ivan.simonides@uniag.sk
[2] Institute of Landscape Ecology of Slovak Academy of Sciences, Štefánikova 3, P. O. Box 245, Bratislava, Slovak Republic

Conservation of the soil production potential, involves the elimination of the negative processes which can be achieved by several measures: a new structure of crops (distribution of agricultural crops or crop rotation from the aspect of erosion control effects), a change in plot borders, plantations of erosion control vegetation, reductions in slope length, erosion control vegetation belts, the spatial arrangement of vegetation according to runoff relations in micro catchments and stabilization of talwegs.

We studied the erosion processes in detail in the study area of the Smrečianka river catchment in the Liptovská kotlina Basin. It is an intensively used agricultural area with almost no non-forest woody vegetation. The area of agricultural plots varies from 20 to 50 ha; the overall length of the slope reaches a maximum of 800 m. Erosion processes are influenced mainly by slopes length and are only partially modified by changes of use. Relief microforms are other factors causing the concentration of surface runoff, the consequence of which is an increase of erosion processes. Major water runoff takes place during rainstorms forming large erosion rills developing into gullies in the upper part of the slope. From the viewpoint of landscape ecological use, it is necessary to proceed to land use zoning of plots lying above each other, to specify the barrier in order to modify the surface runoff, e.g. to complete also the elements of ecological network and to propose different anti-erosion crop rotations dependent on the limits of erodibility.

This work was supported by the Ministry of Education of the Slovak Republic under the contract No. 1/4404/07 Influence of erosive processes on the agricultural landscape organizational change and No. 2/7027/27 Evaluation of landscape diversity changes and by the Slovak Research and Development Agency under the contract No. APVV-51-035102 Creation of environmental limits for sustainable development (on example of model territories).

Using public inquiries in the validation of expert based landscape assessment: a case study in Southern Portugal: Castelo de Vide

H. Menezes[1], T. Pinto-Correia[2], I. L. Ramos[3]

[1]National Agrarian Station, Quinta do Marquês, Oeiras, Portugal.
e-mail: menezes.helena@hotmail.com
[2]University of Évora, Largo dos Colegiais 2, Évora, Portugal.
[3]CESUR – Technical University of Lisbon, Avenida Rovisco Pais, Lisbon, Portugal.

There is an increasing awareness at the European level (e.g. European Landscape Convention, 2000) of the importance of classification of all landscapes. Public participation can provide more information, to help identify areas of distinctive character and determine key characteristics and special qualities (Bingham *et al.*, 2002). As a result, the understanding of people's relationship with the landscape is required to complement technical characterization.

The goal of this study is to use the public's perception of landscape as the validation of an expert based landscape classification. The case study is the municipality of Castelo de Vide, in the centre of Portugal, near the border with Spain.

The methodological flow applied in this study is represented in the poster. The first phase (Abreu *et al.*, 2004) consists of the interactive combination of literature review, field work, expert judgement and the incorporation of map data. The human experience of the landscape and the opinions and rights of stakeholders, represent relevant topics within the landscape character assessment for further definition of landscape units (Groom, 2005). A photograph based questionnaire was developed, with representative photos of each landscape unit, to understand if the assessment of landscape areas done by experts was consistent with people's perception. The sample (n=30) was stratified according to age, gender, profession/activity and education level.

Three landscape areas have been identified, in which two are sub-divided (total of six landscape areas). In general, the landscape of the municipality is not seen as much widely differentiated. However, the majority of the interviewed people could identify the main visible characteristics of each area. People connected to farming showed more knowledge in issues regarding landscape management, with a finer perception regarding landscape issues. Land abandonment was frequently raised by those interviewed, pointing out the increase of shrubs as the main visual indicator, and the decrease of people connected to farming as the main cause. It was possible to understand which elements were mostly appreciated and valued by the interviewed.

References

Abreu C., Correia, T., Oliveira, R. (2004) Contributos para a identificação e caracterização da paisagem em Portugal continental. DGOTDU, Colecção de Estudos 10, Lisboa.

Bingham L., Parfitt A., Swanwick C. (2002) Landscape Character Assessment Guidance for England and Scotland - Topic Paper 3: Landscape Character Assessment – how stakeholders can help. The Countryside Agency and Scottish Natural Heritage.

Groom, G. (2005) Methodological review of existing classifications. In: Wascher. D.M. (ed). European Landscape Character Areas - Typologies, Cartography and Indicators for the Assessment of Sustainable Landscapes. Final Project Report as deliverable from the EU`s Accompanying Measure project *European Landscape Character Assessment Initiative* (ELCAI), funded under the 5th Framework Programme on Energy, Environment and Sustainable Development (4.2.2).

Saxon cultural landscapes: what amphibians would like most? Getting baseline data for the management of a woodpasture

K. Öllerer, T. Hartel

Institute of Biology – Romanian Academy, Splaiul Independentei 296, Bucharest, Romania, e-mail: evetke17@yahoo.com

Introduction

The *Breite* woodpasture is on a 135 ha plateau, at about 500 m elevation, situated nearby the town of Sighişoara (Transylvania, Romania). A 70 ha area of the plateau is legally protected (IUCN IV) due to the large density of scattered several-century-old oaks (*Quercus robur* and *Q. petraea*, most of the trees being hybrids). The area is currently threatened by desiccation conditions that appeared after fifteen drainage ditches were built in the 1980s, and which led to major decrease of the initial marsh system. The results of the disappearance of former humid areas are: (i) the reduction of spatial heterogeneity, (ii) degradation of the veteran oaks as key determinants of this landscape, and bearers of saxon cultural heritage (iii) reduction of suitable habitat of several species of conservation interest.

Beside the oaks, several plant and animal species of conservation interest are negatively affected by the progressive drainage. It was therefore decided to study amphibians, due to their dependence on the aquatic habitats. Therefore, we've began an amphibian monitoring project in 2003, with the aim to create the basis of a management plan for the whole plateau.

Methods and results

102 temporary water bodies (10 drainage ditches, 20 archaeological ditches and 72 ponds) were studied and eight amphibian species were identified. The water bodies were grouped in three categories, based on their hydroperiod: ephemeral (that dried up in 2-3 weeks after filling up with rainwater), transient (those that dried up once or twice per season) and constant (those that hold water throughout the year in characteristic climatic conditions) (Hartel *et al*. 2005). Large variations were recorded regarding (i) the number of water bodies with reproductive amphibians, (ii) number of water bodies used for reproduction and (iii) the number of water bodies with successful reproduction. Reproductive success was estimated based on the number of water bodies where metamorphosis occured. The number of species breeding in the specific water bodies and the success of reproduction was mostly dependent on the hydroperiod. The percentage of water bodies with successful metamorphosis varied between 0 and 39%. *Bufo bufo*, *Triturus cristatus*, *Pelobates fuscus* and *Hyla arborea* had complete reproductive failures in 2003 and 2004 whereas *Bombina variegata* was the most successful species.

Discussion

Our results show that the most suitable habitats for amphibians are represented by the drainage ditches. Based on the four-year observations we predict that an increased hydroperiod of the existing aquatic habitats will positively influence the amphibian community, both through increases in the reproductive success and in the number of species present in specific water bodies. Therefore, the ditch enclosures would be the most suitable management intervention, both for the amphibian community, and would also help regaining the initial marshy characteristic of the plateau, key and necessary action for the maintenance of the veteran oaks and species of conservation interest.

References

Hartel, T., Moga, C.I., Nemes, Sz. (2005) Use of temporary ponds by amphibians in a wooded pasture, Romania. *Biota* **6**: 21-28.

Integrating livelihoods and multiple biodiversity values in landscape mosaics: a new global initiative

P.K. Koponen [1], J-L. Pfund[1], M. van Noordwijk[2]

[1] CIFOR Jalan Cifor, Sindang barang, 16680 Bogor barat, indonesia . e-mail: p.koponen@cgiar.org
[2] ICRAF Jalan Cifor, Sindang barang, 16680 Bogor barat, Indonesia.

Introduction

Conventional approaches to biodiversity conservation are still mainly based on the segregation of protected areas and biodiversity corridors from the surrounding landscape. The joint CIFOR-ICRAF Biodiversity Platform aims to promote flexible and broadly applicable approaches for integrating livelihoods and biodiversity conservation (Pfund et al 2006). In a new project, our objective is to find negotiated ways to combine local resource use and global conservation objectives in forest landscape mosaics of five main sites (Cameroon, Indonesia, Kenya, Laos, Madagascar).

Objectives and approach

The aim is to design desirable multifunctional landscape states in a participatory and bottom up process, and to negotiate the needed changes of social, economic and ecological conditions towards such states. Key elements of the project are 1) analyzing the driving forces that have influenced conservation and development at the landscape level, 2) assessing the current biodiversity and livelihood values of local and external key actors, local rules, how local rules are incoporporated into customary and regulatory frameworks and potential incentives for biodiversity conservation, 3) projecting and negotiating desirable changes and 4) developing commitments to implement measures to change.

In order to have robust information to feed negotiations between local and external stakeholders CIFOR and ICRAF have developed tools, such as Multidisciplinary Landscape Assessment (MLA) and Rapid Agrobiodiversity Assessment (RABA) to assess what, where and why certain land types, species and services are valued (multiple reasons are analyzed in time and space) by the local people and potential environmental service buyers. Chosen research sites are well known and accumulated information is our advantage. Improvements of specific locally and externally identified biodiversity related issues will be studied from the angle of 1) traditional knowledge on biodiversity products, services and related livelihoods 2) incentives and reward mechanisms for biodiversity conservation 3) consideration of local rules and effects of external regulation and 4) understanding and modeling landscape patterns and processes. One of the sites in Jambi province of Sumatra, Indonesia, is presented as an example of what the approach will focus on and how. In Jambi the widespread and ongoing conversion of forest to oil palm and rubber monoculture is resulting in great loss of biodiversity. At landscape level high biodiversity diversity is found in natural forest that mainly remains in national parks and traditional diverse rubber agroforests. Diverse reward mechanisms are sought for biodiversity conservation such as green marketing or improved management and access rights. Sampling of local landscapes will be conducted along a gradient from low to high land use intensity.

References

Pfund J-L; O´Connor T; Koponen P. & Boffa J-M. (2006) Transdisciplinary research to promote biodiversity conservation and enhanced management of tropical landscape mosaics. Lafortezza (Ed) Patterns and processes in forest landscapes, consequences of human management. IUFRO Landscape ecology working party, Locorotondo, Bari, Italy

Arasbaran forest ecological conditions and studying to establish forest park (case study: Ilgineh Chay basin)

M. Akbarzadeh, S. Babaei Kafaki

Islamic Azad University, Science & Research Branch, Tehran, Iran.
e-mail: mandegarana20@yahoo.com

Introduction

Arasbaran is located in the north-eastern part of East Azerbaijan province and due to the increased destruction along time the mountainous forests were converted into a fragile ecosystem**.**

Material, methods and conclusions

<u>Ilgineh chay basin</u>

These forests have special ecological conditions, with a unique fauna and flora. There is also much topographical and climatologically structure in this forest which is different from any another forest structure in Iran. Ilghineh chay basin is the biggest basin of this district, with an area about 58000 ha.

<u>Ecological evaluations for establishing the park</u>

In this study, satellite and field data were used from the study area, and matching these data together, and with a Digital Evaluation Model (DEM), finally 4 points were determined as suitable for the forest paradise park (Makhdum, 1999 & Darvish Sefat, 1990). The total area of the 4-forest Paradise Park is 3000 ha and forest management model is the basis of the study foundation. In this model, each district has segmentation to three main parts; one (part alpha): the regions under protection programs (time of programs in each site is different with another one). Two (part beta): the regions under reforestation and silvicultural growing program, Three (part gamma): the regions under harvesting with secondary, forest production. Time of protection = (Number of trees in each ha * species situation * topographical condition).

References

Makhdum, M.F. (1999). *Introducing a methodology for integration of ecological and socio economic data in regional planning*. The Karolinum Press.Prague: 390-393-414.

Darvish Sefat, A.A. (1990) *Information analysis of a spatial database for ecological land classification*. Tehran University Press, Tehran, Iran

Representing biodiversity: Spatial analysis of multi-taxon species composition in the Netherlands

A. Barendregt, M. Schouten

Department of Environmental Sciences - Utrecht University Copernicus Institute for Sustainable Development and Innovation, PO Box 80115, Utrecht – The Netherlands
e-mail: a.barendregt@geo.uu.nl

Landscape ecology combines the information of physical and biological components in spatial distribution. The analysis of the spatial distribution of biodiversity in combination with environmental variables is crucial to understand the biogeographical pattern and can be applied as effective source of information for nature conservation.

Here, we used species occurrence data of a broad array of taxonomic groups (Syrphidea, Orthoptera, Odonata, herpetofauna and bryophytes) to produce a quantitative classification of the Netherlands. We focused hereby on regions that contain several characteristic species of different taxonomic groups, so-called umbrella regions, as these are the most interesting areas from a conservation perspective.

For each of the taxonomic groups we were able to define regions that are clearly distinct in terms of species composition. However, not all regions comprised characteristic species. We identified five regions that appeared in at least two taxonomic groups and are characterized by a set of unique species (e.g., see fig. 1). Stepwise discriminant analysis revealed significant environmental differences among these five regions.

These five regions each comprise a unique set of species from several taxonomic groups. The combination of these regions covers the majority of the represented species of the studied groups in the Netherlands; these regions represent the characteristic biogeography within the country. Therefore the umbrella regions can play a leading role in future nature conservation planning.

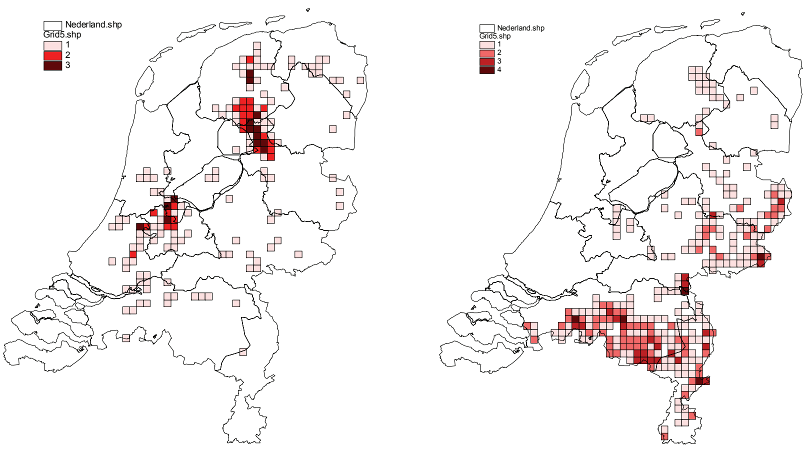


Figure 1. Distribution of two multi-species regions in The Netherlands. Numbers in grids refer to the number of taxonomic groups for which a grid square is identified to the regions: left = peaty wetlands; right = southern sandy soils.

Indigenous landscape conception, management and conservation: lessons for bird conservation from Mexico.

L. Cabrera

[1]McGill University, Department of Geography, Montreal, Quebec, H3A 2K6, Canada.
e-mail: leonardo.cabrera@mail.mcgill.ca

Introduction

Natural resource managers increasingly recognized the relation between biodiversity rich regions and the traditional societies owning and managing them. Few studies have yet investigated what the social-ecological mechanisms are subjacent of this amalgam, especially on reference to bird conservation. This study addresses this gap by examining how local communities are related to the endangered Sierra Madre sparrow's core distributional area, and how these are compatible with bird conservation goals.

Methods

The study employed a combination of ethnographic, participative and ecological approaches to address human-land interactions and their impacts on the bird habitat. Three types of data were generated for this study with local participation: historical (land occupation and demarcation), traditional knowledge (landscape management and social institutions) and ecological (breeding bird habitat suitability).

Results and discussion

Local inhabitants or Momoxcas own a particular ethnic history. They consider themselves direct descendants of the Aztecs and inheritors and defenders of the land. People is geographically and culturally embedded in this landscape. They recognized to own their ethnic identity and survival to the *monte comunal* or communal mountain. For them, "*the monte is everything".* Their conception corresponds with the core fundament of *landscape* as a holistic physical-social entity (Troll, 1938 cited by Bocco, 2007 and see Sauer, 1939). Hence, for Momoxcas, the Sierra Madre Sparrow and its habitat are only part of the landscape and they can not be abstracted for independent scientific conservation purposes.

The bird habitat is a tall bunchgrassland traditionally managed with rotation of fire and grazing to achieve diverse purposes, including pasture renewal, species selection, and prevention of dangerous fires. A rich traditional ecological knowledge system was documented to exist behind these disturbance-based management practices. Through this historical interaction of land dominance and management, the Sierra Madre Sparrow's habitat is renovated and guarded by legitimate land stewards.

Yet what is not clear is for how long this bird will find its last refuge in this land. External conservation interests and perspectives, land use change pressures, and internal land disputes are lessening the social-ecological resilience of this cultural landscape and the conservation possibilities of this vulnerable bird species. What is clear is that collaborative research with the Momoxca is needed to strengthen local organizational capacities and integrate ecological knowledge to impulse adaptive and co-management resource management projects.

References

Bocco, G. (2007). Carl Troll y la ecologia del paisaje. Instituto Nacional de Ecologia, Mexico City, Online publications, retrieved on March 15, 2007 from: http://www.ine.gob.mx/ueajei/publicaciones/gacetas/399/bocco.html#top].

Sauer, C. 1939. Man in nature: America before the days of the white men. A first book in Geography. Scribners, New York.

Soft-system approach to stakeholder participation in landscape planning & management

L.F. Cassar, S. Morse, G.H. Griffiths

Department of Geography, School of Human and Environmental Sciences,
Faculty of Science, University of Reading, Whiteknights, Reading UK.
e-mail: louis.f.cassar@gmail.com

Introduction

Although there is increasing emphasis on the need to involve stakeholders in landscape planning and management, conventional social science methodologies are constraining when addressing complex issues such as landscape. Simple questionnaires and interviews can be limiting in the depth of data acquired, where a complexity of natural, cultural and social elements are concerned. Direct participation and expression may also be difficult for stakeholders. This study presents results derived from research on landscape pressures which used a soft systems methodology (systemic sustainability analysis - SSA) for assessing stakeholder perceptions of landscape threats.

Methodology

Varied groups of key respondents were brought together in three workshop-style fora on the island of Gozo, part of the Maltese archipelago. The respondents were briefed on the SSA methodology, which involves the drawing of 'rich pictures' from which issues are subsequently prioritised (Bell & Morse, 2003). A further stage comprises the identification of appropriate sustainability indicators. The results derived were subsequently used as the basis for a ranking exercise with a wider group of stakeholders (230 individuals). Cards containing photographs that were recognizable and simple to understand were presented to stakeholders, and these were asked to rank the pressures in relation to their perceived importance as agents in changing the Gozitan landscape.

Results

The key respondent groups identified eight key issues affecting landscapes in Gozo, namely urbanisation, quarrying, pollution from agriculture, visitor pressure, hunting & trapping, grazing, landfill, and reclamation, land abandonment & proliferation of alien species. The ranking exercise highlighted urbanisation as the predominant pressure on landscapes, a result common to many Mediterranean landscapes. Key differences between stakeholder groups were also evident.

Conclusions

The methodology utilised was found to have numerous advantages over conventional questionnaires and interviews, as there was enhanced stakeholder participation. The process of drawing 'rich pictures' illustrating the landscape and perceived pressures was met with enthusiasm, and vibrant discussion between stakeholders, and the various 'rich pictures' derived succeeded in presenting a significant depth of data in a simple, understandable format. The subsequent ranking exercise also benefited from the simplicity of the method used. Both methods in turn have much potential for adaptation and use as rapid participatory methodologies for situations where more time-consuming methods may not be suitable.

References

Bell, S & Morse, S. (2003). *Measuring sustainability. Learning from doing.* Earthscan, London.

The Influence of Agricultural Roads and Water Channels on Farm Landscape Structure in Taiwan

Y. C. Chen [1], C. P. Chang [2], Z. F. Wu [3]

[1] Chin-Yi Institute of Technology
[2] Chung-Chou Institute of Technology,–6,Line2,Sec.3,Shan-Chiao Rd, Yuanlin Changhwa.51003, Taiwan.
e-mail: plus311@dragon.ccut.edu.tw
[3] Guangdong Institute of Ecology, Environment and Soil Science

Farmland consolidation has been successfully implemented over 391,000 hectares in Taiwan. The consolidation work established standard blocks and installed agricultural water channels so that each block could be directly connected to road, irrigation, and draining. For this reason, the roads and channels are increasing quickly and that changed the farm landscape structure greatly after farmland consolidation. This study used the network connectivity and circuitry indices of landscape ecology theory to characterize the corridors changing in Liu-Xiang farmland consolidation area, Ping-Dong County, the south of Taiwan. The results revealed that connectivity and circuitry of farm road corridor increased after consolidation, the connectivity from 0.405 to 0.504, and the circuitry from 0.102 to 0.267. These results showed that farm roads brought conveniences and added the paths for people, but disturbed the way other creatures pass through the landscape. The connectivity and circuitry of waterway corridor also increased after consolidation, connectivity from 0.35 to 0.50, and circuitry from 0.to 0.241. The results show that transmission's capability of channel corridors is better for creatures after farmland consolidation. If we used the ecological engineering for water channel and planting extensively in farm roads and banks that will be well for the farmland consolidation areas.

Modelling the impact of agriculture policy changes on farmland birds

T.K. Gottschalk, V. Wolters

Justus Liebig University, IFZ, Department of Animal Ecology, Heinrich-Buff-Ring 26-32, Giessen, Germany.
e-mail: Thomas.Gottschalk@allzool.bio.uni-giessen.de

Our objectives were to forecast and to analyse the effects of agricultural subsidies on faunal richness by applying a spatially explicit biodiversity model to socio-economic scenarios. We exemplarily used changes of the EU Common Agricultural Policy (CAP) from “volume of production dependent subsidies” to "single farm payments".

We used a GIS-based model GEPARD (Geographically Explicit Prediction of Animal Richness Distributions) to estimate the current pattern of bird diversity in different regions of Hesse, Germany, and to predict future avian diversity patterns under land use scenarios based on the CAP policy. The model combines (1) a spatial regression model, (2) maps of spatial resource coverage, (3) quantifications of landscape pattern and environmental factors within different scales, and (4) information from an agro-economic simulation model predicting future spatial patterns of land use. For each study site, the surrounding landscape was analysed within a radius varying from 200 to 1000 m to take into account species-specific differences in the perception of the landscape matrix. Accordingly, simulations were conducted using circular-moving window analysis for landscape metrics. To quantify the impact of a changing agriculture policy, the model was used to predict areas with gains or losses of farmland birds.

The results show that alterations of species richness are caused not only by gains and losses of major land use types but also by overall changes in landscape configuration. The model predicts the breeding population of the skylark *Alauda arvensis* to profit from production dependent subsidies. Population density will even more increase under the CAP reform, compared to the present situation. Total species richness of the avifauna, in contrast, is predicted to decline in many areas under both policy scenarios. In general, however, income support programs allowing farmers to improve environmental performance in specific resource and management settings have a more positive effect on farmland bird diversity than production based subsidies. The spatially explicit nature of the model’s output provides a powerful tool for analysing the current and the future diversity and abundance of key bird species. The model can thus support decision makers and nature conservationists to evaluate trade-offs between economic values and values of nature conservation.

The West Weald Landscape Project, south east England

R.T. Howorth, T. Whitbread

West Weald Landscape Project, Sussex Wildlife Trust, Woods Mill, Henfield, W. Sussex, UK.
e-mail: richhoworth@sussexwt.org.uk

Overview

The West Weald Landscape Project (WWLP) is a partnership initiative working to promote integrated management of a viable and enhanced landscape in the West Weald for people and nature. It focuses on improving wildlife conservation, 'ecosystem service' provision, environmental quality and public involvement in particular. The specific objectives are:

1. Conservation, enhancement and expansion of core areas of ecological interest.
2. Better-connected habitats and species populations across the whole landscape, through improved linkages and less intensive land use and management.
3. Improved and more integrated delivery of conservation mechanisms to support targeted land management to achieve greater environmental improvements.
4. Enhanced public enjoyment, understanding, access to and inspiration from the landscape, with greater provision of local 'sustainable' natural goods and services.

This landscape-scale project covers an area of 240 km^2 in the English counties of West Sussex and Surrey, located at the western end of the clay-based Low Weald character area in south east England. The West Weald Landscape (WWL) is internationally important for nature conservation, a unique lowland environment dating back to the early-medieval period that is one of the best wooded landscapes in the UK (woodland covers one-third of the area). It is thus a rare example of a part-functioning lowland forest ecosystem in Western Europe, as well as being an island of tranquillity in the built-up south east region of England.

Landscape ecology & land management

The ancient semi-natural woodland of the core forest areas in the WWL occur within a surrounding matrix of mostly intensive agriculture, and thus are relatively isolated and fragmented in the landscape. An analysis of functional ecological connectivity is being conducted, based upon the distribution of semi-natural habitat patches and priority focal species (listed under the UK Biodiversity Action Plan), to identify key areas and management options for ecological enhancement. This contributes to a spatial targeting framework being developed for proactive application of state-funded land management schemes, to secure effective measures for biodiversity, the historic landscape and public access.

Research

A comprehensive baseline assessment has been carried out of the West Weald's whole natural environment and peoples' use of it, as a foundation for implementation of the WWLP and to enable monitoring of future change at this landscape scale. Detailed research has been conducted additionally on the provision of 'ecosystem services' by more natural landscapes at the scale of river catchments, establishing links between past land use change and the water environment. This has highlighted impacts on hydrology and water quality from intensive arable agriculture and the potential to reduce flood risk to human populations downstream. Further project studies have assessed the development of pasture woodland from ex-arable land reversion subject to a naturalistic grazing regime, and long-term monitoring of forest dynamics in a minimum-intervention woodland. Project research reports are available at www.westweald.org.uk.

Resolving landuse conflicts through pedogeomorphic knowledge of farmers in Hararghe highlands, Ethiopia

D. Kassahun

Environmental Researcher, Forum for Social Studies (FSS), P. O. Box 25864 Code 1000, Addis Ababa, Ethiopia.
e-mail: daniel_kassahun@yahoo.com

In Ethiopia, the commonest land use conflicts were taking place between the arable and pastoral farming farmers (Tesfaye, 2004). Since recently, however, a new type of conflict has emerged in the Hararghe highlands. This is due to the rapid expansion of Chat (*Catha edulis*), a mild narcotic crop, which is a highly competitive cash crop, affecting the food security through replacing subsistent food crops. While farmers and businessmen want to boost the cultivation of chat, government has been against it, leading to land use conflict. This paper has attempted to trade-off the conflicting approaches through systematic collating of farmers' pedogeomorphic knowledge.

Farmers drawn from sample districts of East Hararghe were involved in the questionnaire-based survey. Attempts were made not only to capture the information on the comparative environmental, economical, and social advantages or disadvantages of chat vis-à-vis food crops, but also to let farmers allot each topographic units with either chat, cereal crop, or the combination there of.

Results of the study shows that chat fulfils the five pillars of sustainability but with a range of suitability to different units of toposequence, called "cathasequence". This is a pattern where the density of chat is getting scanty down the slope while the reverse is true for cereal crops. Such finding logically resonates with the biophysical gradient of pedo-geomorphological models developed by Wrieght (1993), Wilson and Gallant (2000), and Ruhe (1975).

Results of this study would help not only to unravel the emerging landuse conflict, but also to lay the basis for low-tech and site-specific landuse planning in the region. Therefore, experimental-based research is recommended for wider application.

References

Ruhe, R. (1975) *Geomorphology*. Boston: Houghton Mifflin.

Tesfaye, T. (2004) Natural resources scarcity and rural conflict, *Environment, Poverty and Conflict*. FSS Studies on Poverty, Addis Ababa, No. 4, 1-14.

Wilson, J. & Gallant, J. (2000) Terrain Analysis: Principles and Applications. John Willey & Sons, Inc.

Wrieght, L. 1993. *Environment systems and human impact*. Cambridge University Press.

Naturalistic grazing in modern British landscapes

K.J. Kirby

Natural England, Northminster House, Peterborough, UK,.
e-mail: Keith.kirby@naturalengland.org.uk

Introduction

There is increasing interest in Britain in 're-wilding' and naturalistic grazing, where animals live largely free from human intervention (Hodder *et al.* 2005), inspired by the Dutch experience at Oostvaardersplassen and ideas put forward by Vera (2000). Rather than grazing being a tool to achieve specific habitat or species targets, under 're-wilding' scenarios the grazing process itself becomes part of the conservation aim. Primitive breeds of stock (typically cattle) are used as analogues of past natural grazers such as the aurochs.

Key elements of naturalistic grazing are that the animals are allowed to breed, form family groups and may eventually die on site. (In practice welfare considerations mean that animals are likely to be removed from the site before this happens or are humanely killed when 'beyond hope' of recovery.) The populations are resource-limited, rather than kept at prescribed densities and fluctuations from year-to-year lead to variations in grazing pressure.

Factors to consider under British conditions

The outcome of 'naturalistic grazing' is unpredictable: it may or may not produce the type of mosaic of open and closed habitats suggested by Vera (2000); or as seen in the New Forest (Hampshire) which is a managed grazing system. Habitats and species currently on the site may be lost. Conflicts may arise with landscape and cultural heritage interests.

The reserves must be large enough to sustain all-year grazing of sufficient animals to allow social groups to form. Cattle and other domestic stock, even if allowed to run wild are still subject to health and welfare legislation, which means that leaving the animals completely alone is not an option. Often the sites being considered for such trials are also open to public access, such that human health and safety is also an issue.

Active management or rewilding?

Large herbivores can play a key role in large-scale conservation schemes; they are likely to contribute to creating and maintaining habitat mosaics. By reducing the level of intervention, i.e moving towards more naturalistic grazing systems, we may create systems that are more resilient in the face of environmental change. However Britain is a predominantly cultural landscape and over much of the countryside, including most sites protected for nature conservation, active, targeted management is likely to be the normal approach to meeting our conservation aims.

References

Hodder, K.H., Bullock, J.M., Buckland, P.C. & Kirby, K.J. (2005) *Large herbivores in the wildwood and modern naturalistic grazing systems*. Peterborough: English Nature (Research Report 648).

Vera, F.W.M. (2000) *Grazing ecology and forest history*. CABI, Wallingford.

Are traditional and new planted hedgerows part of the sustainable development of agricultural landscapes?

A. Lotfi, F. Burel

Ecobio, CNRS-Université de Rennes 1, campus de Beaulieu, 35042 Rennes cedex, France, e-mail : ali.lotfi-jalalabady@univ-rennes1.fr

Introduction

Typical agricultural landscapes of western France called"bocage". They are constituted of hedgerows networks limiting pastures and corps parcels. In these landscapes hedgerows have been used for a long time, they produce wood for timber and energy and provide many services to farmers (Baudry *et al*., 2000, Burel and Baudry, 1995). In recent decades agricultural intensification has led to a drastic decrease of these elements in most of European agricultural landscapes (Baudry and Jouin, 2003).

We study the effects of these changes on fire wood production as a mean to assess sustainability of the current landscapes. Our objectives are to understand the spatio-temporal distribution of pruning, its recent changes and its relations with landscapes characteristics.

Methods and study area

The study area is situated in northern Brittany, France and is a long term ecological site. In order to test differences among landscapes, we chose three sites (650 ha to 1800 ha) that differ in hedgerow density and agricultural characteristics. For study the changes of hedgerows (identification of pruning or coppicing of all the hedgerows and their date), the aerial photos at scale of 1:10 000 acquired yearly on the study site during 10 years (from 1996 to 2005) were used.

Results

At the level of landscape, our results indicate that there is a relation between the presence of the hedgerows, their management and the land use type of the adjacent parcels. Around pastures there are more hedgerows than around the cultivated lands. On the other hand, the hedgerows surrounding the cultivated fields are pruned more often than around the pastures. Time between two pruning increase, as most of the hedgerows were not managed during the surveyed period.

At the farm level, a study of 18 farms shows that there is no relation between the existence of the hedges, the rate of pruning and the type of farming system. There is a significant relation between the rate of the pruned hedges and the use of wood to heat house.

Conclusion

In spite of importance role of hedgerows in agricultural landscapes, they are the threatened elements in these landscapes. Agricultural intensification, mechanization, changes in management techniques and rhythms are a threat for these landscapes. new planted hedgerows have to be integrated within this new socio-ecological context.

References

Burel, F. & Baudry, J.(1995). Social, aesthetic and ecological aspects of hedgerows in rural landscape as a framework for greenways. Landscape and urban plan. 33, 327-340.

Baudry, J; Bunce, R.G.H. & Burel, F.(2000) Hedgerow: an international perspective on their origin, function, and management. J. Environ. Manage 60, 7–22.

Baudry, J.& Jouin, A.(2003). De la Haie Aux Bocages.Organisation, dynamique et gestion, INRA, Paris

The spatial plan as instrument for protection of the underground water basin

S. Hadzi Pecova[1], P. Penev[2], K. Taleska[3]

[1] Faculty of Agricultural Sciences and Food, University "St. Cyril and Metodius" Skopje, Bul. A. Makedonski bb, 1000 Skopje e-mail: stefanka@zf.ukim.edu.mk
[2] Ministry for Local self government, ul. Dame Gruev 14, 1000 Skopje
[3.] Faculty for Natural Sciences and Mathematics, University "St. Cyril and Metodius" Skopje, Gazi Baba bb, 1000 Skopje

Environmental protection and conservation of natural resources could be efficiently managed through development of spatial plans. Ministry of Environment and Physical Planning in the Republic of Macedonia initiated and conducted development of the Spatial Plan for the protection zones of the spring Rasche, which is the main water supply source for Skopje, the capital of Macedonia and above 500.000 inhabitants.

Spatial plan of the Rasche groundwater aquifer and adhering protection zones subsequently defining four grades of protection regimes (2003) encompass several municipalities. Using predominantly hydro-geological criteria (permeability of the subsoil as well as geological features allowing for migration of pollutants), the Plan has distinguished four areas of different vulnerability; accordingly, four protection regimes setting certain development indicators and thresholds have been established.

Spatial development, environmental and natural resources management have been recently delegated as a new duty to the local administration. Consequently, municipalities are solely responsible for the implementation of the Spatial Plan. It would require local governments to adopt the action plan, and to establish an institutional mechanism for inter-municipal cooperation, originating from the regional character of the protected area. Local Self Government is not yet prepared to cope with delegated responsibilities and with the environmental management in particular. Dynamic changes in the national legislation towards aligning with the EU requirements can not be followed by the current local capacities. This point out the discrepancy between national policies for environmental protection and relatively low capacities of the local self government to implement locally concrete measures in line with broadly recognized national priorities. In the article the policy for spatial development combining restrictive and stimulation measures towards ensuring appropriate protection regimes for the groundwater aquifer of the spring Rasche are presented.

References

Public Enterprise for Spatial and Urban Plans, (2003), *Spatial Plan of the Protected Zones of Rashche Source,* Government of the Republic of Macedonia.

Public Enterprise for Spatial and Urban Plans, (2004), *Spatial Plan of the Republic of Macedonia*, Government of the Republic of Macedonia.

Institute for Spatial Planning, (1986), *Spatial Plan of the Polog Region - municipalities Tetovo, Gostivar, Debar*, Government of the Republic of Macedonia.

What is the role of riparian areas set aside from production in a large-scale industrial tropical plantation landscape in Riau, Sumatra for vegetation and primates?

P. Koponen[1], R. Nasi [1,2], J.G. Poulsen[1], M. Buitenzorgy[3], W. Rusmantoro[4]

[1]CIFOR, Bogor Barat 16680, Indonesia,
e-mail: p.koponen@cgiar.org.
[2]CIRAD, Montpellier, France [3]University of Wageningen, The Netherlands [4]Lantana, Indonesia

Introduction

At present more than 2 million hectares across Indonesia are in fast growing plantation forests and 9 million hectares are targeted for plantation development (FWI/GFW 2002). In Indonesia plantations are generally consist of large mono-specific blocks interspersed with natural forest remnants. The extent of these forest remnants vary and legislation for sustaining the ecological basis of plantation establishment is fragmented and/or left to the interpretation of the plantation companies. In Riau, Central Sumatra, the Tesso Nilo natural forest complex represents one of the large intact diverse rain forests remaining on the island of Sumatra (Gillison 2001). Our study comprises off three large scale industrial *Acacia mangium* plantation sectors bordering Tesso Nilo, with average of 18 % of their area being set aside from production, mainly as natural riparian forests protecting the riparian areas.

Methods

We sampled natural vegetation diversity in the Baserah sector (systematic sampling of set aside areas, involving a total of 347 plots measured giving a sampled area of 0.14 ha, 0.9 ha, 3.5 ha and 13.9 ha for seedlings, saplings, poles and trees respectively), Tesso Nilo National Park (29 plots, area of 0.012 ha, 0.07 ha, 0.3 and 1.6 ha respectively) and examined patterns of primate species richness and abundance using transects in set aside and in planted areas in three plantation sectors. Results were analyzed in relation to spatial arrangement and dimensions. We tested the hypothesis that patterns of primates are independent of connectivity, width, distance to roads, crown closure, age of neighbouring plantation stands and height, respectively, riparian forests set aside from plantation.

Results and discussion

Natural forest remnants inside plantations may, if appropriately designed, be used to mitigate the negative impact of large scale industrial plantations on biodiversity by providing some degree of connectivity with and between remaining natural forest patches (MacDonald 2003). With eight species of primates and more than 250 tree species recorded from riparian forests, set aside areas inside plantation are comparable with primate diversity to Tesso Nilo, but have lower tree diversity. Primates were not abundant in any of the *A. mangium* plantation stands, irrespective of stand age, size and location. They were only observed in riparian forests that were connected to either a larger conservation area inside the concession or other natural forest areas. A well-connected network of natural forest corridors is of critical importance to maintain primates in such landscapes. This study provides a rigorous baseline data but further monitoring is needed

References

FWI/GFW (2002) The state of the forest: Indonesia. Forest Watch Indonesia and Washington DC: Global Forest Watch, Bogor.

Gillison, A.N. (2001) Vegetation survey and habitat assessment of the Tesso Nilo forest complex. WWF-US, Pekanbaru.

MacDonald, M.A. (2003) The role of corridors in biodiversity conservation in production forest landscapes: a literature review. *Tasforests* 14:41–50.

One step back, one step forth: agricultural expansion and landscape change trajectories in shifting cultivation system of Southern Cameroon

V. Robiglio, F. L. Sinclair

University of Wales, Bangor, Gwynedd, UK.
e-mail: v.robiglio@yahoo.fr

Forests in the Humid Forest Zone (HFZ) of Cameroon are encroached by logging and small-scale farming. Local land users combine shifting cultivation with cocoa agro-forestry, gathering of NTFPs, hunting, fishing, and small-scale logging for domestic use. The proportion of land annually cleared for cultivation, its spatial distribution, together with fallow sequence and length affect shifting cultivation landscape dynamics. Here we studied on a fine scale the land cover dynamics in Southern Cameroon. We quantified the impact of agricultural expansion on the landscape pattern of two contrasting villages: the magnitude, spatial configuration and distribution of land-cover transitions and trajectories. We focused on secondary forest regrowth and the patterns of shortening fallows.

Fine-resolution GIS-based models captured Land Use/Land Cover trajectories. Modelling was based on analysis of land-cover patch dynamics over 50 years. An interdependent on-screen interpretation, based on a LCCS-derived hierarchical legend, was applied to historical aerial photographs (1951, 1984) and very high resolution satellite images (Ikonos-2001). Transitions were classified in modification or conversions depending on the distance between classes in the legend frame. Patch trajectories were defined from the sequence of classifications as either agriculture or forest for each observation date. The relation of the spatial pattern of trajectories with locational factors was assessed (distance from the residential unit-accessibility, distance from watercourses, distance from already farmed fields).

Quantitative analysis of transitions highlighted an intense clearing/secondary regrowth dynamic, and a significant shortening and intensifying of fallow rotations. Forest loss rates increases but not due to an increase in primary forest clearing. Spatial analyses of transitions and trajectories highlighted the fine-grained fragmentation of land cover dynamics in our study. Similar contiguous processes aggregate, originating wider patches. These are mosaics of farmed fields or fallows in the same cohort.

In Akok, the southernmost village, a balance existed with intensification and shortening fallow cycles on already cleared areas, yet long cycles of secondary vegetation regrowth in fallow areas and little change in primary forest. In Awae, the more accessible village, continuous clearing has almost exhausted all natural old growth forest with little secondary forest regrowth. Land Use / Land cover trajectories present different spatial patterns. For example stable agriculture patches are rarer with increasing distance from the village but average patch size is constant. Forest regrowth patches are larger with increasing distance from the village.

These aspects are relevant for integrating macro and meso-level assessments of deforestation in Central African forests and for evaluating the potential of shifting cultivation landscapes in providing ecological and environmental benefits for local communities and of global environmental services.

Future research

Influence of fragmented landscape structure on secondary vegetation processes will be assessed through patch level vegetation analysis in two1 Km^2 quadrates per village (45 sampling plots per quadrate along ideal transects crossing bordering vegetation units). Information on local ecological knowledge, on locational properties of land cover units that influence farmers' decision-making, on land use practices (e.g. fallow management) as well as on tenure and demographic dynamics over time will be integrated into a panel data set for the analysis of dynamics at the plot level.

Rationalising biodiversity conservation in dynamic ecosystems (RUBICODE project)

P.A. Harrison[1], R. Bugter[2], RUBICODE partners[3]

[1] Environmental Change Institute, Oxford University Centre for the Environment, South Parks Road, Oxford OX1 3QY, UK.
e-mail: paharriso@aol.com
[2] Alterra, P.O.Box 47, 6700 AA Wageningen, The Netherlands.
[3] see www.rubicode.net

Rationalising Biodiversity Conservation in Dynamic Ecosystems (RUBICODE) will review and develop concepts of dynamic ecosystems and the services they provide. Nature is fundamentally dynamic, as are the pressures of human activities on biodiversity, yet most conservation strategies focus on protected areas and are still developed around a static view of nature. For the realisation of future conservation objectives it is critical that new strategies and policies incorporate these dynamics. RUBICODE will address this by developing innovative concepts for conservation strategies that concentrate on managing dynamic ecosystems for maintaining their capacity to undergo disturbance, while retaining their functions, services and control mechanisms (ecological resilience; Gunderson (2000)).

Our approach in developing concepts of dynamic ecosystems and the services they provide is based on a new category of population, the Service Providing Unit (SPU), which provides a recognised service at some temporal or spatial scale (Luck *et al.*, 2003). For example, if the service is conservation of a rare insect, the SPU would be the population of its host plant present in suitable habitat in the area over which special conservation measures are required. SPUs often comprise more than one species and any given species may contribute more or less than another species to a given service. They may also contribute to more than one service or be antagonistic to another service (termed Service Antagonizing Units (SAUs)). For example, wild flowers may support crop pollinators and biocontrol agents, but also harbour pests or compete directly with crops. Quantifying the potential positive effects of biodiversity on a service should involve the subtraction of the effects of SAUs. Additionally, one person's SPU may be another's SAU and thus, stakeholder involvement in the process is required from an early stage.

The SPU/SAU concept provides a framework for linking changes in key characteristics of populations with implications for service provision. Indeed, identifying quantitative links between components of ecosystems and service provision is crucial to providing specific rather than vague management guidelines for policy makers and land managers. Relationships between SPUs and socio-economic and environmental drivers of biodiversity change are being evaluated in case studies covering the main ecosystem service categories of the Millennium Ecosystem Assessment across multiple scales. Methods for linking biodiversity traits to service provision and for improving and testing indicators are being developed and used to explore effective management strategies for the SPUs and to inform priorities for biodiversity conservation policy. RUBICODE will also identify current gaps in knowledge and propose a roadmap for future research.

References

Gunderson, L. (2000) Ecological resilience - in theory and application. *Annual Review of Ecological Systems* **31:** 425-439

Luck, G.W.; Daily, G.C. & Ehrlich, P.R. (2003) Population diversity and ecosystem services. *Trends in Ecology and Evolution* **18:** 331-336.

EucaLand European Culture expressed in Agricultural Landscapes

G. Pungetti[1], A. Kruse[2]

[1] CCLP – Cambridge Centre for Landscape and People, 9 Selwyn Road, Cambridge CB3 9EA, UK,
e-mail: gp114@cam.ac.uk
[2] BfLS – Bureau for Landscape & Services, 162 Av. de Paris, 92320 Châtillon, France,
e-mail : Landschaft@BfLS.de

Land use is interlinked with the culture and history of its society, and the Agricultural Landscape (AL) is the one of most evident expressions of it. Valuable and typical ALs are part of European heritage and character. Explaining this character makes people aware of their landscapes and helps in turn to foster a European identity. Without this, future generations will perceive ALs from a mere industrial land use point of view and will abandon them losing identity.
Agricultural landscapes are indeed expression of our identity and heritage, and yet retain ecological values and play an important role in sustainable development. However they are currently mostly considered as places for production. To overcome this limit, EucaLand has been set up with the following goals:

- To consider the European Agricultural Landscapes (EALs) as part of our cultural heritage, including their values and meaning for the Europeans;
- To describe past and present EALs for a common classification;
- To produce recommendations on alternatives to deal with future EAL, culturally and sustainably oriented, addressed to scientists and planners, but also to policy makers and especially to the European public.

EucaLand unites a large network of research departments and institutes with interdisciplinary and intercultural vision: more than 40 partners from over 30 countries have already started to work together towards a Pan-European description of EALs history and types, raising awareness on the cultural values of EALs and constructing a website to disseminate the finings. Links with the CoE European Landscape Convention, UNESCO World Heritage Centre, ECOVAST, FAO, WWF and IUCN are established.

The EucaLand network aims to disseminate knowledge on EALs, and in particular to:

- **Scientific experts and cultural operators**, which will gain know-how in disciplines not directly linked to heritage preservation but essential for it;
- **The public**: people living and working in the countryside, which can become familiar and aware of EAL heritage;
- **Authorities**: institutions at different levels dealing with agricultural land and its development, which will benefit of cross border connection of regions of same AL type;
- **Economic sectors**: people in disadvantaged areas, land owners and land developers from public and private sectors, and local tourism in the agricultural countryside, which will be able to use the EucaLand toolkits and recommendations;
- **CAP**: the Common Agricultural Policy will benefit of an elaborated concept on AL, including guidelines to address their specific values and types. The EucaLand findings can assist the development of a more rationalised agricultural policy, regarding AL as part of our common and valuable cultural heritage. Therefore a strong link of each partner to its agricultural ministry is envisaged.

Landscape context affects the abundance & diversity of bees on annual crops in Europe

G. Carré[1]*, B.E. Vaissière[1], R. Chifflet[1], N. Morison[1], R. Bommarco[2], S.G. Potts[3], S.P.M. Roberts[3], G. Rodet[1], J. Settele[4], I. Steffan-Dewenter[5], H. Szentgyörgyi[6], C. Westphal[5], M. Woyciechowski[6] and P. Roche[7]

[1]INRA, UMR Ecologie des Invertébrés, Avignon, France. e-mail: carre@avignon.inra.fr
[2]Department of Entomology, Swedish University of Agricultural Sciences, Uppsala, Sweden.
[3]Centre for Agri-Environmental Research, University of Reading, UK.
[4]Umweltforschungszentrum–Centre for Environmental Research, Halle, Germany.
[5]Department of Animal Ecology, University of Bayreuth, Bayreuth, Germany.
[6]Institute of Environmental Sciences, Jagiellonian University, Krakow, Poland.
[7]CEMAGREF, Aix en Provence, France.

Introduction

Bee populations are declining worldwide (Biesmeijer *et al.* 2006), and this loss may alter the stability of the pollination service bees provide (e.g. Chapin *et al*. 2001). It is therefore urgent to better understand the relationship between bee populations and biogeographic conditions. We assessed the impact of landscape contexts on the abundance and diversity of bees. The same protocol was used in 5 countries over Europe (France, Germany, Poland, Sweden & the United-Kingdom) in order to be able to generalize results on a larger scale.

Methods

Bees in 5 crops (one per country) were sampled over a total of 45 sites x 4 dates in 2005 and a detailed land-use classification was used in a 3 km radius around each study site ((CORINE Land cover database). We extracted landscape parameters (nature & structure) using GIS & specific software (GRASS & FRAGSTAT). Then we used multivariate methods (correspondence, clustering, and partial least-square regression analyses) to quantify the impact of landscape features and geography on the abundance and diversity of bees in Europe at the sub-generic taxonomic level.

Results

Three groups of bees emerged based upon their diversity and abundance patterns (1-Poland, Germany & Sweden; 2-United-Kingdom; 3-France). Overall abundance and diversity were positively affected by some natural habitat, such as transitional woodland-shrub, but also by some urban habitat, such as sport and leisure facilities and crops, such as pastures. But there were differences among the three groups due to the specific habitat response from the bees that dominated each group. We characterized bee groups that were positively affected either (i) only by natural habitat, (ii) only by urban habitat, (iii) by some natural, urban and crops habitats. Despite different pollinator guilds among the countries and crops, the landscape context still had a significant effect on the abundance and diversity of bees.

References

Biesmeijer, JC *et al.* (2006) Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. *Science*, **313**, 351-354.
Chapin, FS *et al.* (2000) Consequences of changing biodiversity. *Nature*, **405**, 234-242.

Landscape organization and plant biodiversity in an intensively used agricultural region of central France

F. Di Pietro

Université de Tours, Equipe Dynamiques Environnementales et Paysagères, UMR 6173, Parc de Grandmont, F-37200 Tours;
e-mail: dipietro@univ-tours.fr.

European agricultural landscapes were shaped by agroecological units, now changing into new landscape units more linked to farms' spatial patterns. Therefore farms, which are main management units, are nowadays also main landscape units and play an essential role in enhancing biodiversity, through agricultural practices of field management and field margins' care. Field margins are a crucial landscape element for supporting biodiversity (Marshall, 2002; Le Coeur et al., 2002). Especially in intensively used agricultural regions, because of the scarcity of grasslands, field margins play a key role in allowing species dispersion and thus in enhancing biodiversity (Petit & Burel, 1998).

In this poster our aim is to outline the results of a several-years research on landscape organization and field margins structure and botanical composition in an agricultural landscape of central France (Gâtine lochoise) (Di Pietro, 2006).

Our objectives are: (i) to study the relationships between agriculture and landscape units, and to understand at which extent farms can represent landscape units, in addition to being management units; (ii) to assess the respective contribution of landscape factors Vs agricultural practices to plant biodiversity of field margins.

Methodology and results

In order to deal with this issue, several units have been studied: farms, fields, field margins. The contribution of many variables to field margins' botanical composition of about 400 margins has been analysed using Canonical Correspondence Analysis (CCA), and has led to a hierarchy of relevant variables.

Among these variables we will focus particularly on land use characteristics including crop rotations and agricultural practices of management of field margins. Their impact over life traits of field margins plants, particularly perennials versus annual weeds, will be examined.

We emphasize the role played by some agricultural variables, especially spatial pattern of farms, farm size, and crop rotations involving grasslands on the one hand, and by some structural parameters such as forest edges on the other hand. The role of landscape factors, such as density and size of woodlots, is suggested. We particularly underline the major effect of farm size over the plant composition of field margins. The increase of field size is a major trend of modern agriculture; its effects over biodiversity, by related loss in habitats and corridors, are known. We suggest that also the increase of farms size has a dramatically harmful impact on biodiversity, because of the more drastic management of field margins that it entails.

References

Di Pietro, F. (2006) Agriculture and biodiversity: assessing the contribution of agricultural and structural parameters to field margins plant diversity. A case study in a crop field region (Centre region, France), In: Meyer BC (Ed). *Sustainable Land Use in Intensively Used Agricultural Regions*, Landscape Europe, Wageningen, pp. 140-151.

Le Coeur, D.; Baudry, J.; Burel, F. & Thenail, C. (2002) Why and how we should study field boundary biodiversity in an agrarian landscape context. *Landscape and Urban Planning* **89**:23-40.

Marshall, E. J. P. (2002) Introducing field margin ecology in Europe. *Agriculture, Ecosystems & Environment* **89**:1-4.

Petit, S. & Burel, F. (1998) *Quelle biodiversité en zone de grande culture ?*, Ministère de l'Environnement et CNRS.

Theme 2: Urban Environment and Transport

2.1 Symposium 2: Efects of roads and traffic on wildlife populations and landscape functions

Effects of wildlife passages on the viability of badger populations in the Netherlands

E.A. van der Grift, J. Verboom

Alterra, Wageningen University and Research Centre – P.O. Box 47, Wageningen, The Netherlands,
e-mail: edgar.vandergrift@wur.nl

Introduction

In the Netherlands badger (*Meles meles*) populations declined rapidly in the 1970s and 1980s. Besides habitat loss and habitat fragmentation, mortality due to collisions with traffic at roads and railroads was found to be one of the main reasons for this decline (Van der Grift et al. 2001). To reduce road-kill and counteract the barrier effect of transport corridors numerous wildlife crossing structures, such as badger tunnels, have been built for badgers since the 1970s in the Netherlands. The use of these structures by badgers has been repeatedly documented. Whether the restored habitat connectivity resulted in an increase in badger population viability is, however, a question that is harder to answer than whether the planned mitigation measures will be sufficient to ensure the survival of (local) populations.

The planned extension of highway 73 will intersect core badger habitat. To prevent habitat fragmentation and an increase in the number of road-kill, a plan has been worked out for mitigating the negative impacts of the new road, including the construction of wildlife passages and fences to keep the animals from entering the road. Furthermore, the plan contained proposals for habitat restoration and the development of small-scale linear landscape elements in order to improve connectivity between foraging areas and sett sites, and to guide the animals to the wildlife passages. Our objective was to assess whether the proposed set of mitigating and compensating measures for the planned extension of highway 73 would be sufficient to ensure the survival of badgers in the area.

Methods

We used the model DASSIM to assess badger population viability after the proposed construction of the southern stretch of highway 73 in the Netherlands. DASSIM is a spatially explicit, dynamic (meta)population model (Lankester et al. 1991). The modelhas the ability to distinguish individual badgers, badger clans, local populations, i.e. clusters of badger clans, in which random mating occurs, and metapopulations, i.e. clusters of local populations, connected by dispersal. Local populations are spatial explicit, which is expressed in differences in the exchange probability between local populations. In addition, differences in mortality probability between local populations due to high or low road densities or differences in traffic volume can be applied. Other characteristics of DASSIM are the inclusion of demographic stochasticity, the ability to distinguish male and female badgers in two age classes (juvenile and adult), and the ability to include knowledge about the social structure of badger populations (Verboom 1996, Van Apeldoorn et al. 1998).

We analysed three scenarios for highway construction, which differ in the amount of mitigation and compensation measures taken, and the expected effectiveness of these measures (100% versus 50% effectiveness, i.e. half the wildlife tunnels cannot be used and half the fences are defective). These scenarios were compared with the situation that no highway is constructed.

Results

The study showed that highway construction is not necessarily bad for the viability of badger populations in the region. That is, if all proposed wildlife passages and fences are constructed and all these measures remain functional, i.e. all wildlife tunnels can be used year-round and fences show no failures. Proper management of measures appears to be of decisive importance to the survival of the species in the region: if only half of the measures is effective the badger population is likely to disappear (fig. 1). If no construction of the highway takes place, and consequently no mitigation measures are installed, expected autonomous increase in traffic volume at local and regional roads would result in high badger mortality. That is why badger population viability is expected to be lower for this scenario than in case the highway, including all wildlife measures, is constructed.

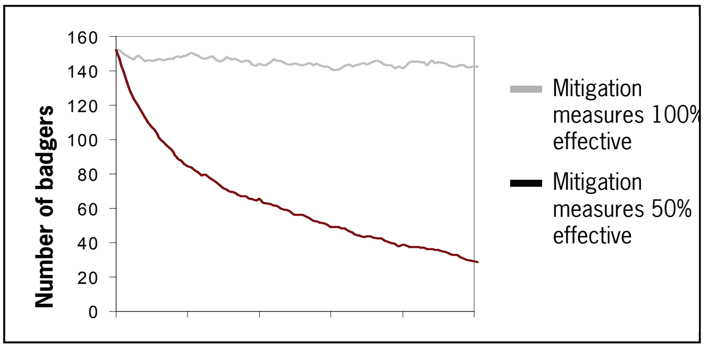


Figure 1. Simulated trends in badger numbers after highway construction in case all mitigation measures (1) or only half of the mitigation measures (2) function well.

Conclusions

Road planning more and more requires the assessment of impacts on nature and the environment. Although impacts on individual animals have to be addressed, e.g. expected road kill rates, more emphasis should be put on the impacts of road construction and road use on the viability of populations. Models and expert systems may be helpful tools to assess population viability. These tools give the possibility to predict changes in viability, or even threats to the (local) survival of a species, before road construction is started and thus may play a key role in comparing scenarios and in decision making.

References

Lankester, K.; van Apeldoorn, R.C.; Meelis, E. & Verboom, J. (1991) Management perspectives for populations of the Eurasian badger (Meles meles) in a fragmented landscape. *Journal of Applied Ecology* **28**: 561-573.

Van Apeldoorn, R.C.; Knaapen, J.P.; Schippers, P.; Verboom, J.; Van Engen, H. & Meeuwsen, H. (1998) Applying ecological knowledge in landscape planning: a simulation model as a tool to evaluate scenarios for the badger in the Netherlands. *Landscape and Urban Planning* **41**: 57-69.

Van der Grift, E.A.; Hoogeveen, Y.R.; Kamphorst, D.A.; Jaarsma, C.F.; Kleijberg, R.J.M.; Piepers, A.A.G.; Snep, R.P.H.; Soesbergen, M.; Veenbaas, G. & de Vries, J.G. (2001) Fragmentation by existing infrastructure. A.A.G. Piepers (ed). *Infrastructure and nature; fragmentation and defragmentation.* Road and Hydraulic Engineering Division, Delft, The Netherlands, pp 47-72.

Verboom, J. (1996) *Modelling fragmented populations: between theory and application in landscape planning.* Institute for Forest and Nature Research, Wageningen, The Netherlands.

Species level differences in the road effect zone of a major motorway for anuran populations in Ontario, Canada

F.Eigenbrod[1], S.Hecnar[2], and L. Fahrig[1]

[1]Geomatics and Landscape Ecology Research Laboratory (GLEL), Department of Biology, Carleton University, Ottawa, Ontario, Canada K1S 5B6
e-mail: felix.eigenbrod@gmail.com
[2]Department of Biology, Lakehead University, Thunder Bay, Ontario, Canada P7B 5E1

Introduction

The term 'road effect zone' (Forman & Alexander, 1998) describes the extent of significant ecological effects from the edge of a road. Anurans (frogs and toads) are known to be negatively affected by roads at the landscape scale (Vos & Chardon, 1998; Houlahan & Findlay, 2003), with the major negative effect of roads on anurans thought to be direct mortality from traffic (Fahrig et al., 1995; Hels & Buchwald, 2001). However, the extent of the road effect zone of a single high-traffic road on anurans has never been quantified.

Methods

We measured the population abundance of seven common species of anurans at 36 ponds located between 50 m and 3600 m from a 60 km section of a major motorway (highway 401) in a rural portion of eastern Ontario, Canada in the spring and summer of 2006. We measured relative abundance as the sum of call intensity indices (scale of 0-3) for each species over 8 nocturnal surveys. For two species (leopard frog *Rana pipiens* and green frog *R. clamitans*), we also included the number of adult frogs seen at each pond as an additional measure of relative abundance. We regressed relative abundance against distance to the motorway using generalized linear models.

Preliminary Results

We found a significant positive relationship between distance from the motorway and relative abundance for three of seven species. All three of these species – wood frog (*R. sylvatica*), spring peeper (*Pseudacris crucifer*), and gray treefrog (*Hyla versicolor*) - showed a threshold-type response within 300 m of the motorway (Figure 1). We also found a borderline significant effect of distance to the motorway for two other species (leopard frog and green frog), but for these species there was gradual decrease in abundance with decreasing distance, rather than the clearly defined road effect zone exhibited by the previous three species. There was no significant relationship between the distance to the motorway and the relative abundance of two other species – American toad *Bufo americanus* and western chorus frog *P. triseriata*. Re-sampling of a subset of the study ponds is planned for the spring of 2007 to confirm that the 2006 results are not simply an artefact of the year of sampling.

Discussion

Our results indicate that the motorway in this study has a severe road effect zone of 300 m for at least three species of anurans. Interestingly, the three species which showed the strongest effect of distance to the motorway – wood frog, spring peeper and gray treefrog – have been previously shown to be relatively unaffected by traffic density in the landscape (Felix Eigenbrod, unpublished data). However, the motorway in this study (highway 401) is unusual in its very high levels of night-time heavy truck traffic. We suggest that the 300 m road effect zone we found for these species may be due to their avoiding ponds near the motorway as the very high noise levels found at these sites may interfere with their nocturnal mating calls. The avoidance of roads with high night-time traffic volumes may thus be another factor besides the well-documented negative effect of traffic mortality on anuran populations in human-dominated landscapes.

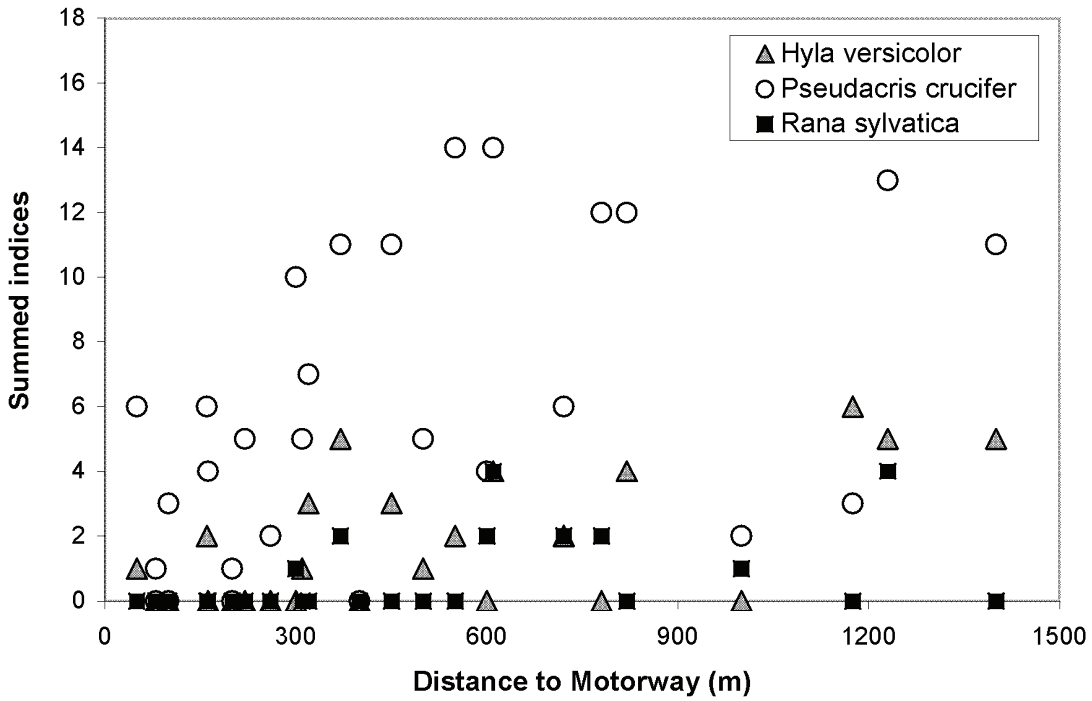


Figure 1: The relationship between the distance of breeding ponds to a motorway and the relative abundance (summed call intensity indices) of three species of anurans.

References

Fahrig, L.; Pedlar, J.H.; Pope, S.E.; Taylor, P.D. & Wegner, J.F. (1995) Effect of road traffic on amphibian density. *Biological Conservation* **73**:177-182.

Forman, R. T. & Alexander, L.E. (1998) Roads and their major ecological effects. Annual Review of Ecology and Systematics, **29**: 207-231.

Hels, T. & Buchwald, E. (2001) The effect of road kills on amphibian populations. *Biological Conservation* **99**: 331-340.

Houlahan, J. E., & Findlay, C. S. (2003) The effects of adjacent land use on wetland amphibian species richness and community composition. *Canadian Journal of Fisheries and Aquatic Sciences* **60**:1078-1094.

Vos, C. C., & Chardon, J. P. (1998) Effects of habitat fragmentation and road density on the distribution pattern of the moor frog *Rana arvalis*. *Journal of Applied Ecology* **35**:44-56.

Effects of traffic infrastructure on patch dynamics

H. Reck, D. Lorenzen, J. Schrautzer

University of Kiel, Ecology Centre, Department of Landscape Ecology; Olshausenstrasse 75;
D- 24118 Kiel (Germany);
e-mail: h.reck@ecology.uni-kiel.de

Introduction

Spatiotemporal interactions between habitats and populations are complex and difficult to communicate especially in planning procedures concerning road traffic. For the analysis of population vulnerability due to traffic infrastructure or to forecast impacts of barriers and compensation measures on landscape level we should combine ideas from the theories about: 1. patch dynamics, 2. intermediate disturbance (both e.g. triggered by migrating megaherbivores) and 3. metapopulations (Fig.1). Regarding those theories, potentials for migration of species strongly determine the functioning of changing landscapes for safeguarding biological diversity. But until today local metapopulations are within the focus of impact assessment at best. Local habitat dynamics are mostly neglected and dynamics of species or habitats on regional level are ignored.

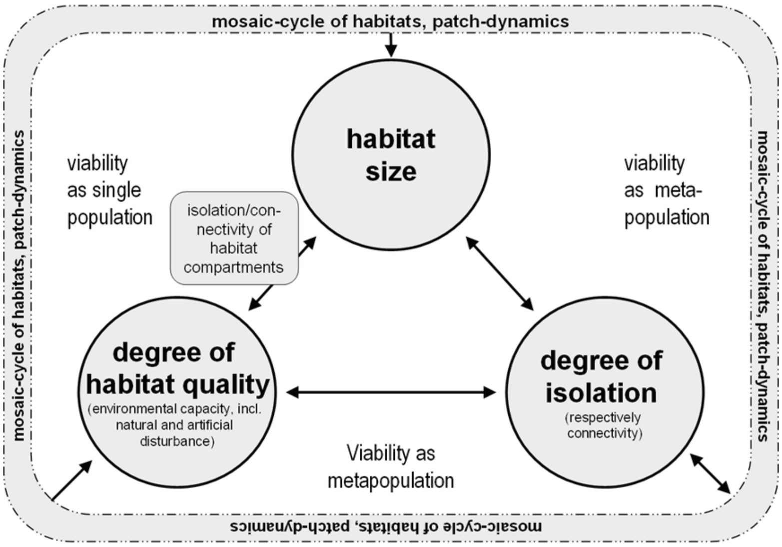


Fig. 1: Conceptual framework; main factors for the spatiotemporal viability of populations

Experiments

To find out how patch dynamics, habitat dependant mobility and barriers could affect each other we use several monitoring projects. Our most integrative investigation started when in 1998 a new habitat corridor of 0,5 km x 8 km, the “Eidertal Valley” (ETV) near Kiel, was implemented as part of the Schleswig-Holstein (SH) ecological network which is thought to compensate large scale landscape fragmentation. SH, the 2nd smallest state of Germany is 15.761 km^2 in size and strongly dissected by traffic infrastructure. The current landscape analysis of Lorenzen shows that 50 % of the SH area is already divided by canals or by roads (with a traffic flow of more than 1000 cars / day) into patches smaller than 30 km^2 and most of the remaining valuable habitats are isolated and enclosed within the smaller patches. Thereby it is noticeable that the size of the remaining undissected areas and their share of valuable habitats are correlated slightly negative.

The investigations in the ETV are combined with experiments on grasshopper dispersal along highways and on overpasses and with the analysis of habitat topology in SH at all.

Results

Looking at processes or on habitat heterogeneity created by species themselves in the ETV we found, that patch dynamics due to disturbance by cattle lead to habitat change and to significantly increased patchiness in all investigation units (between 1999 and 2003 e.g. from 8 to 14 vegetation types per 2500 m^2) while the number of microhabitats increased even more. Consequently the density e.g. of the egg clumps of grasshoppers (mainly the flightless *C. apricarius*) were affected. Disturbance sites near vegetation borders mainly caused by the makrofauna contain on average more than 40 times higher numbers of egg clumps (max. 188 egg clumps / 900 cm^2) than the average grassland and the inhabited area of the respective species has increased about 300 %. Higher grasshopper densities then can affect vegetation structure and plant composition additionally and altogether the resulting patchiness increases grasshopper emigration or dispersal respectively as well as effective immigration. In comparison active grasshopper dispersal across frequently used roads is completely inhibited so that isolated newly developed habitats remain deserted as long as they are not connected e. g. by overpasses. But overpasses without combined landscape development have low effect on insect connectivity again.

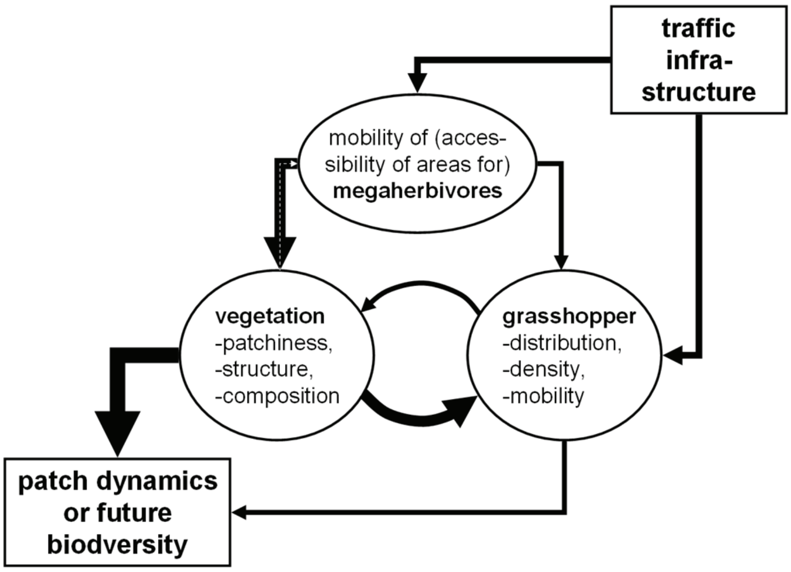


Fig. 2: Cascade or effects due to traffic infrastructure within the examined system

Modelling

Modelling habitat quality and habitat distribution in space and time and regarding the influence of megaherbivores as well as modelling insect dispersal and immigration (as indicator for the possibility of flightless species to react to changing landscapes) we can show

1. the importance of accessibility of areas for big mammals or the importance of high mobility of big mammals between habitats respectively and
2. the long-term risk of species loss on landscape level caused by barrier effects inhibiting adaptive processes and
3. requirements on habitat connectivity in ecological networks.

Thereby we are suffering a lack of information about the barrier effect of roads with low traffic density and about the effects of very narrow linear compound biotopes. But even more important is the lack of information about the quantitative role of free living megaherbivores as vectors for non-vertebrate species and their role as habitat builders since transhumance is obsolete in Central Europe.

Effects of road network density on abundance and road mortality of wildlife populations

I. A. Roedenbeck

Biometry and Population Genetics – IFZ Research Centre for BioSystems, Land use and Nutrition, Heinrich-Buff-Ring 26-32, 35392 Giessen, Germany.
e-mail: inga.roedenbeck@agrar.uni-giessen.de

Introduction

Numerous indices have been developed in the latest past quantifying the degree of landscape fragmentation by roads. One example is effective mesh size m_{eff} (Jaeger 2002), being used in environmental monitoring programmes in Germany and Switzerland (Jaeger 2001). It is argued, that these indices indicate the state of wildlife populations, because local-scale road effects on animals are proven (review in Glitzner et al. 1999, Trombulak & Frissell 2000), and hence, we could extrapolate these results to larger scales and populations. However, this argumentation poses formidable extrapolation problems. Little is known about the landscape-scale effects of roads on wildlife, thus far, and relationships between the values of fragmentation indices and the abundance of populations have not been proven yet.

The aim of our study was to analyse landscape-scale road effects by comparing road network density with abundance and road mortality of wildlife populations. We conducted our study in Hesse, a 21´115 km² federal state of Germany. We used m_{eff} as index for the degree of fragmentation, and official hunting statistics for roe deer to obtain abundances and mortality rates of one of the last remaining mammal species in Germany with a large home range. When conducting the analysis and interpreting the results we were confronted with several problems, which we think are representative for empirical road studies at the landscape scale. This paper should be a starting point for a discussion about how to deal with problems of study designs at large scales. It is alarming that conducting studies and generating results of high evidentiary weight is highly problematic at large scales, although the most pressing policy and management decisions (e.g. decisions about the de-fragmentation of road networks) take place at the landscape-scale.

Results

Landscape fragmentation in Hesse increased seriously since the 1930. The higher road network density in an administrative district the smaller local populations of roe deer (**Fig. 1**). Road mortality rates increased with increasing road network density (for details see Roedenbeck & Köhler 2006). In a multiple regression analysis we included potential roe deer habitat (area of forest, settlements, grasslands and agriculture) to correct our correlations. Following the final model, roe deer abundances can be explained by the amount of forest and settlements per administrative district, but m_{eff} was not included in the final model equation.

Although roe deer populations seem to be larger in non-fragmented forest areas, we cannot say whether this is due to few roads, much forest or the absence of settlements. It is quite obvious that our study design failed to exclude habitat suitability as potential impact factor. However, with the data in hand this was simply not possible. Base unit for regression analysis were highly variegated administrative districts (base unit for hunting statistics), and the small sample size of 27 districts did not allow any further classification.

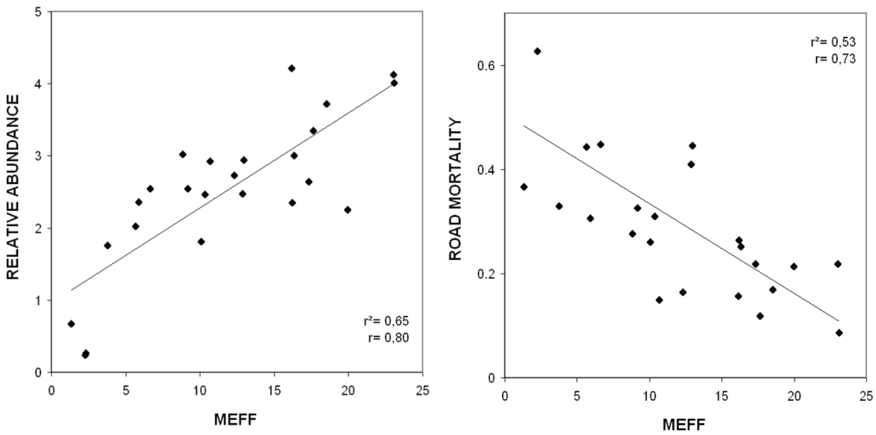


Figure 1. Effects of road network density (effective mesh size) on abundance and road mortality of roe deer in the federal state of Hesse, Germany (published in Roedenbeck & Köhler 2006).

Discussion

We argue that empirical studies about road effects at the landscape-scale are exposed to many problems. First, it is highly problematic to find investigation sites with a comparable amount of habitat. The larger the scale of investigation (e.g. due to dispersal ranges of target species), the more difficult it is to find comparable sites. Second, large investigation areas decrease the sample size. The smaller the sample size, the less replication is feasible, and the lower evidentiary weight of the study results. Third, at large scales the researcher cannot collect data by himself. Consequently, there is an urgent requirement for large-scale, systematic wildlife monitoring programmes. These are seldom available for the species of interest, and often of very low quality. Fourth, studies analysing potential impacts of human activities on the environment should analyse the reaction of populations before and after an intervention. In the context of road ecology this means monitoring populations over several decades following the densification of road networks. But it is impossible to find sites in the landscape, where all other potential impact factors (e.g. development of settlements, intensification of agriculture) were similar over the entire time span of the study. Consequently, results of large-scale studies have to be interpreted with caution, and we urgently have to develop ways to incorporate such results into decision making albeit the inherent limitations.

References

Glitzner, I., Beyerlein, P., Brugger, C., Egermann, F., Paill, W., Schlögel, B. & Tataruch, F. (1999) *Literaturstudie zu anlage- und betriebsbedingten Auswirkungen von Strassen auf die Tierwelt. Endbericht.* Magistrat der Stadt Wien, Abteilung 22-Umweltschutz. „G5“-Game-Management, Graz, 178 S.

Jaeger, J., Esswein, H., Schwarz-von Raumer, H.-G., Müller, M. (2001) Landschaftszerschneidung in Baden-Württemberg - Ergebnisse einer landesweiten räumlich differenzierten quantitativen Zustandsanalyse. *Naturschutz und Landschaftsplanung* **33(10):** 305-317.

Jaeger, J. (2000) Landscape division, splitting index, and effective mesh size: new measures of landscape fragmentation. *Landscape Ecology* **15 (2):** 115-130.

Roedenbeck, I.A. & W. Köhler (2006) Effekte der Landschaftszerschneidung auf Unfallhäufigkeiten und Bestandsdichte und von Wildtierpopulationen. *Naturschutz und Landschaftsplanung* **38 (10/11):** 314-32.

Trombulak, S. C., and C. A. Frissell (2000) Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities. *Conservation Biology* **14(1):** 18-30.

How does the configuration of road networks influence the degree to which wildlife populations are affected by roads?

J.A.G. Jaeger[1]

[1] Swiss Federal Institute of Technology ETH Zurich, Department of Environmental Sciences D-UWIS, Group for Ecosystem Management, Universitaetstr. 22, CHN F 73.2, CH-8092 Zurich, Switzerland.
e-mail: jochen.jaeger@env.ethz.ch

Introduction

Roads act as barriers to animal movement, increase wildlife mortality due to collisions with vehicles, and reduce the amount and quality of habitat (Forman *et al.*, 2003; Jaeger *et al.*, 2005). The persistence probability of wildlife populations in response to increasing road density exhibits a critical threshold above which populations are prone to extinction (Jaeger and Holderegger, 2005). To explore the potential of designing less detrimental road networks such as the bundling of roads and traffic, I used a spatially explicit individual-based simulation model of population dynamics. The purpose of this study was (1) to assess the relative importance of the mechanisms through which the configuration of road networks influences the degree to which roads detrimentally affect wildlife populations, (2) to better understand how this influence depends on the behaviour of the animals at roads, and (3) to identify characteristics of road network configurations that make road networks less detrimental to the persistence of animal populations. My initial expectation was that the effect of a road network on population persistence is the more detrimental the more patches it creates.

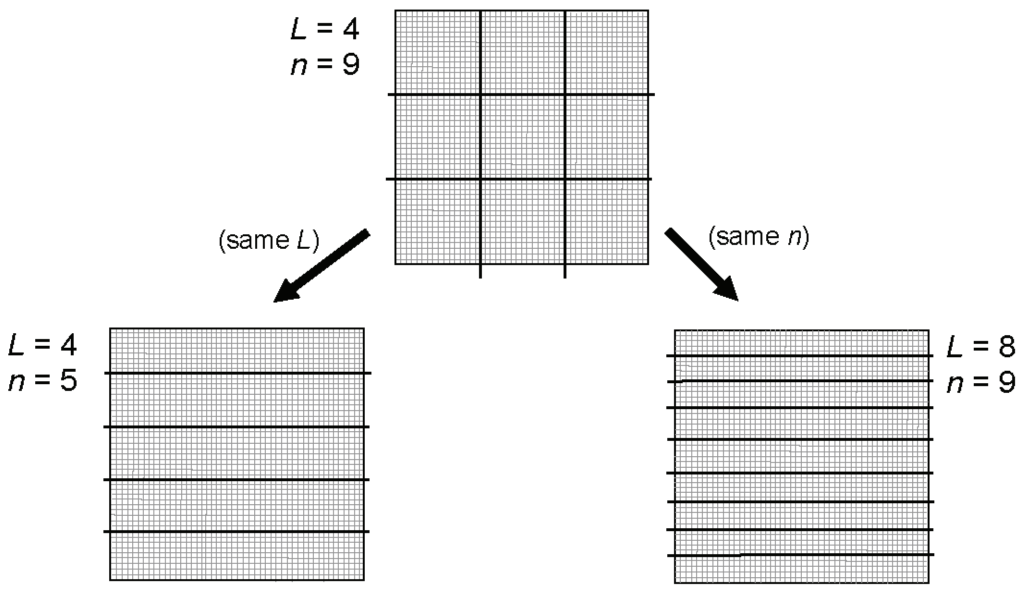


Figure 1. Comparison of the effect of road network configuration (gridded pattern vs. parallel configuration) on population persistence. The roads (black lines) are located between the cells of the landscape model (indicated by the grey lines). L = number of roads, n = number of patches (modified after Jaeger *et al.*, 2006).

Methods

I compared two groups of networks: (1) roads that were evenly distributed across the landscape versus roads that were bundled together in one part of the landscape (close to each other or combining all traffic on one larger road); and (2) a parallel pattern of roads versus a gridded pattern where the patches or “meshes” form a checkerboard (Fig. 1). I recorded persistence probability, times to extinction, and critical road densities in the runs of a stochastic individual-based simulation model of population dynamics (Jaeger *et al.*, 2006).

Results

The model results clearly supported the bundling concept: The overall barrier effect created by a group of several roads bundled together, or by an upgraded road with more traffic on it, was never more harmful to population persistence than the negative effects of an even distribution of roads across the landscape (with the same overall traffic). However, the results for a gridded versus parallel road pattern were surprising: The expectation that fragmenting the landscape into more patches (gridded pattern) would be more harmful to population persistence (while total road length is kept constant) was contradicted by the model results when the degree of road avoidance by the animals was low (and traffic mortality was the most relevant mechanism). Therefore, for animals that do not very strongly avoid roads (e.g., amphibians) it is more important to preserve core habitats at sufficient distances from roads than keeping the number of patches low. For animals that strongly avoid roads, the more relevant mechanism is isolation, and the configuration with the higher number of patches is more detrimental (as expected).

This implies that the relative importance of the mechanisms affecting the persistence of populations strongly depends on the behaviour of the animals at roads, which, in turn, depends on the road characteristics such as road width, traffic volume, and the surrounding landscape. Road network configuration

The results from this model are an important step towards developing a network theory for road ecology and towards the design of less detrimental road networks. Empirical studies comparing landscapes with differing road network configurations (while total road length is constant) should be conducted to validate the model results and provide a basis for developing more practical models for use in planning and designing of highway networks.

References

Forman, R.T.T.; Sperling, D.; Bissonette, J.A.; Clevenger, A.P.; Cutshall, C.D.; Dale, V.H.; Fahrig, L.; France, R.; Goldman, C.R.; Heanue, K.; Jones, J.A.; Swanson, F.J.; Turrentine, T. & Winter, T.C. (2003) *Road Ecology. Science and Solutions*, Island Press, Washington.

Jaeger, J. & Holderegger, R. (2005) Schwellenwerte der Landschaftszerschneidung. *GAIA* **14**(2): 113-118.

Jaeger, J.A.G.; Bowman, J.; Brennan, J.; Fahrig, L.; Bert, D.; Bouchard, J.; Charbonneau, N.; Frank, K.; Gruber, B. & Tluk von Toschanowitz, K. (2005) Predicting when animal populations are at risk from roads: an interactive model of road avoidance behavior. *Ecological Modelling* **185**: 329-348.

Jaeger, J.A.G.; Fahrig, L. & Ewald, K. (2006) Does the configuration of road networks influence the degree to which roads affect wildlife populations? C.L. Irwin, P. Garrett & K.P. McDermott (Eds). *Proceedings of the 2005 International Conference on Ecology and Transportation (ICOET)*, Center for Transportation and the Environment, North Carolina State University, Raleigh, NC, pp. 151-163.

Road effects on wildcats on different spatial scales

N. Klar[1,2], M. Herrmann[3], S. Kramer-Schadt[1]

[1]Department of Ecological Modelling, Helmholtz Centre for Environmental Research - UFZ, Permoser Str. 15, 04318 Leipzig, Germany,
e-mail: ninaklar@gmx.de
[2]Department of Human Biology and Anthropology, Freie Universität Berlin, Albrecht-Thaer-Weg 6, 14195 Berlin, Germany
[3]OEKO-LOG.COM, Hof 30, 16247 Parlow, Germany

Introduction

Once widely distributed throughout Europe, wildcats (*Felis s. silvestris*) have suffered significant reduction in their original range due to extensive hunting and trapping resulting in fragmented and small populations (Piechocki, 1990). Despite a slow recovery of some populations they are still a species of conservation concern throughout Europe (Stahl and Artois, 1995). Their large home ranges and their high mobility make this species highly vulnerable to traffic mortality in areas with a high human population density like in Central Europe. This is especially important since knowledge on population dynamics is limited.

Small scale analysis

For the small scale analysis 12 wildcats were radio-tracked from 2001-2004 along a newly built motorway in Southwest Germany. All road casualties were collected during the study period on a 18 km long section of the road with different fencing (Table 1).

Between 23 and 35% of the estimated wildcat population living along the motorway was killed per year in the sections without the complete wildcat proof fences. The wildcat proof fence was effective. Most individual wildcats did not adjust their home ranges to the major roads and crossed them regularly where possible .

Table 1: Road casualties of wildcats along the motorways A60 and A1/A48 in 2003 and 2004. Three different fence-types are compared.

Type of fence	**Length of road section (km)**	**No of wildcat casualties**	**Wildcat casualties / km / year**
Ordinary wildlife fence	7.5	7	0.41
Wildcat fence without anti-overclimbing	4.0	4	0.44
Complete wildcat proof fence	6.4	1	0.07

Large scale analysis

On the larger scale a dataset of about 2400 wildcat sightings and 350 casualties from 30 years and the whole federal state Rhineland-Palatinate (RLP), Germany was used (Knapp *et al.*, 2000). Habitat models on different spatial scales were built using logistic regression. Sink- and source-like areas were defined from the casualties to sightings ratio and proofs of reproduction.

Wildcats occupy areas characterised by a high amount of forest and a low density of roads and human settlements. Even so, more than 30% of the potential 2000 wildcat home ranges in RLP include major roads like highways and motorways. 45% of the sinks were found in areas with a road density of more than 1.1km/km², whereas only 25% of the sources were found in these areas. The amount of road casualties per kilometre increased with traffic amount (Figure 1).

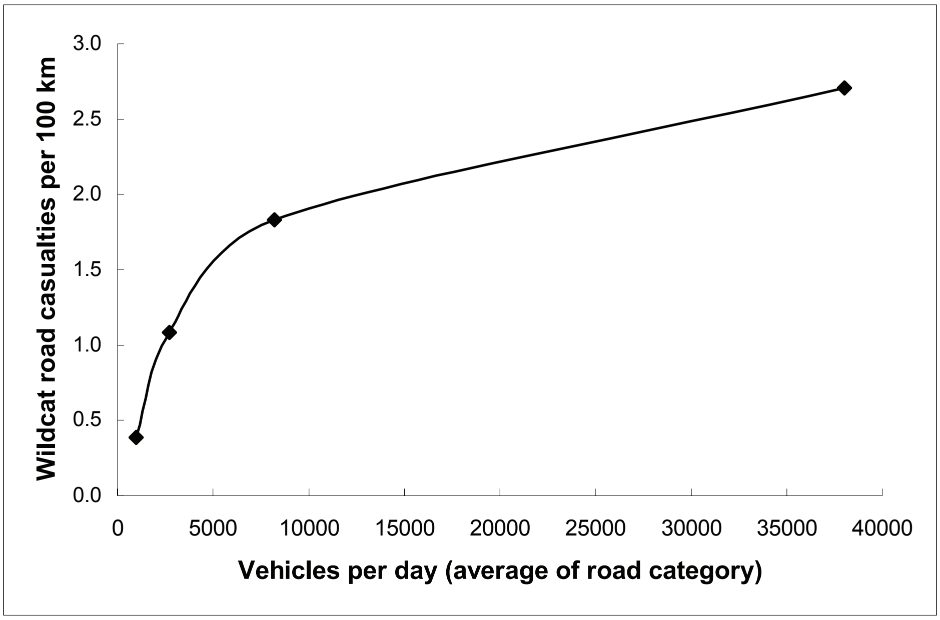


Figure 1. Number of wildcat casualties on different road categories (county roads, country roads, national highways and motorways) with different average traffic amount.

Discussion

Since wildcats, unlike other carnivores (Kaczensky *et al.,* 2003), seem not to adjust their home ranges to major roads, single roads within good habitat can pose a sink-like situation to the adjacent wildcat population. Especially areas with a high road density put such risks to the wildcat population. On average 30% of the wildcats in RLP have to cross a major road on a daily basis. The resulting high mortality rate could be one reason for the extremely slow expansion of this species after the complete protection 70 years ago. So far the lack of information on population dynamics in the wild is a major problem in wildcat conservation and hinders us quantify the risk of road mortality on the population level. Our models can be used to define conflict areas and target roads where wildcat-proof fences together with crossing possibilities should be established.

This work was supported by the Dr. Joachim and Hanna Schmidt Stiftung für Umwelt und Verkehr.

References

Kaczensky, P., Knauer, F., Krze, B., Jonozovic, M., Adamic, M., Gossow, H. (2003) The impact of high speed, high volume traffic axes on brown bears in Slovenia. Biological conservation 111, 191-204.

Knapp, J., Herrmann, M., Trinzen, M. (2000) Artenschutzprojekt Wildkatze (Felis silvestris silvestris SCHREBER, 1777) in Rheinland-**Pfalz.** Oppenheim: Landesamt für Umweltschutz und Gewerbeaufsicht**.**

Piechocki, R. (1990) Die Wildkatze. 1st edn., A. Ziemsen, Wittenberg Lutherstadt.

Stahl, P., Artois, M. (1995) Status and conservation of the wildcat (Felis silvestris) in Europeand around the Mediterranean rim, pp. 76. Strasbourg: Council of Europe**.**

A management dilemma – when habitat for threatened species occurs primarily along and across roads

R. van der Ree[1], C. Stewart[2], S. Cesarini[3], S. McCall[2], A. Hahs[1].

[1] Australian Research Centre for Urban Ecology, Royal Botanic Gardens Melbourne, Care of School of Botany, University of Melbourne, 3010, Victoria, Australia.
e-mail: rvdr@unimelb.edu.au
[2] School of Botany, University of Melbourne, 3010, Victoria, Australia
[3] School of Biological Sciences, Monash University, Clayton, Victoria, 3800, Australia

Introduction

The agricultural landscape of much of south-eastern Australia is characterised by large expanses of cleared farmland, interspersed by a few “blocks” of wooded habitat and numerous linear strips of habitat along roads and watercourses. Dominated by open *Eucalyptus* woodland, these linear strips of vegetation (in many respects analogous to hedgerows and fencerows) represent more than 85% of the available wooded habitat within some regions. For some threatened species, these linear strips are important for their conservation because they comprise a large proportion of the best quality habitat available. Indeed, many recovery plans have highlighted the role and importance of these linear strips and promote their inclusion in the conservation network. However, a potential problem arises when these strips are adjacent to roads and traffic (and cause mortality) or when roads act as barriers that may limit their function as ecological corridors (e.g. van der Ree 2006).

In this paper we have evaluated the importance of the linear habitats for the conservation of the Squirrel Glider, a small arboreal marsupial that is threatened with extinction. We then incorporate the additional effect of roads on the viability of local populations. The overall objective is to synthesise data from a number of different studies and evaluate the trade-off between the habitat function of the linear strips of vegetation along roadsides and the potential negative effects of increased mortality and fragmentation.

Methods and Results

This presentation is the combination of a number of ongoing studies which in broad terms aim to identify and quantify the role and function of roads in the landscape, including their habitat function, barrier effect and cause of human-induced mortality. We have combined radiotracking, repeat trapping, GIS analyses and population viability modelling to investigate this issue.

<u>Habitat</u>

The role of woodland adjacent to roads as habitat for the Squirrel Glider and other wildlife has been demonstrated by extensive trapping and radiotracking previously (e.g. van der Ree, 2002, van der Ree and Bennett, 2003). GIS analyses confirmed that a significant proportion of the best quality habitat for the Squirrel Glider in south-east Australia occurs as linear strips of woodland along roadsides, unused road reserves and watercourses.

<u>Human induced mortality</u>

In late 2005 trapping for Squirrel Gliders was conducted at 9 sites along minor country roads and 12 sites along a major freeway (Hume Freeway with 10,000 vehicles per day, connecting the two largest cities in Australia, namely Melbourne and Sydney), and a subset of 7 of the sites with the highest capture rates were retrapped in late 2006. This allowed us to estimate the difference in annual turnover of individuals at sites adjacent to a busy freeway and along quiet country roads (typically unsealed, with approximately 100 vehicles per day). Annual survival (calculated using recapture histories) along the Hume Freeway was approximately 30%, compared to approximately 50 – 60 % along the minor country roads. Previous capture data and allometric regressions suggest that the likely survival rate for Squirrel Gliders in continuous habitat would be about 50%.

Roads as barriers
Fifty six Squirrel Gliders were fitted with radiocollars and radiotracked for up to 6 months at sites along the Hume Freeway and minor country roads. Squirrel Gliders regularly crossed the minor roads, and only crossed the major freeway when mature trees were present within the centre median. Analyses of gene flow across the freeway are currently underway.

Population viability
Modelling of the viability of Squirrel Glider populations is currently underway. Preliminary results indicate that the increased annual mortality as a result of the Freeway is likely to pose a significant threat to local populations of Squirrel Gliders. However, the extensive network of linear strips adjacent to the highway appears to act as a source population, providing a supply of individuals to fill what may be acting as a sink. Further modelling and field research is required to clarify this.

Discussion

This study confirms that roadside vegetation has an important ecological and biological function. These narrow strips of vegetation support populations of many species, including those of conservation concern. We also show that different parts of the landscape contribute differently to the functioning of populations. Annual survival of Squirrel Gliders was significantly lower when populations occurred adjacent to major roads, when compared with populations along minor unsealed roads. The identification of this potential “source-sink” arrangement is significant because it may cause a rethink in the management of roadside vegetation along major roads. The habitat adjacent to the major roads is high quality, and thus supports (attracts) high numbers of individuals. However, the increased turnover (presumably from increased mortality due to collision with vehicles) may negate its habitat function. Further research is required to clarify the source-sink processes, and its significance for roadside management. The regular crossing (by gliding) of the major and minor roads by Squirrel Gliders demonstrates that they are willing to attempt the crossing. Wide roads that cause treeless gaps of approximately 60 – 80 m or more appear to present a barrier that most gliders are unwilling to cross. In contrast, if trees are provided in the centre median, then regular crossing resumes. However, this provision of trees (and habitat) in the median also increases the risk of collision of gliders with motor vehicles, because more animals are residing close to the road.

References

van der Ree, R. (2002) The population ecology of the Squirrel Glider *Petaurus norfolcensis*, within a network of remnant linear habitats. *Wildlife Research.* **29,** 329-340.

van der Ree, R. (2006) Road upgrade in Victoria a filter to the movement of the endangered Squirrel Glider *Petaurus norfolcensis*: Results of a pilot study. *Ecological Management and Restoration.* **7,** 226-228.

van der Ree, R. and Bennett, A. F. (2003) Home range of the Squirrel Glider *Petaurus norfolcensis* in a network of linear habitats. *Journal of Zoology (London).* **259,** 327-336.

van der Ree, R., Bennett, A. F. and Gilmore, D. C. (2003) Gap-crossing by gliding marsupials: thresholds for use of isolated woodland patches in an agricultural landscape. *Biological Conservation.* **115,** 241-249.

Impacts of roads and development on functional landscape connectivity for wildlife in eastern Collier County, Florida, USA

D. J. Smith[1], R. F. Noss[2], M. B. Main[3]

[1]Western Transportation Institute, Montana State University, Bozeman, MT USA 59717
e-mail: dan.smith@coe.montana.edu
[2]Department of Biology, University of Central Florida, Orlando, FL USA
[3]Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, FL USA

Introduction

Roads are one of the greatest threats to wildlife worldwide. Especially in areas with high traffic volume, strategically placed wildlife crossing structures can assist wildlife to successfully cross highways and maintain connectivity and gene flow within and among populations.
South Florida has experienced explosive growth over the last 25 years with conversion of agriculture and wildlands to residential and urban developments. Population increase over the next three decades is projected to average 29%. Consequences that accompany such growth include construction of new roads and widening of existing alignments, increases in traffic volume, increases in invasive species, rapid levels of habitat loss and fragmentation, and loss of native biodiversity. Evidence of these impending effects is demonstrated by the increase in road mortality of Florida panthers *Puma concolor coryi* and black bears *Ursus americanus floridanus* on rural roads in Collier County. Since 2000, the road mortality rate of Florida panthers on rural roads in Collier County has quadrupled relative to previous decades.
In 2002 a Rural Land Stewardship Area (RLSA) was designated in the northeastern portion of Collier County, which contains approximately 80,743 ha of wilderness and rural agricultural lands. The plan is to preserve 36,344 ha of environmentally sensitive land and maintain approximately 30,279 ha of agricultural land over the next 25 years. Two primary corridors were designated as Habitat Stewardship Areas and include restrictions on development and land use. Concessions given to landowners in exchange for these designations include allowances for increased development densities outside the stewardship areas. The designated habitat corridors were identified by the U.S. Fish and Wildlife Service as key landscape linkages for conservation of the endangered Florida panther. Based on results of our preliminary study, we discuss the efficacy of the plan and potential threats to functional habitat connectivity for the Florida panther and other species by recently proposed developments. We also make recommendations for corridor improvements and road crossings to ameliorate these impacts.

Methods

We used several methods to determine candidate sites for wildlife crossings by monitoring and analyzing wildlife movement patterns along highway corridors (SR 29, CR 846 and CR 858) adjacent to designated stewardship areas. These included roadkill and track surveys, and infra-red camera stations at selected sites. We also synthesized existing data from radio telemetry, roadkill reports, and other studies, and conducted a landscape analysis using GIS.

Results and Discussion

For all road sections, we recorded 67 different species (from Dec 2005 through Aug 2006) from roadkills, tracks, and cameras, categorized by faunal groups that included American alligator, birds, carnivores, ungulates, domestic animals, meso-mammals, small mammals, frogs, snakes, turtles, and river otter. A total of 136 tracks and 73 photos (focal species only:

bobcat, coyote, deer, panther, turkey, and wild pig) and 333 roadkills (all species) were recorded.

We recorded no new roadkills of panthers in our study; yet, many panthers have been killed on these roads in prior years. Nine panther roadkills occurred along CR 846 East between 1993 and 2006. In our study, Florida panther tracks were recorded on this same stretch on five separate dates in April and May 2006; these tracks occurred in the same road segments as previously recorded panther roadkills. Based on roadkill, track, telemetry, and landscape information, six significant crossing areas (landscape linkages) exist along CR 846 East. The most critical for Florida panther is the Okaloacoochee Slough and adjacent upland buffers. Panther roadkills have also been recorded along CR 846 West on either side of the Camp Keais Strand (a large cypress swamp). Several black bear roadkills were also recorded from this general area. Significantly, we obtained photographs of an uncollared panther in this area.

Significant wildlife crossing areas on CR 858 include the area east of SR 29 in the vicinity of the Okaloacoochee Slough. The central portion of CR 858 produced two panther roadkills, and we found a panther track in January 2006 along this stretch. Telemetry data also indicate regular crossings in much of this area, which requires major restoration (conversion of citrus groves) to improve functional connectivity. Also important is the western section of CR 858 along the Camp Keais Strand and adjacent upland buffers. Significant restoration is required to create upland buffers adjacent to the strand to improve the functionality of this corridor.

Other hotspots for Florida panther roadkills are along certain segments of SR 29. Four Florida panther roadkills have been recorded along the north section of SR 29 between 2003 and 2005, and eight panther roadkills were recorded along the south section of SR 29 between 1980 and 2003. Several black bear roadkills were recorded from these stretches of SR 29. An important wildlife crossing area along the north section of SR 29 would connect the Florida Panther National Wildlife Refuge to the Okalaocoochee Slough corridor. Significant restoration is needed in both areas to restore functional connectivity for wildlife.

Based on roadkill locations and other data analyzed in this study, we identified significant sections of each roadway that should be considered for retrofits. To improve habitat connectivity within the RLSA, we propose a system of culverts, bridges, and barrier fences to reduce roadkills and increase the permeability of each road for wildlife. Specific recommendations are located in the final report at http://swfrec.ifas.ufl.edu/pubs/pdf/imok_rpts/wildlife_movement.pdf.

Three critical components are necessary to establish a functionally connected reserve system—core habitat areas of sufficient size, connecting habitat corridors of sufficient width, and buffers that protect the interior quality of the primary network features (core areas and linkages). The study area currently contains several large, protected, habitat-areas patchily connected by extensive wetland corridors (Camp Keais Strand and Okalaocoochee Slough). Road impacts such as wildlife-vehicle collisions, and habitat fragmentation and isolation need to be addressed in plans to protect habitat connectivity if populations of wide-ranging species such as the Florida panther and black bear are to remain viable. We recommend conceptual design improvements to the RLSA habitat corridors that include a tiered-buffer design and the addition of a central travel corridor, with particular reference to the needs of the Florida panther. Implementation of this conceptual design would require restoration of some agricultural areas to native habitat.

Methodological and epistemological constraints on the estimation of the effects of roads on ecosystem function

S. Findlay

Institute of the Environment, University of Ottawa, 555 King Edward, Ottawa, Ontario K1N 6N5, Canada

With the increased interest in the economic valuation of ecological goods and services, there is a corresponding heightened interest in the ecological functions that sustain them generally, and, in particular, the impacts of human activities thereon. De Groot et al. (2002) note that ecological functions are of four general types: regulation functions, production functions, habitat functions and information functions. At issue is the extent to which the construction and operation of roads and road networks affects these functions.

Answering this question is problematic on several counts. First, road construction and operation inevitably results in subsequent modifications to the landscape: forest removal, residential or commercial development, agricultural development, etc., all of which are expected to have independent effects on ecological functions. Thus disentangling the effect of roads and road networks from the subsequent effects of other human activities presents a formidable experimental design challenge.

Second, past road studies have been almost invariably been concerned with the *structural* attributes of communities or ecosystems (e.g. population abundance, diversity, etc.). Yet our interest is in ecosystem *function*, and there is ample evidence that, at least for some important ecological functions, the structure-function link is highly reticulate. Consequently, predicting the impacts of roads and road networks on ecological function from their observed effects on structure will be problematic except in those (probably comparatively rare) cases where the structure-function map is well-characterized,

Third, there is the question of scale and, in particular, the potential divergence of scale of application versus scale of effect. The effect of a road on community or ecosystem structure need not be restricted to locations in the immediate vicinity of a road: if, for example, a road imposes a significant barrier to wildlife movement, the spatial effect may be felt at local to regional scales, especially for populations with metapopulation structure. But for structural attributes, if the (statistical) relationships between local and regional scales is known, then – at least in principle – studies that evaluate local impacts can be used to estimate impacts at larger scales. For ecosystem function, however, this is much more problematic because spatial scaling relationships – if indeed they exists - are, in general, much more poorly described. This despite the fact that certainly there exist ecological functions (e.g. water regulation) for which local disturbance arising from road construction can have both direct and indirect impacts over a range of spatial scales.

From these and other considerations, I contend, first, that for a given experimental design, *a priori inferential* strength (see, for example, Roedenbeck et al. 2007) will inevitably be greater for the estimation of road effects on ecosystem structure compared to ecosystem function, and in some cases, considerably greater. Given that virtually all study designs used to date in road ecology have rather low a priori inferential strength (Roedenback et al.,2007), this implies that even in a Panglossian (experimental) world, the inference that roads have caused (or will lead to) a specified effect on ecosystem function is/will be rather tenuous. This in turn, begs the question of whether such studies are even worth doing in the first place.

Should we then abandon the attempt to estimate the effect of roads on ecosystem function? Not yet. But I contend that the universe of candidate studies worth prosecuting is severely circumscribed along at least two dimensions. The first relates to the nature of the functions themselves: (1) selected functions are those for which there exist strong, well quantified empirical relationships with coarse resolution ecosystem structural attributes (e.g. above ground biomass versus, say, the species-abundance distribution of trees); (2) these structure-function mappings also have known spatiotemporal scaling relationships or, even better, are scale-invariant. These two conditions will allow for the strongest inference from the estimated impacts of roads on ecosystem structure at a given scale, to predicted impacts on ecosystem function at the same – or possibly different – scales. Note that neither of these conditions has anything to do with roads *per se*: indeed, they apply to *any* attempt to estimate the effect of *any* stressor on ecosystem function.

The second dimension pertains to experimental methodology. Specifically, because of the (likely) highly reticulate nature of ecosystem functional response to stress, road studies should explicitly adopt a Bayesian experimental approach (Berry 2006; Stephens et al. 2006;); in which a set of ecosystem functions which differ dramatically in the *a priori* likelihood of being affected by roads, are *simultaneously* considered. The pattern of observed differences between "control" and "experimental" sites over the set of different functional endpoints in relation to the specified prior then provides for a much stronger inference about the impact of roads on ecosystem function because other factors which might give rise to artifactual differences between control and experimental sites for a given function are more effectively controlled through the between-function comparison.

References

Berry, D.A. 2006. Bayesian clinical trials. Nature Reviews Drug Discovery 5: 27-36.

De Groot, R.S., Wilson, M.A and R.M.J. Baumans 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological Economics 41: 383-408.

Roedenbeck, I.A., Fahrig, L., Findlay, C.S., Houlahan, J., Jaeger, J.A.G., Klar, N., Kramer-Schadt, S., van der Grift, E.A. (2007): The Rauischholzhausen-Agenda for Road Ecology. - Ecology and Society 12(1): 11. [online] URL: http://www.ecologyandsociety.org/vol12/iss1/art11/

Stevens, P.A., Buskirk, S.W and C. Martinez del Rio 2006. Inference in ecology and evolution. Trends in Ecology and Evolution. (2006), doi:10.1016/j.tree.2006.12.003

Multi-scale analysis of wildlife crossing structures effectiveness in Spain

C. Mata, I. Hervás, J. Herranz, J.E. Malo, F. Suárez.

Departamento de Ecología, Facultad de Ciencias, Universidad Autónoma de Madrid.
Spain
e-mail: cristina.mata@uam.es

Several studies have dealt with the use by vertebrates and/or failure of wildlife crossing structures (see review in Forman et al 2003). However, few attempts have been made to analyze the question with a wider scope comprising the whole tiered spatio-temporal scales embracing from planning (and its Strategic Environmental Assessment, SEA) to the monitoring of corrective measures, and including the project design phase (and its Environmental Impact Assessment, EIA). Here we present a multi-scale evaluation of the question based on experiences developed by our research group, beginning with the fine scale monitoring of corrective measures for fauna and attempting to foresee up to the effects of strategic plans for infrastructure development along the next decade. It s important to note that only a correct development and coupling of the different levels can lead to an effective long-term conservation of natural systems correctly interconnected at a regional scale.

Our first approach is based on intensive monitoring the vertebrate use of 113 crossing structures of the A-52 motorway (Zamora, North-western Spain) during 2001-2003. From this work we can conclude that i) a large set of terrestrial vertebrate species use crossing structures, with some selection patterns based mainly on structural features of passages. Such patterns seem constant throughout the year while the intensity of use varies seasonally. As a consequence, ii) different crossing structure types play complementary roles in reducing the barrier effect of linear infrastructures. Thus, functional structures as culverts, bridges and underpasses do increase road permeability, at least in locations with low human use. In parallel, structures specifically designed for wildlife play a key role, especially so for the most reluctant species such as ungulates (Mata *et al.*, 2005; in prep). Therefore, the implementation of an integrated set of crossing structures in an infrastructure can be an effective way to maintain connectivity between populations splitted by it.

Widening the scope of our research, we have tested the possibility to predict vertebrate use of crossing structures on an independent motorway 70-300 km away from first one (Mata *et al.*, 2006). Both areas share 80% of the vertebrate fauna and the relative frequency of use by each species of the 5 structure types (including wildlife- and non-wildlife engineered passages) was highly predictable (ANCOVA test, $p<0.001$) and unbiased among species ($p=0.752$). Therefore, we can conclude that selection patterns shown by vertebrates can be generalized and there is a real possibility to predict from the local fauna the type of crossing structures needed by a new infrastructure during its design stage.

From this scale, we go up to the regional level by an analysis of present permeability of linear infrastructures through an analysis of high capacity highways and railways whose projects where passed after 1986. By these means, we focus only on infrastructures subjected to the EU Directive on EIA (85/337/CEE) that include in their design mitigation measures for fauna. So, 200 crossing structures (wildlife specific ones and adapted culverts) from projects scattered through the Spanish territory were visited and checked for their basic features of location, building and maintenance. Several mismatches were detected like the fact that 32% structures defined in projects as wildlife specific were in fact passes of mixed human-fauna use and scarce attention to adaptation for vertebrates. Regarding dimensions, only 40.6% wildlife underpasses and 23.1% adapted culverts meet the minimum requirements established for ungulates (Reed *et al.*, 1975; Olbrich, 1984; Iuell *et al*. 2005). This is rather noteworthy as wild boar (*Sus scrofa*) and roe deer (*Capreolus capreolus*) have wide distributions and represent a serious threat to road/railway safety. Another key point is a deficient revegetation of wildlife passes (both across and around them): only 25% wildlife overpasses and 3.4% wildlife underpasses had been planted with vegetation. Revegetation was almost non-existant in other pass types (over 90% without it) and only 11% adapted culverts had prefabricated concrete walkways above the water level.

As a conclusion, projects under scrutiny showed a trend towards an increased attention to environmental integration of infrastructures, though some recent projects were also found to pay little care to fauna. Moreover, the implementation to the field of corrective measures planned in the design phase shows several deficiencies that should be attended in order to properly minimize the barrier effect on fauna.

Finally, under this framework of mitigation measures in Spain, it is necessary to assess the main points of confrontation among the Spanish Strategic Plan for Infrastructures and Transport ('PEIT 2005-2020') within conservation strategies. On the one hand, Spain faces an expected exponential development of the transport network, with 6,000 km of new motorways and 7,000 km of new high speed railways to be constructed. On the other hand, the country has a social and political commitment with the European Nature conservation policies as the EU action plan to Halting Biodiversity Loss by 2010 and Beyond. As a pinpoint, it has been estimated that at least 180 Natura-2000 sites will be crossed by more than 550 km of high capacity routes. Just this feature helps to clarify the need for a proper evaluation and a coherent policy to balance the confronting interests of transportation and nature conservation. However, the SEA carried out to the PEIT does not analyze in depth but postpones the solution to this situation for later stages of planning and infrastructure design.

As a conclusion, we can state that basic knowledge for the mitigation of the barrier effect of linear infrastructures on fauna exists and it is firmly established at the EIA stage. However, the whole tiered process from planning to the implementation of new infrastructures shows severe deficiencies that mainly affect the two extremes of the process: i) the strategic planning for an environment-friendly development of infrastructures, and ii) the correct development of projects during construction and a proper monitoring and maintenance of mitigation measures.

References

Forman, R.; Sperling, D.; Bissonette, J.A.; Clevenger, A.P.; Cutshall, C.D.; Dale, V.H.; Fahrig, L.; France, R.; Goldman, C.R.; Heanue, K.; Jones, J.A.; Swanson, F.J.; Turrentine, T. y Winter T.C. (2003). *Road Ecology. Science and Solutions*. Island Press, Washington, DC. 479 pp.

Iuell, B.; Bekker, G.J.; Cuperus, R.; Dufek, J.; Fry, G.; Hicks, C.; Hlavác, V.B.; Rosell, C.; Sangwine, T.; Torslov, N.. (2003). *Wildlife and Traffic: A European Handbook for Identying Conflicts and Designing Solutions*. KNNV Publishers.

Mata, C.; Hervás, I.; Herranz, J.; Suárez, F. & Malo, J.E. (2005). Complementary use by vertebrates of crossing structures along a fenced Spanish motorway. *Biological Conservation* **124:** 397-405.

Mata, C.; Hervás, I.; Herranz, J.; Malo, J.E. & Suárez, F. (2006). A step forward in mitigation of fragmentation by highways: predictability of terrestrial vertebrate use of crossing structures. *Conservation Without Borders. 20th. Annual Meeting. Society for Conservation Biology*. San Jose, CA, USA.

Mata, C.; Hervás, I.; Herranz, J.; Suárez, F. & Malo, J.E. (in prep.) Are motorway wildlife passages worth building? Terrestrial vertebrate use of crossing structures and the implications for barrier effect mitigation.

Olbrich, P. (1984). Study of the Effectiveness of Game Warning Reflectors and the suitability of Game Passages. *Zeitschrift Fur Jagdwissenschaft* **30:** 101-116.

Reed, D.F.; Woodward, T.N. & Pojar, T.M. (1975). Behavioral response of mule deer to a highway underpass. *Journal of Wildlife Management* **39:** 361-367.

Road effect on fragmentation of forests and agricultural landscapes: examples from Italy

E. Padoa-Schioppa, M.C. Poggesi, L. Bottoni

University of Milano-Bicocca, Department of Landscape and Environmental Science, – piazza della Scienza 1, 20126 Milano, ITALY.
e-mail: emilio.padoaschioppa@unimib.it

Introduction

Fragmentation is a process that may be defined as "the breaking up of a habitat, ecosystem or a land use type into smaller parcels" (Forman, 1995). It is widely recognized that fragmentation is one of the major causes of the loss of biodiversity (Wilson, 2004). Roads may be barriers and for some species roads verges may act as ecological corridors but the major effect of roads is habitat fragmentation. Far from being just paved ribbons, with a variable width, built to connect two or more areas, roads may affect not only their surroundings but also the "horizontal" processes (water flow, fire spreading, plant dispersal or animal movements) that dynamically contribute to landscape evolution. (Forman & Alexander,1998). Road fragmentation causes biodiversity loss at the landscape level. The effects of roads on animals are registered not only at the individual (traffic casualties) level but, through the alteration of metapopulation dynamics and land transformation, they also affect population persistence (Forman *et al*., 2003).

In Italy were road density and car density reach the highest levels of European Union (Eurostat, 2005) may be useful evaluate the contribute of roads on fragmentation processes.

Materials and methods

Many fragmentation metrics have been proposed by landscape ecologists. We chose to work on three metrics (division, splitting index, effective mesh size and the corresponding auxiliary quantities, coherence, splitting density, net product) based on the probability that two animals randomly placed in different areas somewhere in the region of investigation can find each other (Jaeger 2000).

The use of mesh size and other related metrics is widespread in Germany (Jaeger et al., 2001; Von Roedenbeck et al. 2005) and in other country (i.e. Switzerland and Canada): the application of this metric in Italy too may appear useful.

We analyzed three regions (Lombardy, Sardinia and Piedmont). We divided the regions in ecological units based on river basins (Padoa-Schioppa *et al.* 2006). For each ecological unit we evaluated these fragmentation metrics in forest (in Lombardy also we carried out the same analysis for agricultural landscapes) and then we elaborated a ratio between non-road and road data sets in order to give a quantitative evaluation of the role of road network in landscape fragmentation process.

Results and discussion

Results (see an example in figure 1) show that roads may be the most important cause of fragmentation in many areas: in some ecological units the mesh size changes by 95% when we add the road network. Were data on wildlife are available we were able to evaluate effects on wildlife. As an example, in Lombardy, we observed "winners" and "losers" both for forest and agricultural landscapes. Among winners there are Hooded crow (*Corvus corone cornix*) in agricultural landscapes and starling (*Sturnus vulgaris*) in forest landscapes. Both the species are more abundant in more fragmented areas. Loser birds are species that are more abundant in less fragmented forest landscapes (i.e. the Buzzard, *Buteo buteo* but also wren, *Troglodytes troglodytes,* and robin, *Erithachus rubecola*) or in less fragmented agricultural landscapes (i.e. the Lesser Gray Shrike, *Lanius collurio* and a declining species as sparrow, *Passer domesticus*).

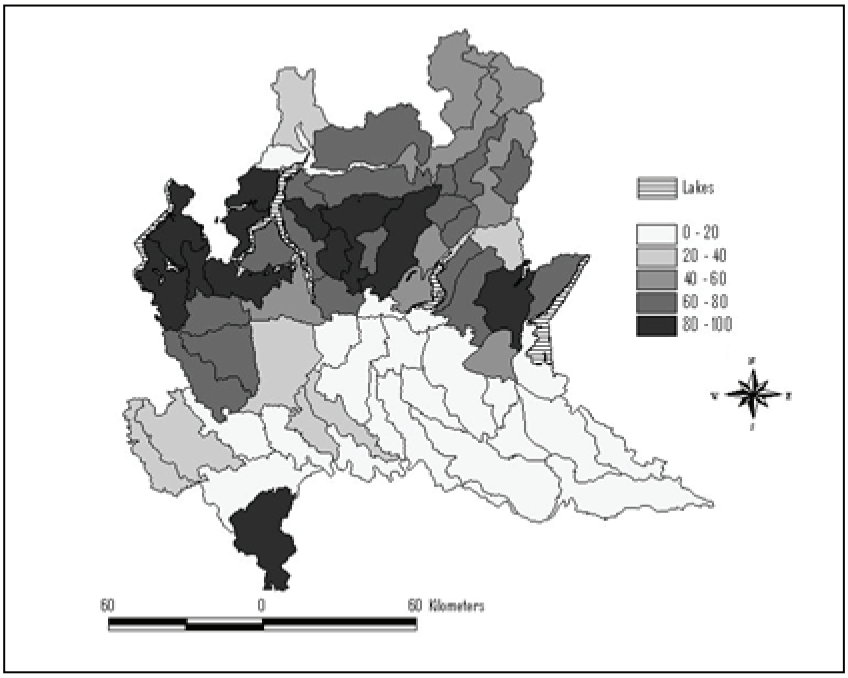


Figure 1. Percentage of forest fragmentation caused by roads in Lombardy

From this analysis river basins appear a good ecological unit and fragmentation of forested and cultural landscapes may be considered an element that contributes to the overall quality of river basins, and may be measured easily by means of mesh size and other related metrics. This approach allows us to identify the main areas where road construction should be avoided. Furthermore we\are allowed to identify ecological units that are most severely affected by road fragmentation and where therefore road construction is more problematic or mitigation measures are needed.

References

EUROSTAT(2005) *Europe in figures. Eurostat Yearbook 2005***.**

Forman, R.T.T., Alexander, L.E. (1998) Roads and their ecological effect. *Annual Review of Ecology and Systematics* **29:** 207-231

Forman, R.T.T., (1995) *Land Mosaics* Cambridge University Press, Cambridge (UK).

Forman, R.T.T., *et al.* (2003) *Road ecology* Island press Press, Washington.

Jaeger, J. (2000) Landscape division, splitting index, and effective mesh size: new measures of landscape fragmentation. *Landscape Ecology* **15 (2):** 115-130.

Jaeger J., Esswein H., Schwarz-von Raumer H.-G., Müller M. (2001) Landschaftszerschneidung in Baden-Württemberg - Ergebnisse einer landesweiten räumlich differenzierten quantitativen Zustandsanalyse). - *Naturschutz und Landschaftsplanung* **33(10):** 305-317

Padoa-Schioppa, E. Poggesi, C., Bottoni L. (2006) River basins as ecological unit to evaluate landscape fragmentation. In Landscape Ecology of Freshwaters

von Roedenbeck I.A, Esswein H, Köhler. W. (2005) Landschaftszerschneidung in Hessen *Naturschutz und Landschaftsplanung* **37(10):** 293-300

Wilson, E.O. (2004) *The future of life*. Knops Publishing Group, New York

Landscape variables determining movements and road crossing by ungulates

J.E. Malo, C. Mata, F. Suárez.

TEG, Grupo de Ecología y Conservación de Ecosistemas Terrestres, Department of Ecology, Universidad Autónoma de Madrid, E-28049 Madrid, Spain.
e-mail: je.malo@uam.es

Ungulates are key elements for landscape function in many ecosystems and they conflict with road/railway function. Therefore, coupling knowledge of patterns of ungulate movement through landscapes, their use of wildlife- and non wildlife-engineered crossing structures is necessary. The main determinants of crossing structure design and location are also needed for correct evaluation of both the extent of the problem and the possibilities for mitigation. Addressing the coherence of information gathered from such different sources would enable a) the statement of the possibility for generalization of patterns, b) the detection of their main inconsistencies and c) the identification of the key points for research at the landscape scale aimed at minimizing the future impact of roads and railways on large herbivores.

The knowledge about patterns of habitat use and movement through landscapes of ungulates has broadened along the last decades thanks to advances of telemetry instrumentation. Habitat selection by most ungulates of concern for road ecology (either due to collisions or to population fragmentation) has been shown to favour forested areas intermingled with scrubs, grasslands and/or crops. Within this mixed habitats, habitat selection at finer scales led to a heavier use of the most productive patches but always in the vicinity to sites with deeper shrub/tree cover that provides protection (potential or effective) from predators (Spitz and Janeau, 1995; Tufto *et al.*, 1996; Licoppe, 2006).

Research carried out independently on animal displacement in the wild has shown biomechanical restrictions imposed by weight playing a key role (Richman and Aitchison, 1981), and that should lead to common trails reflecting minimum cost lines as it has been shown for human mountain paths (Minetti, 1995). Thus, taking into account their weight, ungulate trails are expected to form angles smaller than 10-15º with respect to contour lines except when facing a steep slope.

In short, the studies referred above point to a theoretical location of ungulate trails and thus the ideal location of wildlife crossing structures (or the fatal location of animal-vehicle collision sites) in places that meet the following criteria: i) within forested areas and at a finer scale ii) wherever some habitat heterogeneity exists, specially so iii) in the proximity of forest edges. Moreover, iv) trails most commonly used should connect points with these characteristics through lines of minimum displacement costs, in general flat.

Besides, studies on the location of ungulate crossing of roads are useful for contrasting these patterns. In this sense, it is important to note that animal-vehicle collision sites in Mediterranean patchy habitats seem to be linked to events of ungulate displacement meeting a road (Malo *et al.*, 2004) in a road-avoiding behaviour also described for reindeer under an extremely different situation (Luell and Strand, 2005). The cases when animals move towards roads in search of salt or other benefit are radically different and will not be a focus of the present study.

Models developed to analyze landscape features of ungulate-vehicle collision sites (Malo *et al.*, 2004; Seiler, 2005) support the idea that trails reflect patterns of vegetation and geographical features as pointed above based on habitat selection and displacement costs. Thus, collisions usually happen within forested areas in points with some habitat heterogeneity and where scattered trees or hedges get closer to the road. Moreover, the presence of over- or under-passes, even if not specifically for fauna, reduces the probability of collision. In the same vein, the study carried out by Dussault *et al.* (2006) in Quebec shows moose-vehicle collisions happening in areas where the road crosses potential corridors defined as those with slopes less tan 2%. Therefore, this kind of study point to animal trails meeting the criteria previously exposed based on habitat selection and biomechanics.

Two elements should be taken into account regarding ungulate use of crossing structures on motorways. First, some minimum requirements should be met by any structure in order to be used by any large species as ungulates. In this sense, ungulates are noteworthy by their use of large structures (over- or under-passes) and those specifically designed for wildlife (Ng *et al.*, 2004; Mata *et al.* 2005). Secondly, crossing structure location should be close enough to natural animal paths in order to be used. Therefore, over-passes are expected to be the most appropriate solution when forested areas and their edges appear on hillock tops, as in this case passes (especially false tunnel-type *ecoducts*) can become a natural section of trails. By comparison, under-passes can be expected to be the best solution in a wider set of situations as their position in valley bottoms more easily coincides with sites where animals are unconsciously funneled in search of minimum effort trails. Accordingly, a more intense use of under-passes by ungulates than over-passes has been stated (Olbrich 1984).

Patterns of coherence among independent information sources have been shown above, but several discordant observations exist that open new perspectives for applied research. Thus, ungulates have been shown to use narrow culverts in some occasions (Krawchuck *et al.* 2005) and in some cases they make a heavier use of wildlife over-passes than under-passes (Mata *et al.*, *unpublished*). What's the underlying reason for these anomalies? Though time since construction plays a role in animals getting used to crossing structures (Olbrich, 1984; Clevenger and Waltho, 2005), even well after the 2-3 year adaptation time described the structures show an extremely uneven or even infrequent use by ungulates.

References

Clevenger, A.P. & Waltho, N. (2005). Performance indices to identify attributes of highway crossing structures facilitating movement of large mammals. *Biological Conservation* **121:** 453-464

Dussault, C.; Poulin, M.; Courtois, & Ouellet, J.P. (2006) Temporal and spatial distribution of moose-vehicle accidents in the Laurentides Wildlife Reserve, Quebec, Canada. *Wildlife Biology* **12:** 415-425.

Iuell, B. & Strand, O. (2005) Monitoring effects of highway traffic on wild reindeer. C. Leroy, P.; Garret, & K.P. McDermott. (Eds.) *On the road to stewardship Proceedings of the International Conference on Ecology & Transportation (ICOET-05)*. Center for Transportation and the Environment, NC State University. Raleigh, NC, USA, pp. 292-300.

Krawchuk, A.; Larsen, K.W.; Weir, R.D. & Davis, H. (2005). Passage through a small drainage culvert by Mule deer, Odocoilus hemionus, and Other Mammals. *Canadian Field-Naturalist* **119:** 296-298.

Licoppe, A.M. (2006) The diurnal habitat used by red deer (*Cervus elaphus* L.) in Haute Ardenne. *European Journal of Wildlife Research* **52:** 164-170.

Malo, J.E.; Suárez, F. & Díez, A. (2004) Can we mitigate animal-vehicle accidents using predictive models?. *Journal of Applied Ecology* **41:** 701-710.

Mata, C.; Hervás, I.; Herranz, J.; Suárez, F. & Malo, J.E. (2005). Complementary use by vertebrates of crossing structures along a fenced Spanish motorway. *Biological Conservation* **124:** 397-405.

Minetti, A. (1995) Optimum gradient of mountain paths. *Journal of Applied Physiology* **79:** 1698-1703.

Ng, S.J.; Dole, J.W.; Sauvajot, R.M.; Riley, S.P.D. & Valone, T.J. (2004). Use of Highway Undercrossings by Wildlife in Southern California. *Biological Conservation* **115:** 499-507.

Olbrich, P. (1984). Study of the Effectiveness of Game Warning Reflectors and the suitability of Game Passages. *Zeitschrift Fur Jagdwissenschaft* **30:** 101-116.

Reichman, O.J. & Aitchison, S. (1981) Mammal trails on mountain slopes: optimal paths in relation to slope angle and body weight. *The American Naturalist* **117:** 416-420.

Seiler, A. (2005) Predicting locations of moose-vehicle collisions in Sweden. *Journal of Applied Ecology* **42:** 371-382.

Spitz, F. & Janeau, G. (1995) Daily selection of habitat in wild boar (*Sus scrofa*). *Journal of Zoology* **237:** 423-434.

Tufto, J.; Andersen, R. & Linnell, J. (1996) Habitat use and ecological correlates of home range size in a small cervid: the roe deer. *Journal ofAnimal Ecology* **65:** 715-724.

Reflecting on the Big Picture for Road Ecology, Transportation, and Society

R.T.T. Forman

Harvard University, Graduate School of Design, Cambridge, USA.
e-mail: rforman@gsd.harvard.edu

With roots in many nations, road ecology has just burst onto the scene for the benefit of transportation and society. Its diverse principles are being put right to work for solutions to numerous detailed problems at countless locations. The big picture however has yet to reach our radar screens. Four overriding objectives for transportation and society, for which road ecology is central, are highlighted. Then two of the many steps required are introduced.

The Four Road-Ecology Objectives for Transportation and Society

1. Improve the natural environment close to the entire road infrastructure.
2. Reestablish a sustained emerald network of large vegetation areas and effective major wildlife corridors across the landscape through which roads pass.
3. Reestablish near-natural water conditions (e.g., groundwater and surface-water flows, water-bodies, aquatic ecosystems, and fish populations) across the landscape through which roads pass.
4. In new road construction, maintain the emerald network and near-natural water conditions.

The first big-picture objective emphasizes a trajectory of improvement rather than a specific end product. Location-by-location solutions fit, road-segment-by-road-segment solutions may often be better, and road-network-by-road-network solutions are probably most efficient and cost effective. The types of improvement, such as habitat enhancement, vegetated stormwater-pollutant depressions, and reduction of the highway barrier effect, will vary from location to location along the road system. This objective can be accomplished with ample flexibility for transportation agencies, policymakers, and the public.

The second objective highlights the most important solution for sustaining biodiversity. Indeed the major component of this is identifying, even creating, emeralds on the land undegraded by roads, traffic, and other human effects. Connecting these large patches decreases the barrier and habitat fragmentation effects of roads with traffic, which provides important insurance for biodiversity in the face of an urbanizing and climate-changing world. Road network and landscape ecological planning is a key to accomplishing this objective.

The third objective for transportation and society highlights water as the other major flow across the land. Road construction has almost always significantly altered water flows and water-bodies. Changing the balance to provide both near-natural water flows and traffic flows is the key step. Much can be accomplished during ongoing maintenance work, in revising roadside and ditch designs, and in all rehabilitation and upgrading projects involving roadbeds, bridges, and culverts. Accomplishing the water flows and water-bodies goals is a major step, though additional steps are required, toward accomplishing the goals of near-natural aquatic ecosystems and fish populations.

The fourth objective for transportation and society should be the easiest to accomplish. It accomplishes the second and third objectives without having to do them, a salutary cost-effective and environmentally sensitive solution.

Simple Spatial Models of Road Networks and Landscape Pattern

Existing model results suggest three principles in the search for an ecologically optimum road-network form: (1) maintain a few large roadless natural areas; (2) concentrate the bulk of the traffic on a small number of large roads; and (3) perforate or mitigate roads that separate the few large natural areas (Forman 2006). The ecological effects of simple road networks with up to sixteen enclosures were then compared, while varying the number and arrangement of highways and small roads. A fixed degradation zone (Forman et al. 2002), plus interaction, was used alongside a highway and not along a small road. Transportation geometry and ecological patterns used roughly mimic a 10x25 km urbanizing landscape west of the Boston metro-area. Dependent variables are related to the amount of the degradation zone in a network. Model results suggest curvilinear patterns for (a) the arrangement of different road types, (b) the number of undegraded tiny-enclosures in finer-mesh networks, and (c) the blockage effect on wildlife movement using different permeability assumptions. The goal is to outline better and worse road networks, based on succinct stated principles, in a form that policymakers and the public can understand, explain, and use.

Roadside Woody Vegetation

Adding more woody roadside vegetation typically increases wildlife habitat, and also reduces the barrier and fragmentation effect of busy roads (Forman 2005). The roadkill rate of some species may increase, yet the increased habitat and increased quality of existing habitat behind it should result in significant wildlife population increases. Increasing the amount of shrubs and trees in many (not all) roadsides should help to reduce traffic speeds (driver's perceived width of vision ahead is narrower), and make safer highways (fewer, less-severe crashes per kilometer). Many other environmental and societal benefits, with few disadvantages, can be provided. Widspread pilot projects and research on greatly increasing roadside woody vegetation of various types is needed.

References

Forman, R.T.T., Reineking, B. & Hersperger, A.M. (2002) Road traffic and nearby grassland bird patterns in a suburbanizing landscape. *Environmental Management* 29: 782-800.

Forman, R.T.T. (2005) Roadside redesigns---woody and variegated---to help sustain nature and people. *Harvard Design Magazine* Fall 2005/Winter 2006: 35-41.

Forman, R.T.T. (2006) Good and bad places for roads: effects of varying road and natural pattern on habitat loss, degradation, and fragmentation. *Proceedings of the 2005 International Conference on Ecology and Transportation*. C.L. Irwin, P. Garrett & K.P. McDermott, eds. CTE, North Carolina State University, Raleigh, USA., pp. 164-174.

Missing knowledge to reconcile growing road networks to viable (meta)populations

C.F. Jaarsma[1], F. van Langevelde [2]

[1] Land Use Planning Group, Wageningen University, Wageningen, The Netherlands.
e-mail: Rinus.Jaarsma@WUR.nl
[2] Resource Ecology Group, Wageningen University, Wageningen, The Netherlands.

Introduction

Infrastructure has large impacts on wildlife, as it is one of the principal causes for mortality, and disturbance and fragmentation of their habitat (Van Langevelde and Jaarsma, 2004). The negative impacts on wildlife will increase due to the expected steady growth of road networks and their traffic flows worldwide. We expect, however, that in industrialised countries with a dense population not the network itself will expand (beside relatively small adaptations), but the traffic volumes will explode. Where motorways now already suffer from congestion, it is inevitable that especially the networks of lower order roads will take care of these expanded flows. As a consequence of this shift to lower order roads, fragmentation in the rural area will increase dramatically, because traffic volumes on these minor roads largely determine the disturbance, resistance and mortality risk for animals. In human-dominated landscapes lower order roads have a high density (in the Netherlands 1.55 km/km^2, where primary roads including motorways cover 0.32 km/km^2), so animals will frequently encounter them. To mitigate this, another approach is needed than the traditional one focusing mainly on major roads. This paper explores such an approach, aiming at a balance between transportation and ecology and defines missing knowledge.

On the way to another approach

Traditionally, mitigating focused mainly on technical devices that change roads, such as fences, ecoducts and lighting. However, such expensive technical interventions are only realistic for major roads that have a limited length and no direct access for adjacent land use. The dense network of lower order roads on the contrary offers frequent access to parcels, farms and other rural buildings. These accesses generally prohibit an effective fencing with related bridges, pipes and other facilities to allow wildlife to cross.

Another type of interventions, such as the reduction of traffic volumes (either temporary or permanent) or vehicle speed, might drastically decrease the barrier and mortality effect of lower order roads (Jaarsma *et al*., 2006). These interventions can result in traffic-calmed areas (TCRAs) and may work for minor roads. The through traffic will use surrounding major roads. In transportation planning, the mesh size of such TRCAs is considered to be roughly between 20 and 50 km^2. This is based on the time needed to leave the traffic-calmed area and allows for a major network in grids with mesh width between 4 and 7 km.

The impact of traffic calming is a concentration of former diffuse flows on minor roads at the surrounding major roads. This will result in somewhat higher volumes on major roads. However, within the TCRA volumes and speeds will decrease substantially. Ultimately this drastically increases traffic safety, the main reason for rural traffic calming so far. However, another impact is a decrease of barrier effects and disturbance along minor roads. Based on the assumption that roads with an average daily volume (AADT) below 1000 vehicles are not an ecological barrier, rural traffic calming virtually decreases the number of roads. In Figure 1, the study area (50 km^2) has currently 6 continuous landscape units (each surrounded by roads with volumes > 1000). The smallest one is 0.2 km^2, the largest one 19.4 km^2. After traffic calming, 3 continuous landscape units remain (0.2, 9.3, and 39.7 km^2 respectively).

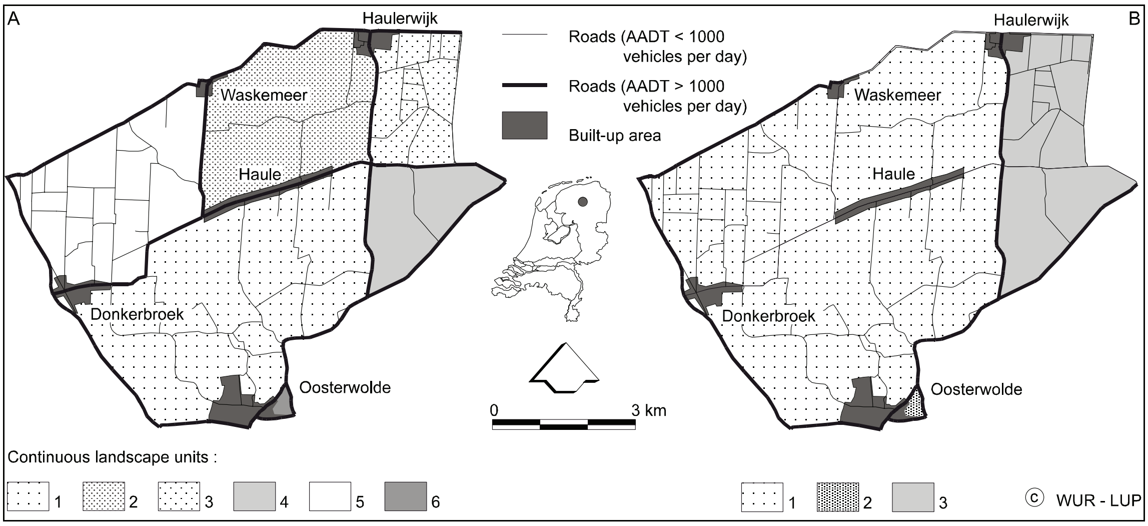


Figure 1. The road network in the Ooststellingwerf region, The Netherlands, with a distinction made between roads with an AADT above or below 1000 vehicles per day and the resulting continuous landscape units in (A) the present situation and (B) the TCRA-implemented situation (Jaarsma and Willems, 2002)

Missing knowledge

In our contribution, we explain how a concentration of traffic flows decreases road density. We argue that planning of TCRAs increases habitat area for wildlife and decreases mortality and disturbance due to traffic. For effective TCRAs, however, crucial knowledge is still missing. For example, the choice for a volume of 1000 vehicles per day (as in Figure 1) is arbitrary. Further research is needed to find threshold traffic volumes where animals can safely cross a road, i.e. there is a sufficient low probability of being killed. So far, indications for mesh size of TCRAs to provide sufficient habitat area for (meta)populations of wildlife is also lacking. We argue that using the method to calculate metapopulation capacity (Hanski and Ovaskainen, 2000) can be used as a tool to estimate parameters to plan TCRAs that support viable (meta)populations of certain species.

References

Hanski, I. & Ovaskainen, O. (2000) The metapopulation capacity of a fragmented landscape. *Nature* **404**: 755-758.

Jaarsma, C.F.; Van Langevelde, F. & Botma, H. (2006) Flattened fauna and mitigation: traffic victims related to road, traffic, vehicle, and species characteristics. *Transportation Research D* **11**: 264-276.

Jaarsma, C.F. & Willems, G.P.A. (2002) Reducing habitat fragmentation on minor rural roads through traffic calming. *Landscape and Urban Planning* **58**: 125-135.

Langevelde, F. van & Jaarsma, C.F. (2004) Using traffic flow theory to model traffic mortality in mammals. *Landscape Ecology* **19**: 895-907.

2.2 Symposium 3: Beyond growth? Scientific and policy strategies for non growing and shrinking urban landscapes

Variety matters! The planners', lawyers' and the landscape ecologists' view on land consumption combined in an interdisciplinary approach

H. Wittmer, H. Nuissl, D. Haase

Helmholtz Centre for Environmental Research UFZ, Permoserstr. 15, D-04318 Leipzig, Germany, e-mail: heidi.wittmer@ufz.de

Background

The conversion and consumption of natural or agricultural land into urban land poses a major challenge to sustainable development worldwide. In Europe, although the population is no longer growing the amount of land developed for urban uses continues to increase (Figure 1 left). Contrariwise, many inner-city areas are shrinking and suffer from extensive vacancies in housing and offices. Consequently, the task of reducing the conversion of open land into urban land fares high on the political agenda at least in densely populated countries such as Germany, Belgium, the Netherlands, Switzerland and the UK (Figure 1 right).

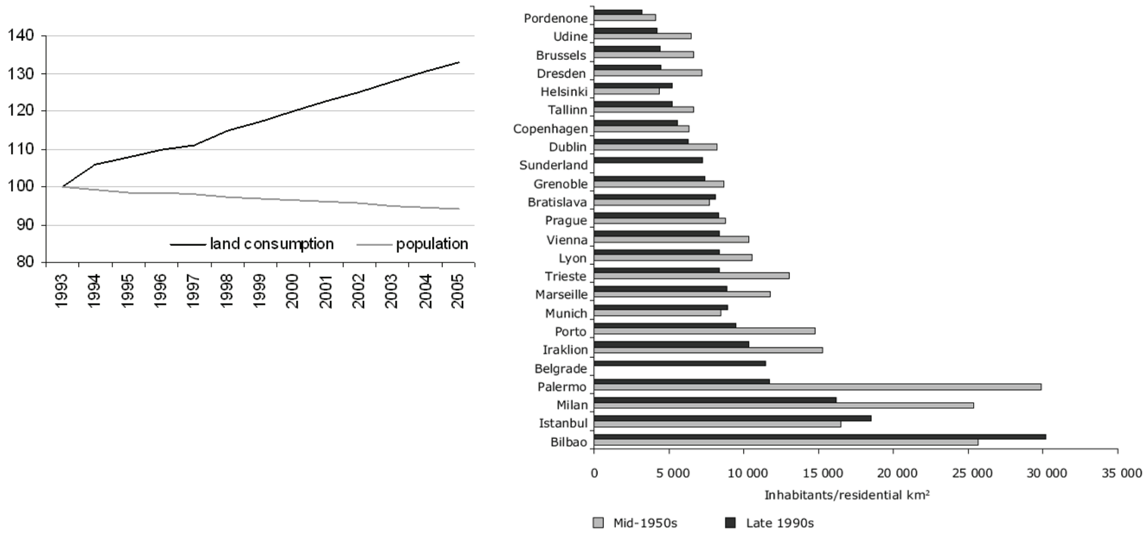


Figure 1. Left: Land consumption (settlement and transport) compared to population development in Leipzig, Germany 1993-2005 (1993 = 100). **Right**: Residential density (= inhabitants/residential km^2) in selected European cities in the mid-1950s and late 1990s (EEA 2006; MOLAND (JRC) and Kassanko et al. 2006)

Various attempts have been made in most countries at restraining the dynamics of land consumption. However, whilst most of these strategies and instruments consist in defining areas that must not be developed, they usually do not allow for the complex interaction of environmental and socio-economic factors in a sufficient manner. This problem also holds for "normative" land use strategies that simply aim at reducing the amount of land consumption to a defined target, such as the German Federal Government's goal to reduce the level of land consumption from currently around 100 ha to only 30 ha in 2020. A review of existing land use evaluation systems reveals that many questions with regard to the consequences of land consumption are left aside. These questions are e.g.: How detrimental are specific land use transitions for water balance and habitat integrity? What costs do they involve for municipal budgets? This shortcoming is mainly a result of a lack of understanding of both bio-physical and socio-economic mechanisms, concerning different landscape functions.

Approach and structure of the paper

Against the background outlined above the question arises how science and research can support the development of more sophisticated strategies and instruments of urban land use management than are currently available. What we think is needed is a methodology which allows to evaluate the overall impact of land consumption and, consequently, to determine which kind of land use is to be prevented at what places. Inspired by the DPSIR-model we have developed a heuristic conceptual framework on the basis of which we are now trying to elaborate such methodology (Figure 2). As an integral part of this methodology we have designed an approach towards an integrated and interdisciplinary assessment of land consumption and its various impacts. This approach differentiates between three analytical levels of impacts of land use transition: plot, context and aggregated level. It combines the (mostly quantitative) evaluation of impacts of land use transition on the individual plot the use of which has actually been changed with an assessment, based on bio-physical models and socio-economic estimates, of those impacts that occur beyond this very plot. Both elements together provide a powerful data set that makes it possible to disaggregate and downscale (supra-) national statistics so as to clarify the implications of land consumption estimates. By pulling together the perspectives of different disciplines, the framework facilitates the assessment and evaluation of impacts of land use transition systematically. The paper concludes with some illustrative remarks on how the framework could be used for decision support in land use management and spatial planning.

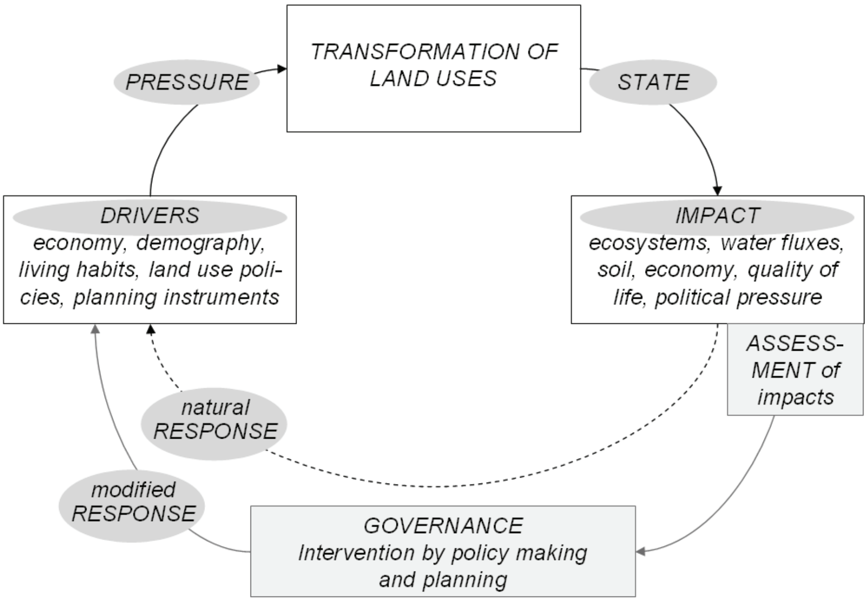


Figure 2. Conceptual framework for the investigation of land use transformation

References

Haase, D.; Nuissl, H. (2007) Does urban sprawl drive changes in the water balance and policy? The case of Leipzig (Germany) 1870 – 2003. *Landscape and Urban Planning*, in print.
Haase, D.; Nuissl, H.; Lanzendorf, M.; Seppelt, R.; Wittmer, H.; Köck, W. (2007) Impact assessment of land use transition in urban areas – a systematic, interdisciplinary approach from an environmental perspective. *Land Use Policy*, in prep.

Landscape impact assessment for multifunctional land uses

K. Helming[1], T. Kuhlman[2], D. M. Wascher[3], M. Perez-Soba[3], S. Sieber[1], P. Tabbush[4], O. Dilly[5], H. Bach[6], K. Tscherning[1], B. König[1], H. Wiggering[1]

[1]Leibniz-Centre for Agricultural Landscape Research (ZALF), Müncheberg, DE.
e-mail: khelming@zalf.de,
[2]Agricultural Economics Research Institute (LEI), The Hague, NL, [3]Alterra. Wageningen, NL, [4]Forestry Commission Research Agency. Alice Holt, UK, [5]Chair of Soil Protection and Recultivation, BTU Cottbus, DE, [6]National Environmental Research Institute (NERI), DK

Land use and multifunctionality

Land use is one of the key pressures translating economic, political and other driving forces into environmental impacts. The motivation of planners and policy makers to interact with land use is devoted to the principle of sustainable development, which in turn is considered to be intrinsically linked to the concept of multi-functionality. The rationale addresses the interdependence of social, economic, and environmental effects of land use, taking into account commodities and both negative and positive externalities (Wiggering et al., 2003).

Impact Assessment at European level

In Europe, one of the important driving forces for land use decisions is policy making. European policies aim at implementing the Sustainable Development Strategy (EC, 2001) through the decoupling of economic growth from environmental degradation while fostering social cohesion. To control progress, ex-ante Sustainability Impact Assessment was introduced as instrument towards the fulfilment of this strategy. It is now a mandatory part of the policy development process at European level. The "*Guidelines for Impact Assessment*" (EC, 2005) of the European Commission require quantitative tools that are built upon available data and provide indicator based information on the impact of any policy related land use change on social, economic and/or environmental sustainability issues.

Approach to Impact Assessment for multifunctional land use

This paper reports on methodological approaches and some results of the EU Integrated Project SENSOR (www.sensor-ip.org), which develops *ex-ante Sustainability Impact Assessment Tools* (SIAT) to support decision making on policy options related to multifunctional land use in European regions. SENSOR is based on 3 assessment streams: (1) European indicator-based driving force and impact analysis of land use policy scenarios; (2) Region-specific problem, risk and threshold assessment making use of spatial reference systems and participatory processes; (3) Case-study-based sensitive area studies using detailed information on sustainability issues. SENSOR addresses rural land uses for Europe at NUTS-X level, which is spatially homogenised integration of the administrative EUROSTAT units NUTS2 and NUTS3. Two additional spatial levels are utilised: (i) 1 km² grid level for land use projections and environmental indicator analyses, (ii) a clustering of European regions based on geo-physical and socio-economic variables.

Spatial impacts of six land use related sectors are addressed: agriculture, forestry, nature conservation, tourism, transport and energy infrastructure. Scenario driven changes of spatial shares of these sectors are simulated with a series of macro-economic and sectoral models iterating with the land use model CLUE-S (Verburg et al., 2002). Scenario studies representing narratives of optional global economic and policy developments for target years 2015 and 2025 are utilised to allow for ex-ante simulation of possible land use changes.

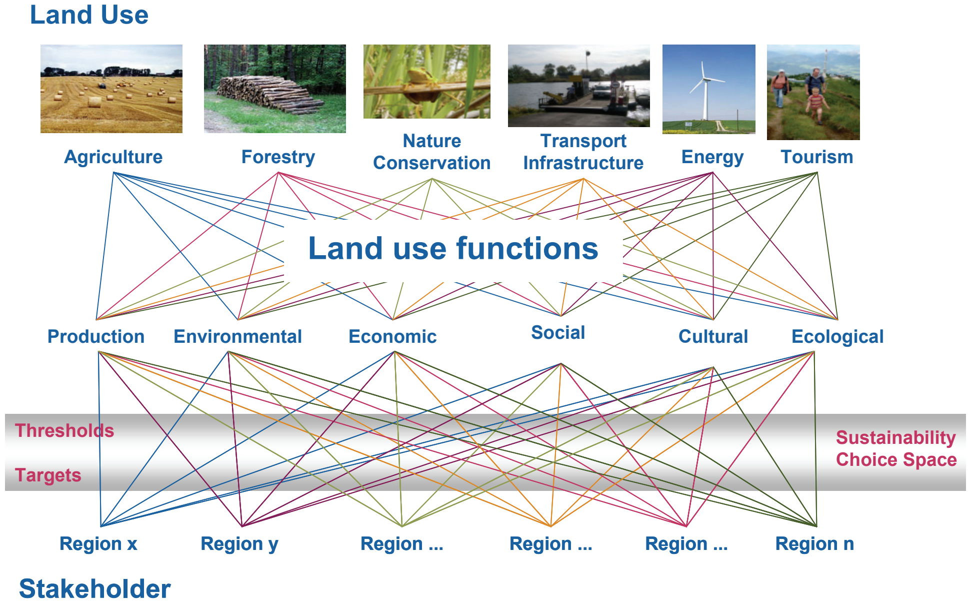


Figure 1. SENSOR analyses impacts of spatial changes in six sectors on social, environmental and economic indicators at regional level for Europe.

Based on an indicator system, land use change scenarios are analysed in their impact on environmental, social and economic issues. For multifunctionality assessments, indicators are grouped into a system of nine land use functions, which represent important goods and services that are provided to society through land use. Simulated changes in land use functions are used for a stakeholder inclusive approach of valuating impacts at regional and local level. Accompanied with a framework for expert driven definition of regional limits and targets, land use impact valuation can then lead to identify so called sustainability choice spaces of land use changes in specific regions.

All the above described approaches are integrated into a Sustainability Impact Assessment Tool (SIAT), which is a scenario driven meta-model based on response functions describing relations between (i) policy options and land use changes and (ii) land use changes and sustainability indicators. SIAT is a quick scan tool designed for policy making purposes at European level. Validation of the tool is to be conducted in case study areas, for which a more profound data and information basis exist, and where stakeholders are consulted to valuate SIAT simulations. The approach is going to be extended to specific issues of urban-rural linkages in the frame of a second project called PLUREL.

References

European Commission (2001) A Sustainable Europe for a better world: A European Union Strategy for Sustainable Development. COM(2001)264final.

European Commission (2005) Impact Assessment Guidelines SEC(2005)791.

Helming K, Tscherning K, Wascher D, Kuhlman T, Sieber S, Bach H, Dilly O, Tabbush P. (2006) SENSOR annual report, public part. In: Helming K, Wiggering H (Eds). SENSOR report series 1. www.sensor-ip.eu. ZALF Germany.

Wiggering H, Mueller K, Werner A, Helming K (2003) The concept of multifunctionality in sustainable land development. In: Helming, K. and H. Wiggering (eds) (2003): Sustainable Development of Multifunctional Landscapes. Springer Berlin, Heidelberg, New York. p 3 – 18.

Verburg PH, Soepboer W, Veldkamp A, Limpiada R, Espaldon V, Sharifah Mastura SA (2002) Modeling the Spatial Dynamics of Regional Land Use: the CLUE-S Model. Environmental Management **30**: 391-405.

Monitoring Urban Sprawl in Germany - Towards a GIS-based Measurement and Assessment Approach

S. Siedentop

Institute of Regional Development Planning, Universität Stuttgart – Pfaffenwaldring 7, 70569 Stuttgart, Germany. e-mail: stefan.siedentop@ireus.uni-stuttgart.de

Background

During the 1990's, the phenomenon of urban sprawl received growing attention in the international urban policy debate. In a recent report, the European Environmental Agency addressed sprawl as one of the major challenges facing urban Europe in the next decades (EEA 2006). However, a survey of the literature yields no agreement in terms of defining and measuring urban sprawl. Some scholars denote sprawl simply as ongoing urbanisation or low density development, others stress the level of suburbanization and deconcentration or characteristics of land use patterns. The absence of a common understanding constrains the analysis of sprawl's causes, costs and consequences as well as the formulation of planning strategies towards economically, ecologically and socially acceptable land use patterns. Urban and environmental planning aiming to combat sprawl must have an agreed-upon way to measure it in order to evaluate the progress of planning strategies and programmes (Siedentop 2004).

Alongside the lacking definition and measuring convention, the specific process character of urban land use change hinders more effective anti-sprawl-policies. Environmental, social and economical problems caused by urban sprawl tend to be cumulative in nature. They build up over a period of time and usually have more than one cause. In contrast, the legal framework regulating the use of environmental resources generally addresses a single pollutant or a single project but ignores multiple actions that can add up or interact to cause cumulative effects. It has to be acknowledged that the mismatch between the scales at which sprawl-related environmental degradation occurs and the scales at which regulatory decisions are made is a significant obstacle to a more effective environmental management. Therefore, the development of a multi-dimensional and multi-temporal measurement approach is of crucial importance for urban and regional development policies.

Measurement Approach

On this background, a methodological framework for the measurement and assessment of land use patterns and dynamics is presented. First, the approach should be able to indicate the multiple driving forces and causative agents of land use change associated with urban sprawl. Secondly, this framework should be qualified for considering and assessing different impacts of land use and land use dynamics concerning ecological, social and economical objectives of urban and regional development policies. It also should recognise direct, indirect and cumulative cause and effect relationships. A third important requirement is that the selected indicators should be applicable with available data sources. And last but not least the approach has to deal with the varying scales on which land use policies are carried out.

The GIS-based measurement tool is based on the assumption that urban sprawl is a multidimensional phenomenon which can only be measured with a multiple-indicator approach. Three general process characteristics of urban sprawl are being discerned: the conversion from natural to artificial surfaces (surface-related impacts); the change of land use patterns from a compact urban form to irregular, dispersed land use patterns (pattern-related impacts) and the reduction of urban density (density-related impacts). Each sprawl-dimension is related to specific environmental impacts as well as unintended social and economic outcomes (Figure 1). These very different kinds of impacts can be addressed in terms of their specific impact pathway (direct, indirect, cumulative impacts), their spatial and temporal scale (local, regional and global impacts; short-term and long-term impacts) and particularly affected environmental components, social groups or economic subsystems.

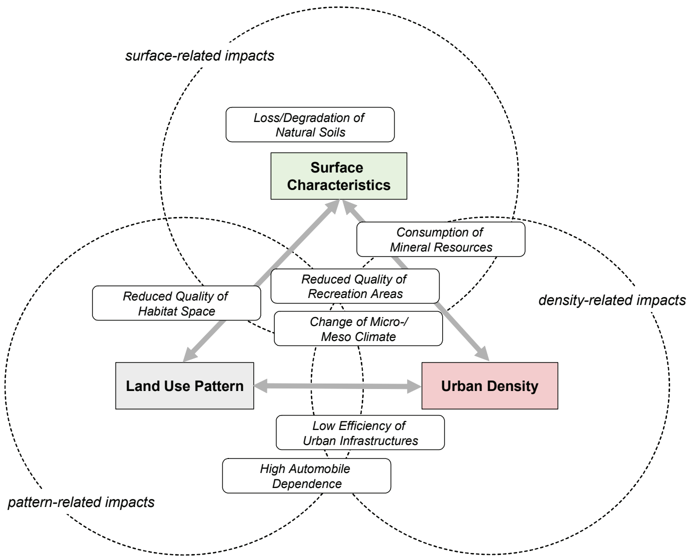


Figure 1. Three dimensions of urban sprawl and impacts explained by one or more dimensions (examples)

The proposed indicator system contains about 20 core indicators. Some indicators can be applied to the measurement of the (aggregate) land use pattern. Due to their low level of elasticity, “pattern-indicators” are suitable for “global” sustainability appraisals of land use in larger time intervals. Other indicators aim to address land use changes within a specific period of time on patch level (see Table 1 with examples). The latter are notably qualified for the continuous controlling of land use development in order to assess the success of regulatory policies.

Table 2. Categorisation of selected sprawl indicators

Indicator	Surface	Pattern	Density	Pattern/Patch
Share of urbanised land (%)	x			Pattern
Consumption of prime agricultural land for urban uses	x			Patch
Per-capita availability of open spaces in a given radius		X		Pattern
Shape-index (of urbanised land patches)		X		Pattern
Integration of new development into already urbanised areas		X		Patch
Integration of new development in the public transport network		X		Patch
Urban density (inhabitants per hectare urbanised land)			x	Pattern
Mean Density of new development (inhabitants per hectare)			x	Patch
Per-capita length of network-related infrastructures (meter)			x	Pattern

References

European Environment Agency (2006) Urban Sprawl in Europe. The ignored challenge. EEA Report No 10/2006. Copenhagen.

Siedentop, S. (2004) Urban Sprawl – verstehen, messen, steuern. *DISP* **160**: 23-35.

A green infrastructure strategy to enhance the adaptive capacity of restructuring city regions to climate change: the case of Greater Manchester

J. Handley[1], S. Gill[1], R. Ennos [2], S. Pauleit[3]

[1] Centre for Urban and Regional Ecology, School of Environment and Development, The University of Manchester
[2] School of Biological Sciences, The University of Manchester
[3] Centre for Forest, Landscape and Planning, The Royal Veterinary and Agricultural University, Copenhagen, Denmark
e-mail: sp@kvl.dk

Climate change is already with us and its impacts are especially evident in towns and cities. With this in mind the Engineering and Physical Sciences Research Council and the UK Climate Impacts Programme established a research programme into Building Knowledge for a Changing Climate (BKCC). One project within this programme is developing ways of preparing for climate change through strategic planning and urban design. An important facet of this work was to explore the potential of urban greenspace for climate adaptation. Greater Manchester, a large polycentric urban region in North-Western Europe, was chosen as the case study area. It is heavily influenced by structural changes with continuing out-migration, and restructuring of peri-urban land use and economic functions.

Urban areas have distinctive biophysical features in comparison to surrounding rural areas. For example, urbanisation replaces evapotranspiring vegetated surfaces with built surfaces which store heat. This modifies energy exchange and contributes to the urban heat island effect. The hydrological regime is also altered, with impervious surfaces increasing the volume and rate of surface water runoff.

Climate change scenarios suggest that the UK will experience warmer wetter winters with increased precipitation intensity, and hotter drier summers. This will impact on both people and buildings, particularly within urban areas. Urban greenspace offers significant potential in adapting cities for climate change through its role in ameliorating the urban climate, by providing shade and evaporative cooling, and reducing surface runoff, through the interception, storage and infiltration of rainwater. However, this potential has not been explored. In addition, little is known about the impact of climate change on urban greenspace, and how this may impact back on its functionality. This knowledge is critical for the creation of adaptation strategies through planning, design and management.

Modelling work was undertaken to quantify surface temperatures during heat waves and surface runoff during rainstorm events, in relation to greenspace cover. This was based upon an urban characterisation which stratified the conurbation into 29 distinctive urban morphology types (UMTs) and then estimated the surface cover of each by aerial photograph interpretation. This data formed a main input into the surface temperature and runoff models, which were run for the baseline 1961-1990 climate, as well as for UKCIP02 Low and High emissions scenarios for the 2020s, 2050s, and 2080s time-slices.

Findings show that surface temperature and runoff are very dependent on the proportion of green cover. This is increasingly important in the future as differences in surface temperatures and runoff become more pronounced between densely built and well greened areas. The surface temperature modelling found that in 1961-1990 the maximum surface temperature of woodlands, the least built up UMT, is 18.4°C (on a day expected twice per summer); 12.8°C cooler than that of town centres, the most built up UMT, at 31.2°C. By the 2080s the maximum surface temperature increases by 1.5°C-3.2°C in woodlands and 2°C-4.3°C in town centres, depending on the emissions scenario. The surface runoff modelling found that, in general, there was more surface runoff from the more built up UMT categories;

but soil type is also very important. The UMTs display the largest range of runoff coefficients on high infiltration soils (e.g. sandy soils) and the smallest range on low infiltration soils (e.g. clay soils). For example, for a one day per winter precipitation event with normal antecedent moisture conditions in 1961-1990, there is 32% runoff from low density residential areas compared to 74% from the more built up town centres on a sandy soil; on a clay soil this changes to 76% and 90% respectively, much higher values and with a smaller difference between them. Thus, surface sealing has a more significant impact on runoff on soils with higher infiltration rates.

Following this, a series of 'development scenario' model runs were undertaken exploring both the effects of current development trends as well as the potential of greening in adapting for climate change. They included: residential and town centres plus or minus 10% green or tree cover, greening roofs in selected UMTs, high density residential development on previously developed land, increasing tree cover by 10-60% on previously developed land, residential development on improved farmland, and permeable paving in selected UMTs.

The findings suggest that urban greenspace offers significant potential in moderating the increase in summer temperatures expected with climate change. For example, adding 10% green cover in high density residential areas and town centres kept maximum surface temperatures at or below 1961-1990 baseline levels up to, but not including, the 2080s High; whilst greening roofs in areas with a high proportion of buildings was also an effective strategy. On the other hand, the modelling work highlights the dangers of removing green from the conurbation. For example, if green cover in high density residential areas and town centres is reduced by 10%, surface temperatures will be 7°C or 8.2°C warmer by the 2080s High in each, when compared to the 1961-1990 baseline case; or 3.3°C and 3.9°C higher when compared to the 2080s High case where green cover stays the same.

The modelling work suggests that greenspace on its own is less effective at moderating the volume of surface runoff under climate change. By the 2080s High, the one day per winter precipitation event has 56% more rain than in 1961-1990, resulting in an 82% increase in runoff from Greater Manchester. Whilst adding green cover can reduce runoff locally, this effect is not enough to counter the extra precipitation from climate change. The use of storage in combination with green surfaces will be required, and could be used to irrigate greenspace in times of drought. There is significant potential to utilise sustainable urban drainage (SUDS) techniques.

Another way of exploring possible climatic adaptations considered the green infrastructure of the conurbation from the perspective of landscape ecology. The green infrastructure is thus viewed as consisting of corridors, patches, and the overall matrix. These components play different roles in terms of climatic adaptation. For example, flood storage is very important in corridors, but has some importance as SUDS in the patches; rainwater infiltration is very important in the matrix, as well as in patches; whilst evaporative cooling is crucial in the patches as well as in the matrix. In the UK there is renewed interest in strategic planning at the city-region level and a City-Region Spatial Strategy is currently being prepared for Greater Manchester. The potential for strategic planning of the urban green infrastructure to contribute to this emergent strategy through climate change adaptation will be discussed in the presentation.

Urban restructuring in Central Eastern Europe – does the late phase of transition still affect the environment?

A. Vaishar

Institute of Geonics, Academy of Sciences Ostrava,
Department of Environmental Geography, 602 00 Brno, Drobného 28, Czech Reoublic
e-mail: a.vaishar@seznam.cz

Introduction

Cities of Central Eastern Europe have been impacted by a very fast advance of processes that took many decades in Western Europe. The social and economic transition has been responsible for many changes in urban structures during the last 17 years. The present state-of-art was investigated by international teams within the two projects: Mobilizing re-urbanisation on condition of demographic change (5th EU framework programme No. EVK4-CT-2002-00086) and Spatial consequences of demographic changes in East Central European cities (Volkswagen foundation No. II/81150).

Present processes of urbanisation in the cities of Central Eastern Europe

Specific development within cities in the mentioned region can be characterised by the rapid change of economic base from the secondary to the tertiary sector, by the mass use of passenger cars as well as by the rapid social polarisation of the society. Such a development has proceeded in relation with objective processes of the present phase of urbanisation: globalisation, sub-urbanisation, counter urbanisation etc.

At the same time, a second demographic transition has taken place in the countries of Central Eastern Europe. Fertility rate is high under natural reproduction. Life expectancy is apparently increasing. Population ageing follows as a logical consequence. Opening of borders and labour markets within EU encourages international migration. Immigrants often settle in the former worker districts of big cities, where quarters (sometimes even ghettos) of socially deprived population groups develop. This development affects the situation of inner cities.

Empirical research

The cities of Central Eastern Europe included in the study are Brno and Ostrava (Czechia), Gdańsk and Łódż (Poland), Leipzig (Germany), Ljubljana (Slovenia). Problems found were identified in Vaishar *et al.* 2006.

The main source of environment pollution has mostly changed from industrial to car traffic. It is not only the number of cars but also the way of their use that adds to the traffic. The role of the car has changed from a source of recreation to the medium for enterprise and prestige. The traffic has moved from the countryside back to the cities. Pollution, noise, accidents, traffic jams, and parking problems illustrate the problem. The difficulties are concentrated in inner cities which were built for substantially lower traffic needs. The extreme situation can be found in Ljubljana that has become the capital of an independent country. Conversely, most Central European cities have maintained a relatively efficient system of public transport.

Withdrawal of heavy industries from inner cities has caused the problem of brownfields. Socially and environmentally degraded areas impair the value of some parts of the inner cities, which are otherwise quite attractive with respect to their location. Some available examples of rehabilitation are e.g. shopping centres Łódż (Manufaktura), Brno (Vaňkovka) or apartments (Łódż-Scheibler). Many of former industrial areas, landfills and worker colonies are still waiting for their rehabilitation.

Urban greenery plays an incrementally important role in improving the urban environment. Unfortunately, street greenery often gives away to new parking places or to the widening of roadways.
The process of sub-urbanisation induces many environmental problems such as the low efficiency of land and energy use and the mass use of cars. On the other hand, inner cities lose the young, educated and socially stronger population. With the exception of individual cases of gentrification, difficulties in the rehabilitation and maintenance of older city parts can be observed.

Evaluation

It is more or less clear, that it is not possible to speak of the environment in general. Target population groups seem to be one of crucial aspects of the problem. The question is for whom is the milieu of inner cities attractive and what demands have such groups of inhabitants on their environment. It shows that the community of inner cities starts to be formed of young urban specialists (not fixed in their place till now) and together living mostly childless couples on the one hand, and of old people or socially deprived and often immigrant groups on the other.

The problem is that the environmental requirements of individual population groups are different. Young educated people prefer almost contradictory aspects than old, less educated people. Taking into account the environment as a part of life quality, we come to the conclusion that the environment has to be measured as a set of objective and subjective indicators.

Discussion

It follows from the research that the environment does not play a decisive role in the settlement preferences of inhabitants. Rather, economic and social aspects are predominant. It seems that not the environmental aspects but the awaked individuality after 40 years of collectivism plays a decisive role even in the sub-urbanisation process. Environment can be important as an impulse of secondary importance namely in the cases of serious problems between special population groups.

In the future, the sustainable development of cities will greatly depend on the efficiency of energy. From such a viewpoint, public transport should be preferred to individual transport and the re-urbanisation of inner cities to the continuous process of sub-urbanisation. Under such a pressure, the perception of big cities as places with extremely polluted environment could change. On the contrary, inner cities are suitable for re-urbanisation as places of effective land use and effective energy consumption.

Conclusion

The perception of environment has changed. People are increasingly concerned with the issue. Unfortunately, the general interest in environmental matters is often not followed by the discussion of individuals. The “not in my backyard” attitude sometimes complicates the solution. Various green parties and movements do not help to make the problems found easier. The unification of European legislation could bring some results in the long-term. A crucial point appears however to be the need for a change in environmental behaviour.

References

Vaishar *et al.* (2006): Urban Environment in European Big Cities. *Moravian Geographical Reports* 14: (1): 46-62.

Too much urban green? the challenge of shrinkage in cities for green space, recreational ecosystem services and public acceptance of related policy strategies

S. Schetke[1], D. Haase[2], J. Breuste[3]

[1]University of Bonn, Institute for Geoinformation and Geodesy, Devision Urban Planning, Nussallee 1, D- 53115 Bonn, Germany
e-mail: sophie.schetke@uni-bonn.de
[2] UFZ-Centre for Environmental Research Leipzig-Halle, Department for Computational Landscape Ecology, Permoserstr. 15, D-04318 Leipzig, Germany
[3] University of Salzburg, Department of Geography and Geology, Division Physical and Environmental Geography, Hellbrunner Strasse 34/III, A-5020 Salzburg, Austria

Background

Compared to the suburban growth at beginning of the 1990's after the societal transition in eastern Germany, today urban shrinkage processes due to demographic change, out-migration and economic decline produce major vacancies in both housing and the commercial sectors. Core city areas are affected as well as socialist housing estates. Abandonment is followed by demolition impacting buildings and population density along the rural-urban gradient. This trend in urban land use development is not only restricted to eastern Germany; it also increasingly occurs in other city regions of Central European countries as well as in western and southern European cities.

The challenge

As a consequence of shrinkage and demolition, there is a surplus of urban waste land and open space which was never expected to become a reality, and furthermore needs to be "designed" for the future. Here, urban landscape planning enters "undiscovered terrain" because urban growth has dominated the agendas of urban planners for decades:
So, what are the effects of increasing potentials of urban open space in core and peripheral districts? Both could be assumed: positive effects in terms of green and recreational quality and negative effects when looking at emptiness and decreasing accessibility of social and transport infrastructure of formerly compact urban bodies. Recently, there has been observed a growth in green spaces accompanied by a decline of social functions within several districts. There are no concepts on how to manage this development in urban parks, which involve the following:

- What are the specific spatial pattern of urban shrinkage, decline of population and related demolition of the urban fabric? How far does the perforation process influence the social neighbourhoods?
- Do urban planning strategies exist to deal with the growth of green space and, what is more, how can they be implemented?
- What are the expected ecosystem services of the newly gained urban green spaces? How could their impact be assessed?

Research design, methods and spatial units of investigation

To find initial answers on the above questions, infrastructural and land use changes related to vacancy and demolition have been detected. Additionally scenarios for the coming 10 years have been incorporated into the assessment. A multi-criteria indicator matrix subsequently quantifies socio-spatio-environmental impacts of such land development (scenarios). Seen from both sides, ecosystems and the urban inhabitant, different scenarios of urban shrinkage thus could be assessed concerning "quality of life" and ecosystem resources related to target values.

The evaluation of the urban green dynamics extension and ecological functionality is based on urban structure types (Breuste, 2002). Urban structure types mark areas of physiognomic homogeneous development, which are predominantly distinguished from each other by characteristics in built up structures and open spaces (vegetation and soil sealing). These are to a large extent homogeneous concerning density and portions of the built-up areas of various forms and of different developments of the open spaces (soil sealing areas, vegetation types and urban forest). Substantial ecological characteristics of a space can be described by the land use form and the structural characteristics. Urban structure types summarize spaces of similar environmental conditions and thus represent units that can be up-scaled on empirical results on urban land use change.

Case Studies

For the case study city regions in eastern Germany, Leipzig and Halle, based on the land use history since 1990 greenery and open land scenarios are presented. Further, for the case of Halle, the current urban planning strategy and its implications had been evaluated.

Preliminary results

The results of the study gave strong evidence that firstly, eastern German cities possess a "for-runner role" in urban restructuring and renewal processes arising from shrinkage. Secondly, a surplus of urban greenery has ambivalent effects for both man and nature and thirdly, that urban planning is not prepared to handle "too much" green (Schetke & Haase, 2007). On the one hand, demolition produces new open space and the potential of natural plant succession and recreational value. In contrast it ignores the idea of "leaving nature to itself" the social and "quality-of-life" dimensions of shrinkage in so far, that simply overgrown areas in an environment of emptiness and decay are not necessarily perceived as attractive for the urban residents (Rink, 2005).
The multi-criteria indicator matrix explores all these different dimensions of shrinkage impacts in a quantitative form as well as permiting the transfer of the numbers into verbal argumentation at both local and structure type level (Schetke & Haase, 2007).
Due to the properties regarding utilization type and building structure there exist direct relations between the scientific framework of the urban structure types and the instruments of urban planning such as a master plan, zoning plan or site/property planning. Scientific findings might be thus easily enter administrative, political and legislation procedures and documents for actions.
The results of both case studies Leipzig and Halle can be transferred to other urban shrinkage examples in order to enhance urban planning strategies and policies in terms of hindering and supporting aspects. This also encloses a better understanding of the management of urban ecosystems.

References

Breuste, J., 2002. Urban Ecology. In: Bastian, O., U. Steinhardt (eds.). Development and Perspectives of Landscape Ecology. Kluwer Academic Publishers, Dordrecht. pp. 405 – 414.

Schetke, S., Haase, D., 2007. Multi-criteria assessment of the socio-ecological development in shrinking cities. Experiences from East Germany. Environmental Impact Assessment Reviews (*in prep.*).

Rink, D., 2005. Surrogate Nature or Wilderness? Social Perceptions and Notions of Nature in an Urban Context, In: Kowarik, I., Körner, S. (eds). Wild Urban Woodlands. New Perspectives for Urban Forestry, Springer, Berlin et al., pp. 67-80.

2.3 Symposium 4: Applying landscape ecological principles in urban environments

The efficacy of the urban-rural approach in studying the ecology of human settlements

M. J. McDonnell, A. K. Hahs

Australian Research Centre for Urban Ecology, Royal Botanic Gardens Melbourne
c/o School of Botany, University of Melbourne, Victoria 3010, Australia,
e-mail: markmc@unimelb.edu.au

Introduction

The ever increasing human population is driving the expansion and creation of cities and towns worldwide. Consequently, there is a tremendous call for more ecological information in urban and exurban environments by natural resource managers, planners, conservationists, scientists, and professionals associated with human health. In the early 1990's, the urban-rural gradient approach was proposed as a useful method for studying the ecology of cities and towns (McDonnell and Pickett, 1990). Since then, researchers have characterised urban-rural gradients and have used the concept to better understand the distribution of plants and animals as well as ecosystem processes in cities and towns around the globe. Thus, we are at an appropriate stage in the development and use of the approach to assess what we have learned, and what improvements can be made in the future to achieve better research and management outcomes.

Urban-rural gradient studies

A review of the literature in May 2006 revealed 220 papers that had explicitly utilised the urban-rural gradient approach. These studies examined the response of plants, animals, insects, invertebrates, fungi, fish, reptiles and amphibians to gradients of urbanisation. The most common organisms studied were birds. In addition, researchers interested in nutrient cycling, conservation biology, landscape ecology, pollution, marine and freshwater ecosystems and humans made use of the urban-rural gradient approach. The richness of these studies, coupled with the quality of their results clearly indicates the value of the urban-rural gradient approach to the ecological and social study of cities and towns.

Characterisation and quantification of urban-rural gradients

Urban-rural gradients were first characterised along transects using simple, easily measured variables such as distance to central business district. Although it was a relatively unsophisticated linear axis, the technique did reveal important trends in the distribution of organisms and the rate of ecosystem processes suggesting that the concept was robust. These studies were followed by more sophisticated variables which could be categorised into three groups: 1) physical and chemical; 2) landscape structure and 3) human population density. These variables were collected and presented along transects (Medley *et al.,* 1995; Luck and Wu, 2002), or across an entire city (Hahs and McDonnell, 2006). The quantification of these variables was important in the development of the urban-rural gradient approach for it allows for the comparisons between gradients within cities and between cities. This was a significant step forward for researchers, planners and managers because it allowed for the amalgamation of ecological and social science information (Theobald, 2004).

Representing urbanisation as a continuous variable also enables more subtle gradients to be identified than when studies rely upon transects. For example, an index of urbanisation (Index *combined*) that includes both demographic and physical data can be presented for the entire city on two dimensional grids or as a three dimensional topographic representation (Fig. 1). Representing urbanisation using three dimensions presents a more accurate depiction of the non-linear, complex urbanisation gradients that occur in cities and towns. The most intensely urban areas are represented by the peaks while the less urban areas form the valleys (Fig. 1b). The depiction of urbanisation gradients in this manner clearly illustrates the “mountain range” pattern of urbanisation which occurs in most cities. This level of spatial resolution makes it possible to assess ecological and social responses to similar levels of urbanisation along the gradients (i.e., peaks with peaks) or between different levels of urbanisation (eg, peaks and valleys) along the gradients.

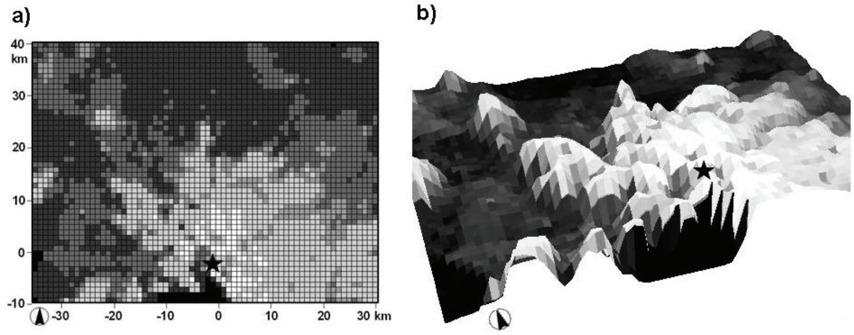


Figure 1. Values of Index *combined* across northern Melbourne, Australia represented as a) a two dimensional grid, and b) a three dimensional representation of the same data. The lighter areas represent high values of Index *combined* (45 – 55; intense urban), and the darker areas represent low values of Index *combined* (0 – 5; rural). The direction of magnetic North (), and the location of the Central Business District (★) are marked.

The large body of work that has been conducted using the urban-rural gradient approach has provided several insights into how urbanisation affects the ecology in and of cities. Our recent work in Australia has also highlighted some areas where the theory and techniques can be refined. First, it is important to explicitly define the urban-rural gradient using quantitative measures, as this allows the study to be compared with equivalent gradient studies, as well as ensuring the status of the study site is captured for the period of the study (Hahs and McDonnell, 2006). Second, we need to move beyond viewing the urban-rural gradient as a linear transect, and begin to represent gradients at the level of the city, as this will allow us to take a more sophisticated approach to defining the location of our study site within the landscape. Third, we need to improve our understanding of the measures used to define the gradient, as well as the measures used for the response variable, as the selection of specific measures can influence the findings of the study.

References

Hahs, A.K. & McDonnell, M.J. (2006) Selecting independent measures to quantify Melbourne’s urban-rural gradient. *Landscape and Urban Planning* **78**:435-448.

Luck, M. & Wu, J. (2002) A gradient analysis of urban landscape pattern: a case study from the Phoenix metropolitan region, Arizona, USA. *Landscape Ecology* **17**: 327-33.

McDonnell, M.J. & Pickett, S.T.A. (1990) Ecosystem structure and function along urban-rural gradients: An unexploited opportunity for ecology. *Ecology* **71**: 1232-1237.

Medley, K.E., McDonnell, M.J. & Pickett, S.T.A. (1995) Forest-landscape structure along an urban-to-rural gradient. *Professional Geographer* **47**: 159-168.

Theobald, D.M. (2004) Placing exurban land-use change in a human modification framework. *Frontiers in Ecology* **2**: 139-144.

Beetle assemblages along urban to rural gradients: an international comparison

J. Niemelä

Department of Ecology and Systematics – PO Box 65, University of Helsinki, Finland.
e-mail: jari.niemela@helsinki.fi

Introduction

Effects of urbanisation can be examined by using urban-rural gradients from densely built city cores to rural surroundings (McDonnell & Pickett 1990). Here, I present results of an international comparison – using the gradient approach – examining how generalisable the ecological effects of urbanisation are around the world. I illustrate how comparative, research can contribute to our understanding of urban ecology and to the development of theory.

The background of the GLOBENET project (http://www.helsinki.fi/science/globenet) is that urbanisation creates modified landscapes that exhibit similar patterns around the world. Nonetheless, little is known on whether or not these changes affect biodiversity in similar ways across the globe, or depend more on local conditions (Samways 1992). A multi-regional programme could potentially distinguish globally recurring patterns and convergence from local phenomena. Such knowledge could foster collaboration among researchers and managers in finding ways to mitigate the adverse ecological effects of urbanisation.

All over the world, urban landscapes consist of densely built cores surrounded by decreasing intensity of development and increasing 'naturalness'. These gradients can provide a framework for ecologists to examine human-induced landscape changes and compare the findings across the world to unravel generalities in biotic community structure in relation to these changes. It is important to note that in the GLOBENET project we do not compare cities *per se*, but patterns along the gradients between cities.

To assess changes in urban landscapes we have developed a programme that uses a common field methodology (pitfall trapping), one taxonomic group (carabid beetles) in visually-similar land-mosaics, in different parts of the world (Niemelä et al. 2000). Carabids are sufficiently varied taxonomically and ecologically, abundant, and are sensitive to human-caused disturbances to be a reliable monitoring group. They have been widely studied in relation to land use throughout the world (e.g. Rainio and Niemelä 2003).

Hypotheses can be derived and tested using the gradient approach. For instance, one can ask whether the intermediate-disturbance hypothesis (Connell 1978) apply to urban-rural gradients or whether the predictions about how community structure responds to stressors (Gray 1989) hold for carabids in urban environments: (a) diversity should decrease from a high in rural areas to a low in urban areas, (b) opportunistic species should gain dominance in urban areas, and (c) mean body size of the dominating species should decrease from less disturbed to more disturbed habitat (Blake et al. 1994), here from rural to urban areas.

Results and discussion

To date the GLOBENET approach has been employed at least in Sofia (Bulgaria), Edmonton (Canada), Helsinki (Finland), Debrecen (Hungary), Hiroshima (Japan) and Birmingham (England) (Alaruikka et al. 2002, Niemelä et al. 2002, Ishitani et al. 2003, Venn et al. 2003, Magura et al. 2004, Sadler et al. 2006). Generally, the carabid beetles collected in forests in these cities showed evidence of an increase in overall abundance and species richness from city centres to the rural surroundings supporting the prediction by Gray (1989), but no evidence of elevated diversity at suburban sites, as predicted by the intermediate disturbance hypothesis. However, there is variation in these patterns. Magura et al. (2004) demonstrated that the number of carabid species was significantly higher in the rural and urban areas compared to the suburban one. Thus, this result did not support the hypothesis that overall diversity should decrease in response to habitat disturbance. Many of the above-mentioned studies demonstrated, as predicted, that the dominance was usually higher in the urban and suburban zones, i.e. urban areas were dominated by few species.

The proportion of large sized carabid beetles usually decreased towards the city centres in the studies mentioned above, again as predicted by Gray (1989). Magura et al. (2006) studied the variation in carabid body size along an urban-rural gradient, and in addition to showing that small individuals were more prominent in urban areas, they demonstrated that the inequality in body size of the carabid assemblages decreased (albeit non-significantly) along the gradient from urban towards rural areas. Furthermore, many of the above studies also showed that the proportion of short winged species decreased from urban to rural areas. Moreover, the proportion of forest habitat species decreased significant from the surrounding rural environments to the city centres, while the proportion of open habitat species increased significant towards the city centres.

The GLOBENET results so far suggest that carabid beetles respond in a predictable manner to urbanisation in different cities. The challenge now is to infer process from the patterns. For example, Sadler et al. (2006) suggested that changes in assemblage structure were related to woodland fragmentation, which led to variations in woodland size, location and site disturbance due to trampling. However, species differ in their response to urbanization. Large, flightless and specialist woodland species are susceptible to changes associated with urbanization (e.g. fragmentation and disturbance), presumably due to their longer life spans, lower reproductive rates, specialized niches and limited dispersal potential.

References

Alaruikka, D; Kotze, D.J; Matveinen, K. & Niemelä, J. (2002) Carabid beetle and spider assemblages along a forested urban-rural gradient in southern Finland. *Journal of Insect Conservation,* 6: 195-206.

Blake, S; Foster, G.N; Eyre, M.D. & Luff, M.L. (1994) Effects of habitat type and grassland management practices on the body size distribution of carabid beetles. *Pedobiologia,* 38: 502-512.

Connell, J.H. (1978) Diversity in tropical rain forests and coral reefs. *Science,* 199: 1302-1310.

Gray, J.S. (1989) Effects of environmental stress on species rich assemblages. *Biological Journal of the Linnean Society* 37: 19-32.

Ishitani, M; Kotze, D.J. & Niemelä, J. (2003) Changes in carabid beetle assemblages across an urban-rural gradient in Japan. *Ecography,* 26: 481-489.

Magura, T; Tóthmérész, B. & Molnár, T. (2004) Changes in carabid beetle assemblages along an urbanisation gradient in the city of Debrecen, Hungary. *Landscape Ecology* 19: 747-759.

Magura, T; Tóthmérész, B; Lövei, G.L. (2006) Body size inequality of carabids along an urbanisation gradient. *Basic and Applied Ecology* 7: 472-482.

McDonnell, M.J. & Pickett, S.T.A. (1990) Ecosystem structure and function along urban-rural gradients: an unexploited opportunity for ecology. *Ecology,* 71: 1232-1237.

Niemelä, J; Kotze, J; Ashworth, A; Brandmayr, P; Desender, K; New, T; Penev, L; Samways, M. & Spence, J. (2000) The search for common anthropogenic impacts on biodiversity: a global network. *Journal of Insect Conservation* 4: 3-9.

Niemelä, J; Kotze, D.J; Venn, S; Penev, L; Stoyanov, I; Spence, J; Hartley, D. & Montes de Oca, E. (2002) Carabid beetle assemblages (Coleoptera, Carabidae) across urban-rural gradients: an international comparison. *Landscape Ecology,* 17: 387-401.

Rainio, J. & Niemelä, J. (2003) Ground beetles (Coleoptera: Carabidae) as bioindicators. *Biodiversity and Conservation,* 12: 489-506.

Sadler, J.P; Small, E.C; Fiszpan, H; Telfer M.G. &. Niemelä, J. (2006) Investigating environmental variation and landscape characteristics of an urban–rural gradient using woodland carabid assemblages. *Journal of Biogeography* 33: 1126-1138.

Samways, M.J. (1992) Some comparative insect conservation issues of north temperate, tropical, and south temperate landscapes. *Agriculture, Ecosystems & Environment* 40: 137-154.

Venn, S.J; Kotze, D.J. & Niemelä, J. (2003) Urbanization effects on carabid diversity in boreal forests. *European Journal of Entomology,* 100: 73-80.

The response of species to urban landscape patterns

U.M. Mörtberg

Dept of Land and Water Resources Engineering, Royal Institute of Technology, Stockholm, Sweden.
e-mail: mortberg@kth.se

Introduction

Urbanisation is affecting biodiversity across the world and to achieve sustainable development, the impacts of urbanisation on biodiversity must be considered on a landscape level (Miller & Hobbs 2002). The urbanisation process causes loss, degradation and fragmentation of natural habitats and at the same time creates new habitats. To explore and compare the consequences of these changes on biodiversity, landscape patterns and the urbanisation process need to be quantified. Further, in order to answer questions that are posed by spatial planning, more research is needed on the response of species to these changes.

Urbanisation can be seen as land use changes causing alterations in landscape patterns in terms of habitat quality, quantity and connectivity, which in turn affects ecological processes. In the same way as landscape pattern can be quantified, urbanisation can be measured in parameters such as the distance to city centres, the density of buildings, roads and of the human population, or as the gradient of fragmentation (e.g. Luck & Wu 2002). The remaining fragments of natural habitat are affected by various measurable disturbances, including management but also recreation, noise, pollution, etc. Examples of the spatial pattern of such variables in and around the city of Stockholm are illustrated in Figure 1. Further, the history of how such variables have affected the landscape is important.

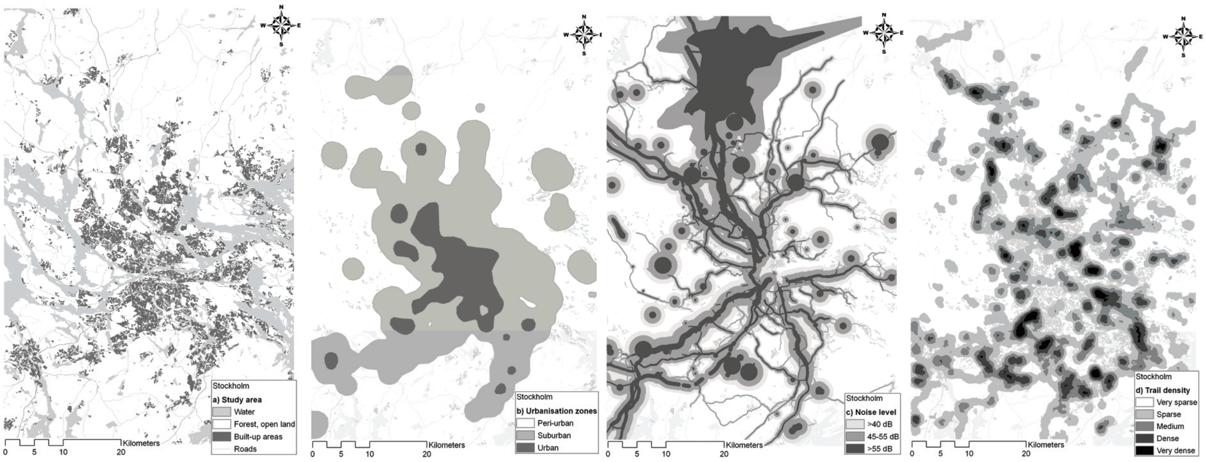


Figure 1. The city of Stockholm, the capital of Sweden (a), with urbanisation parameters; density of human population (b), noise level from road traffic, airport and other sources (c), and recreation pressure measured as trail density in nature areas (d).

Examples of urban landscape patterns affecting species' distribution

Studies in urbanisation gradients in the hemi-boreal zone have for instance shown that urban forest fragments have higher abundances of deciduous trees than the surrounding rural landscapes, where commercial forestry promotes conifers (e.g. Jokimaki 1996, Mortberg 2004). In the Stockholm area, Sweden, forest-interior bird species of coniferous and mixed forest avoid urban forest fragments, in particular those adjacent to busy roads (Mortberg & Karlstrom 2005). Urban forest fragments were more beneficial to deciduous forest birds, including several red-list species (Mortberg & Wallentinus 2000).

Both spatial and time dimensions have been addressed in studies of the large stands of native, broad-leaved deciduous trees, particularly oaks, in and around the city of Stockholm. This habitat supports a very high diversity of invertebrates, despite high disturbance levels, even though the area is relatively isolated today. However, the long historic continuity of old deciduous trees in the area, and the earlier wider distribution of the habitat may have led to a situation where the high diversity of today reflects the historical landscape pattern (Löfvenhaft & Ihse 1998). Large stands of old oaks are still left in highly urban areas, in certain parts with high or recently broken connectivity, and the maintenance and development of habitat quantity, quality and connectivity of these stands will be crucial for the diversity of invertebrates in the area (Mortberg & Ihse 2006).

These studies have shown that species respond differently to urbanisation, and the knowledge can therefore be used to plan for biodiversity in urbanised areas (Mortberg *et al*. 2006). For comparative studies of the consequences of urbanisation on biodiversity, more knowledge is needed on the response of different species to the quantified landscape pattern and processes in the urbanised landscape. Such knowledge is essential for planning and for sustainable development.

References

Jokimäki, J. (1996) Patterns of bird communities in urban environments. Dissertation. Arctic Centre Report N:o 16. University of Lapland. Rovaniemi, Finland.

Löfvenhaft, K. & Ihse, M. (1998) Biologisk mångfald och fysisk planering. Landskapsekologisk planering med hjälp av flygbildsbaserad fjärranalys - metodstudie i Stockholm. Research Report No. 108, Department of Physical Geography, Stockholm University, Stockholm. [In Swedish].

Luck, M. & Wu, J. (2002) A gradient analysis of urban landscape pattern: a case study from the Phoenix metropolitan region, Arizona, USA. Landscape Ecology 17: 327-39.

Miller, J.R. & Hobbs, R.J. (2002) Conservation where people live and work. Conservation Biology 16: 330-337.

Mortberg, U. & Ihse, M. (2006) Landskapsekologisk analys av Nationalstadsparken. Underlag till Länsstyrelsens program för Nationalstadsparken. Stockholm County Council, Report 2006:13. [In Swedish].

Mortberg, U. & Karlstrom, A. (2005) Predicting forest grouse distribution taking account of spatial autocorrelation. Journal for Nature Conservation 13: 147-159.

Mortberg, U. (2004) Landscape Ecological Analysis and Assessment in an Urbanising Environment – Forest Birds as Biodiversity Indicators. Dissertation, Royal Institute of Technology, Dept of Land and Water Resources Engineering, Stockholm. 50 pp.

Mortberg, U.M. & Wallentinus, H.-G. (2000) Red-listed forest bird species in an urban environment - assessment of green space corridors. Landscape and Urban Planning 50: 215-226.

Mortberg, U.M., Balfors, B. & Knol, W.C. (2007) Landscape ecological assessment: a tool for integrating biodiversity issues in strategic environmental assessment and planning. Journal of Environmental Management 82: 457-470.

Urban soil sealing – key indicator for urban ecological functionality and ecological planning

J. H. Breuste

University of Salzburg, Department of Geography and Geology, Hellbrunner Strasse 34/III, A-5020 Salzburg, Austria.
e-mail: juergen.breuste@sbg.ac.at

Soil sealing as urban ecological problem

Cities and towns are characterized by sealed surfaces of different types and structures (buildings, pavements etc.). Urban soil sealing is one of the main drivers of urban ecological functions and ecosystem services (climate, water balance, soil functionality, biodiversity etc.). There is not much knowledge available to quantify these functions depending and steered by soil sealing in cities. Soil sealing is everywhere growing in cities and sealed surfaces grow faster than the city itself (population, economy etc.). Urban soil sealing has been identified as key indicator for de-naturalization and destruction of urban ecosystem services – without many consequences. Planning instruments are proved to reduce soil sealing and its growth rates (Boecker 1985, Pietsch & Kamith 1991, Duhme & Pauleit 1992, Münchow & Schramm 1997, Breuste 2002).

Objectives

The following topics will be investigated on examples of Central European cities:

1. Which functions (qualities) are influenced and in what way (quantities) they are influenced?
2. For what is soil sealing a useful ecological indicator in urban ecosystems and how can it be measured and monitored?
3. How can soil sealing be typified by ecological relevant characteristics?
4. Is there an urban pattern of soil sealing depending form other factors of land use (urban structure)? Can soil sealing be indicated?
5. Why soil sealing is growing (steering processes, interest groups, stakeholders etc.) and How can soil sealing be reduced or new soil sealing be avoided by using planning and decision making instruments?

Methodology

Beside theoretically approaches and evaluation methodologies existing studies of practical investigations in the Central European cities Greifswald, Leipzig and Salzburg will be evaluated. This includes a 10 years long-term study of urban ecological changes on the example of a German city in the economic transformation process of the 90th regarding soil sealing growth. Soil sealing in urban ecosystems will be investigated on different levels (whole city, districts and sites) to identify the indicator quality for ecological functions. In Germany existing planning instruments will be proved for there ability to avoid soil sealing. New economic steering instruments will be proposed.
The expected results of ecological functionality can be transferred to other cities and towns. The specific planning instruments must be proved under different regional and local conditions. This links to a better understanding of urban ecosystems and its management.

Results

Hydrological functions (example)

The most strongly noticed risks of soil sealing are the effects on the urban water regime. High storm water run-off on the one hand and low ground water table in cities on the other hand are increasingly steered by soil sealing. This justifies extensive efforts for the analysis of the expansion and characteristics of the soil sealing (e.g. by areal photographs and satellite images) (Netzband 1998), measurements of influencing factors and urban programs to reduce soil sealing (e.g. by application of adjusting and economic instruments). A general goal of the ecological urban development must be to infiltrate a substantially larger part of the precipitation in cities than so far and by this to reduce the storm water run-off. This should reflect that the different kinds of soil sealing (pavement types) have a different infiltration capacity.

Soil sealing management

For different soil sealing types descriptions and typical characteristics can be summarized in "soils sealing catalogues". These contain statements about infiltration capacity and run-off and evaporation under different conditions of precipitation events and include the ability to assess soil sealing to improve urban environmental management (Breuste et al. 1996, 2002. Münchow & Schramm 1997).

Reduction of the sealed surfaces, improvement of their water permeability and additional decentralized infiltration belong to the necessary measure of a complex management. A necessity of this task is apart from the improvement of the monitoring methodology (remote sensing, geographical information systems) also in the technical process analysis and its spatial evaluation (experimental research and determination of sealing characteristics for different functions).

The results of ecological functionality can be transferred to other cities and towns. The specific planning instruments must be proved under different regional and local conditions. This links to a better understanding of urban ecosystems and its management.

References

Böcker, R. (1985) Bodenversiegelung - Verlust vegetationsbedeckter Flächen in Ballungsräumen - am Beispiel von Berlin (West). *Landschaft und Stadt* **17**, 57-61.

Breuste, J. (2002) Urban Ecology. In: Bastian, O., U. Steinhardt (Eds.). *Development and Perspectives of Landscape Ecology*. Kluwer Academic Publishers, Dordrecht. 405 – 414.

Breuste, J., T. Keidel, G. Meinel, B. Münchow, M. Netzband, M. Schramm (1996) Erfassung und Bewertung des Versiegelungsgrades befestigter Flächen. Leipzig (=UFZ-Bericht **12**)

Duhme, F. &. S. Pauleit (1992) Naturschutzprogramm für München: - Landschaftsökologisches Rahmenkonzept. *Geographische Rundschau* **44**, 554-561.

Münchow, B. & M. Schramm (1997) Permeable pavements – an appropriate method to reduce stromwater flow in urban sewer systems? In: Breuste, J., H. Feldmann, O. Uhlmann (Eds.). *Urban Ecology*. Leipzig. 183 – 186.

Netzband, M (1998) *Möglichkeiten und Grenzen der Fernerkundung zur Versiegelungskartierung in Siedlungsräumen.* Ph.D. thesis, TU Dresden.

Pietsch, J. & H. Kamith (1991) *Stadtböden. Entwicklungen, Belastungen, Bewertung und Planung.* Taunusstein

Suburban habitats and their role in the urban-rural habitat network: Point of local invasion and extinction?

R.B. Blair

Fisheries, Wildlife, and Conservation Biology, University of Minnesota, Saint Paul, Minnesota, 55108 USA.
e-mail: blairrb@umn.edu

Introduction

Urban and suburban habitats are becoming increasingly important to biodiversity conservation efforts in the United States. Current land-use trends show that the acquisition of parks and preserves has levelled off in the US while the amount of developed urban lands is increasing exponentially. The tipping point between these competing land uses occurred in 1990 when the amount of developed lands exceeded the amount of preserved lands (McKinney, 2002). Urban- and suburban- ization is not only an issue of the amount of land used but also of the types of habitats that it alters. Humans tend to settle in areas that are biodiversity “hotspots” which may lead to species extirpation and extinction. An assessment of economic associations causing species endangerment in the US found that urbanization was the second most common factor associated with declines of species on the Endangered Species List; only “interactions with invasive species” outranked urbanization in the number of species that each endangered (Czech et al., 2000).

Because of this, suburban habitats may play an important role in biodiversity conservation; however, they also present a conundrum. Typically, suburban habitats in an urban-rural habitat network of naturally forested areas contain less than half of the native woodland bird species that would exist at these sites if they were not developed. They also contain more total bird species than if these sites were left in a natural state (Blair, 2002). This apparent contradiction raises the questions “How do suburban habitats function in the urban-rural habitat network?” Do these habitats serve as points of local extirpation for urban-avoiding, woodland species? Do they function as points of local invasion for urban-exploiting species? Are they potentially useful for the conservation of the species that are suburban-adapters?

Methods

In this study, I analyze bird distribution data for three rural-to-urban gradients in different cities and ecoregions of the United States: Palo Alto, California; Oxford, Ohio; and Saint Paul, Minnesota. Each gradient consists of six sites of increasingly urban land use: a preserve, an open-space recreational area, a golf course, single-family detached housing, industrial park, and a business district. Each of these sites contains sixteen sampling points, which were surveyed multiple times over two breeding seasons in order to obtain estimates of the densities of all species. I used these density estimates to identify patterns in species distributions and community measures including species richness, Shannon diversity, and evenness. I also used these density estimates to characterize the bird communities in each site with respect to life history characteristics and nesting attributes based in a literature review. Finally, I used various community ordination techniques to compare bird communities within individual gradients as well as across the three ecoregions to examine landscape factors that play a role in bird distributions and to assess whether urbanization is leading to a more homogeneous fauna nationwide.

Results

The patterns of bird distribution in all three ecoregions were remarkably similar. Each region had species that were distinct urban avoiders, species that existed only in the most undisturbed woodlands. Each had a majority of species that were suburban adaptable with highest densities at intermediate levels of development. Each had a small subset of species that were urban exploiters having their highest-densities in the most urbanized sites. The community compositions transitioned gradually across all three gradients with the highest species richness and diversity occurring at intermediate sites of development. In contrast, the most natural and the most developed sites had lower species richness and most urban sites having the fewest species, the greatest number of exotics, and the lowest evenness.

This patterning suggests that suburban land uses, those represented by the intermediate levels of development on the gradients, are a point of extirpation for woodland birds along the gradient as well as an entry point for invasive species into urban systems. Characteristics of the woodland species that go locally extinct include a narrow diet breadth, a single brood strategy, strong territoriality, and a dependence on high nesting sites. Characteristics of the invading species include broad diet breadth, a multiple brooding strategy, a lack of territoriality in the breeding season, and the ability to occupy a variety of nesting substrates.

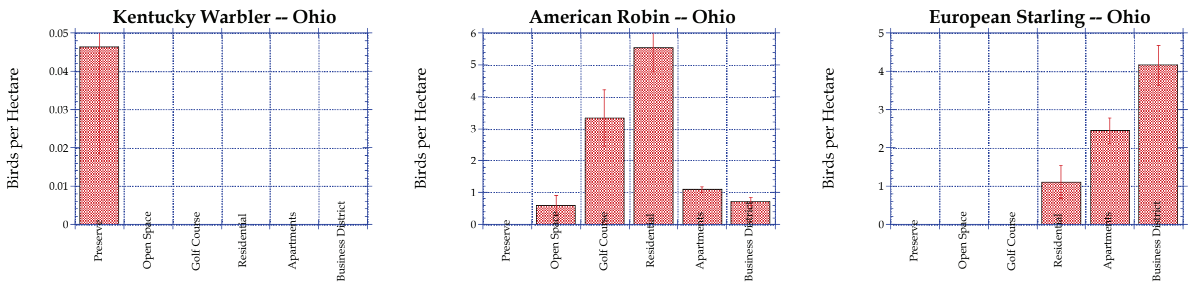


Figure 1. Typical pattern of local extinction and invasion across a rural-urban gradient.

Discussion

Suburban habitat is a growing component of the landscape in the United States and is consistently ranked as a major cause of endangerment. Consequently, understanding the dynamics of extinction and invasion in suburbia is vital to comprehensive conservation planning. Research from three different ecoregions of the United States (California, Ohio, and Minnesota) suggests that urban-avoiding species, including many neotropical migrants such as Kentucky warblers, are replaced by the urban-exploiting species, including many invasives such as European starlings. This substitution of species appears to be driven by differences in the life histories of these groups and suggests that reproductive strategies may be the key to urban exploitation.

References

Blair, R.B. (2002) The effectsof urban sprawl on birds at multiple levels of biological organization. *Ecology and Society* **Volume:9** 2, url www.ecologyandsociety.org/vol9/iss5/art2.

Czech, B.; Krausman, P.R. & Devers, P.K. (2000) Economic associations among causes of species endangerment in the United States. *BioScience* **Volume:50** 593-601.

McKinney, M.L. (2002) Urbanization, biodiversity, and conservation. *BioScience* **Volume:52** 883-890.

Suburban business and industrial sites: an unexplored opportunity for biodiversity conservation?

R. Snep, W. Timmermans, V.Kuypers

Alterra – Wageningen UR, P.O. Box 47, 6700 AA Wageningen, the Netherlands.
email: robbert.snep@wur.nl

Introduction

Business and industrial sites are exclusively designed and managed to provide firms an optimal location for establishment. Often they are situated at the city's edge, nearby important road infrastructure and with extra land available for future expansions. As the fabrication, storage and transport of commodities and goods are main activities, large assembling halls and parking lots dominate the land use of business and industrial sites. Their large portion of paved area and buildings makes them not the first place to think of biodiversity, and earlier research (Blair,2001) confirmed the general idea that business and industrial sites have little to offer for nature.

We, however, think that business and office sites have a certain value for biodiversity conservation, at least in potential. In our research we found several clues that supported this idea, and below we formulate and explain our findings:

I - The land use at business and industrial sites offers space for interesting habitats.

The high turnover rate of companies at business sites, the overcapacity of land as reserved for future expansions and the aim to keep urban green maintenance as low as possible create the perfect conditions for pioneer vegetations. After the business site has been prepared, an open area with sandy soil is waiting for further development. If this development takes several years to start, these vacant lots become habitat for pioneer species that quickly colonize the bare soil. Among them are endangered plant and animal species which habitat has become rare.

With respect to the buildings at business and industrial sites, most of them have flat roofs (e.g. assembling halls). These roofs offer space for coastal birds (if covered with gravel) or other bird species and many flying invertebrates (if designed as a green roof). Current data show that plant and animal species easily colonize flat roofs if designed and managed in the right way.

II – The suburban location of business and industrial sites adds to the habitat value these sites have for biodiversity conservation

Most business sites are situated at the transition from urban to rural land, thereby being a perfect stepping stone location for plants and animals that migrate between cities and their surroundings. Snep et al. (2006) illustrated how habitat patches at the city's edge could act as source area for butterflies that colonize the city's interior habitats. As expected the dispersal capacity of the species and the size of the suburban source population determine the range and impact of the suburban butterflies on the inner-city butterfly population. Green business sites, designed and managed optimally to serve as butterfly habitat (without losing their economic function) could as such strengthen butterfly populations in the adjacent residential areas.

III –Business and industrial sites may already contain high biodiversity values

Preliminary results from a breeding bird survey of 23 business and industrial sites in the Netherlands showed a list of 90 different bird species, of which 18 appear on the national Red List of Endangered Bird Species. Among them the Grey partridge that occurred on at least 6 business sites (Snep et al. in prep).

The largest population of the Natterjack toad in Flanders (northern Belgium) can be found in the Port of Antwerp, where in the period 2003-2005 a chorus of approximately 1250 calling males was recorded. Such large numbers are rarely observed in other habitat areas, and this makes this port area a national hotspot for this endangered and highly protected amphibian species (Snep and Ottburg in prep).

The data on breeding birds and amphibians illustrate the habitat value that current business and industrial sites possess in some occasions, although it is clear that not all sites contain high biodiversity values.

IV – Biodiversity conservation at business and industrial sites may provide benefits for People, Planet and Profit

Cardskadden and Lober (1998) stated that nature conservation at corporate land result in more benefits than for nature only. Firms that participate in nature conservation programs of the Wildlife Habitat Council (WHC) improve their social status by showing environmental awareness and concern for decreasing biodiversity levels and employees of those firms enjoy their working environment much better. In addition, nature conservation measures (like green roofs and green design) could reduce costs by better roof isolation and extension of business site's life time (urban green helps to hold the estate value of the business site). Altogether green and ecological managed business and industrial sites may contribute to a better quality of business and office sites for People, Planet and Profit.

References

Blair, R.B. (2001). Creating a homogeneous avifauna (Chapter 22) In: Marzluff, J.M., R. Bowman & R. Donelly 2001. *Avian ecology and conservation in an urbanizing world*. Kluwer Academic Publishers, Dordrecht, the Netherlands. 459-486.

Cardskadden, H. and D.J. Lober (1998). *Environmental stakeholder management as business strategy: the case of the corporate wildlife habitat enhancement programme*. Journal of Environmental Management 52 (2): 183-202.

Snep, R.P.H., P.F.M. Opdam, J.M. Baveco, M.F. WallisDeVries, W. Timmermans, R.G.M. Kwak & V. Kuypers (2006). *How peri-urban areas can strengthen animal populations in cities: a modeling approach.* Biological Conservation 127: 345-355.

Snep, R.P.H. et al. (in prep). *Breeding birds of business and office sites and industrial areas in the Netherlands. Determining land use factors that optimize business site habitats for birds.*

Snep, R.P.H. and F.G.W.A. Ottburg (in prep). *A habitat backbone as nature conservation concept for industrial areas – the case of the Natterjack toad Bufo calamita in the Port of Antwerp (Belgium).*

Biodiversity in urban habitat patches: habitat quality matters

J.P. Sadler, P.G. Angold

School of Geography, Earth and Environmental Sciences, Birmingham University, Edgbaston, Birmingham B15 2TT, UK.
e-mail: j.p.sadler@bham.ac.uk

Introduction

In cities the biological processes of dispersal interact with the landscape structure in determining the distribution of populations of species present (Niemelä, 1999). Many cities have a network of habitat fragments or 'urban greenways' comprising areas of semi-natural habitats, secondary succession, ruderal and pioneer environments and open areas. These habitats may be important features for biodiversity both as stable and as transient habitats (McIntyre et al., 2000; 2001), and may also be valuable for their possible function as 'corridors' and 'stepping stones' to facilitate species dispersal (Kirkby, 1995).

This research aimed to: (i) examine the effects of habitat fragment size and connectivity upon the ecological diversity and species distributions, and (ii) analyse the extent to which the flora and fauna utilise the 'urban greenways' as corridors and as habitats.

Methods

Study area

The West Midlands conurbation comprises the City of Birmingham and several boroughs collectively known as the Black Country. Birmingham City has a population of one million, with an estimated 6 million others living within a 50 mile radius of the city. The city covers 27,000 hectares, 11% of the land cover is green space in the form of parks, and the city includes approximately 4000 hectares of semi-improved neutral grassland, pockets of ancient woodland, and 250,000 domestic gardens.

Study groups

The project comprised four components involving empirical survey work of both plants and ground beetles (Carabidae) on a range of habitats (derelict, wetland and woodland), a genetic study of four species of grassland butterflies, an examination of the plant communities and hemeroby (Hill et al., 2002) and spatial modelling of mammal populations.

Landscape metrics (e.g. patch size, distance to corridor, area of similar habitat within 100, 1000 and 5000m zones around the sites) were captured in a GIS and related to species metrics in GLM models and using multivariate analyses.

Results

Landscape context

Plants showed little relationships to the landscape metrics although site size ($p<0.05$) and the proximity of the nearest similar sites were significantly for a few (25 out of 378 species) ($p=0.05$). Similarly, for the invertebrates, habitat (patch) quality appears to be the significant factor rather than landscape structure. For example, overall species richness and the number of specialist wetland and derelict land beetles was related to site variables such as age ($p=0.036$) and vegetation type ($p<0.001$), with only limited links to landscape variables (e.g. the amount of similar habitat within 1000m of the sites, $p=0.003$) (Small et al. 2003).

The level of disturbance from recreational users heavily influenced woodland carabid communities. This was most clearly illustrated by increasing dominance of a few ubiquitous urban generalists (e.g. *Pterostichus madidus*) (df=2,21; F=12.345; $p=0.001$) and the decline of the woodland (e.g. *Cychrus carabioides)* (df=2,21; F=8.842; $p=0.002$), and other large-bodied species (e.g. *Cararbus spp.*) (df=2,21; F=19.858; p=<0.001). Although typically of secondary importance landscape effects such as site size, the amount of built up and wooded land within 5km of the sample sites were significantly ($p<0.05$) related to the woodland beetle assemblages indicating some structuring of assemblages as a result of woodland fragmentation and isolation (Sadler et al. 2006).

Corridor proximity

Plant communities of derelict sites showed no greater similarity to each other if adjacent or close to designated urban corridors, suggesting that the corridors do not increase connectivity. Out of a pool of 433 plant species only 7 were positively associated with corridors ($p<0.005$) and these were either invasive wetland species (*Impatiens glandulifera*) or associated with wetlands or disturbed areas (e.g. *Lipinus polyphyllus*). We found no evidence that wetland specialist ($r^2 = 0.0077$) nor derelict specialist (r^2 0.005) beetle diversity is greater on or near the corridors, and no evidence that corridors are necessary for dispersal of butterflies (Wood and Pullin 2003).

Spatially explicit models suggest that dormice and water voles may depend on linear habitats for dispersal and small and medium sized mammals (Muntjac deer) could use corridors. However, this is not the case for plants and invertebrates (Angold et al. 2006).

Implications: planning for wildlife in the urban environment

Although a complex picture, this research provides little evidence that urban greenways affect plants or invertebrate assemblage structure. Similarly, in only a few cases was the landscape structure of the conurbation an influential factor in structuring the communities. The results are consistent with the hypothesis that most urban species are able to move freely around the city. However, there are groups of species (with particular traits) and habitats with particular characteristics (e.g. more stable such as woodlands) where the impact of urbanization is extremely negative. These findings indicate: (i) the importance of identifying a target species or group of species for urban greenways intended as dispersal routeways, and (ii) the maintenance of good quality habitat for other organisms.

References

Angold, P.G., Sadler, J.P., Hill, M.O., Pullin, A., Rushton, S., Austin, K., Small, E., Wood, B., Wadsworth, R., Sanderson, R., & Thompson, K. (2006) Biodiversity in urban habitat patches. *Science of The Total Environment*, **360**, 196-204.

Hill, M.O., Roy, D.B. & Thompson, K. (2002) Hemeroby, urbanity and ruderality: bioindicators of disturbance and human impact. *Journal of Applied Ecology*, **39**, 708-720.

Kirby, K. (1995) *Rebuilding the English countryside: habitat fragmentation and wildlife corridors as issues in practical conservation* English Nature Science, No 10, Peterborough.

McIntyre, N.E. (2000) Ecology of urban arthropods: A review and a call to action. *Annals of the Entomological Society of America*, **93**, 825-835.

McIntyre, N.E., Rango, J., Fagan, W.F., & Faeth, S.H. (2001) Ground arthropod community structure in a heterogeneous urban environment. *Landscape and Urban Planning*, **52**, 257-274.

Niemelä, J. (1999) Ecology and urban planning. *Biodiversity and Conservation*, **8**, 119-131.

Sadler, J.P., Small, E.C., Fiszpan, H., Telfer, M.G., & Niemela, J. (2006) Investigating environmental variation and landscape characteristics of an urban-rural gradient using woodland carabid assemblages. *Journal of Biogeography*, **33**, 1126-1138.

Small, E., Sadler, J.P., & Telfer, M. (2006) Do landscape factors affect brownfield carabid assemblages? *Science of The Total Environment*, **360**, 205-222.

Wood, B.C. & Pullin, A.S. (2002) Persistence of species in a fragmented urban landscape: the importance of dispersal ability and habitat availability for grassland butterflies. *Biodiversity and Conservation,* 11, 1451-1468.

Patterns of exotic species invasion in fragmented native grasslands along urban-rural gradients in South Africa and Australia

S.S. Cilliers*[1], N.S.G. Williams[2] & F.J. Barnard[1]

[1] School of Environmental Sciences and Development, North-West University (Potchefstroom Campus), South Africa,
e-mail: Sarel.Cilliers@nwu.ac.za
[2] Australian Research Centre for Urban Ecology, Royal Botanic Gardens, Melbourne, Victoria, Australia

Introduction

Temperate grasslands are one of the world's major biomes and include some of the most diverse and productive terrestrial ecosystems (Suttie *et al*., 2005). In both South Africa (Cilliers *et al*., 2004, Van Jaarsveld *et al*., 1998) and southeastern Australia (Williams *et al*., 2005a, Kirkpatrick *et al*., 1995) native grasslands have been severely fragmented by agricultural and urban development and few are protected in conservation areas. However, high quality patches of native grasslands of conservation importance persist, in urban and rural landscapes in both countries (Cilliers *et al*., 1999, Kirkpatrick *et al*., 1995). Fragmented habitats have higher perimeter to surface area ratios than continuous habitats and are thought to be vulnerable to invasion by exotic species via edge effects. Recent research in Victoria, Australia indicates that grasslands surrounded by different landscapes exhibit substantially different patterns of exotic species invasion. Rural grasslands had sharp well defined edges dominated by exotic species which declined with distance from edge while urban grasslands exhibited a variety of patterns but most lacked defined edges and had a moderate to high exotic cover across the sites (Williams 2005). In this study we examine the generality of these results by comparing structurally similar remnant grasslands dominated by the same species (*Themeda triandra*) on two continents.

Methodology

Study sites were located in Victoria, Australia and North-West Province, South Africa. The vegetation of rectangular, linear grassland fragments with straight edges adjacent to roads and railways within two landscape matrix types (rural and urban) were surveyed. Urban and rural areas were distinguished from each other based on the total length of roads surrounding the fragment. Sites were surveyed with transects running perpendicular to the two longest sides of the grassland remnant. Percentage cover of all vascular plant species (distinguishing between natives and exotics) were recorded in quadrats spaced evenly along the transect. A variety of edge detection methods were used to determine the depth of edge influence.

Results

Edge effect boundaries at most rural grasslands were sharp and continuous with a relatively short depth of edge influence (Fig.1a,b). Edges of urban grasslands were more difficult to characterize but most had a greater depth of edge influence (Fig. 1 c,d). These studies indicated that urban grassland edges have responded differently to fragmentation than rural grasslands. Similar patterns were observed on different continents suggesting that urbanization is a ubiquitous process that modifies edge effects in a similar manner despite very different environmental, historical and social conditions in the cities examined.

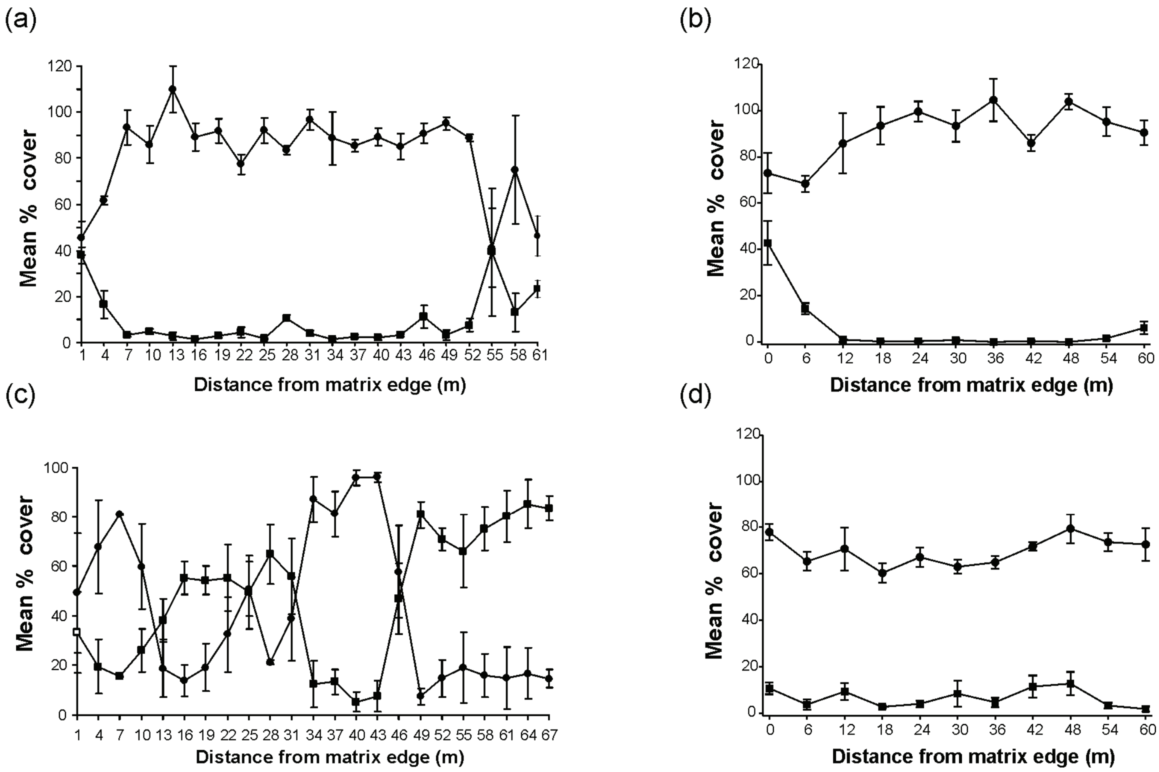


Figure 1. The mean percentage cover of native (●) and exotic (■) species across two representative rural native grassland remnants in a) Western Victoria, Australia and b) North-West Province, South Africa and across two representative urban grassland remnants in c) Melbourne, Australia and d) Potchefstroom, South Africa.

References

Cilliers, S.S., Van Wyk, E. & Bredenkamp, G.J. (1999) Urban nature conservation: vegetation of natural areas in the Potchefstroom municipal area, North West Province, South Africa. *Koedoe* **42**: 1-30.

Cilliers, S.S., Müller, N. & Drewes, J.E. (2004) Overview on urban nature conservation: situation in the western-grassland biome of South Africa. *Urban Forestry and Urban Greening* **3**: 411-419.

Kirkpatrick, J., McDougall, K. & Hyde, M. (1995) *Australia's most threatened ecosystem: the southeastern lowland native grasslands*. Surrey Beatty & Sons, Chipping Norton.

Suttie, J.M., Reynolds, S.G. & Batello, C. (2005) *Grasslands of the World*. Plant Production and Protection Series No. 34, Food and Agriculture Organization of the United Nations, Rome.

Van Jaarsveld, A.S., Ferguson, J.W.H. & Bredenkamp, G.J. (1998) The Groenvaly grassland fragmentation experiment: design and initiation. *Agriculture, Ecosystems and Environment* **68**: 139-150.

Williams, N.S.G. (2005) *The ecology of fragmented native grasslands in urban and rural landscapes.* PhD thesis. University of Melbourne, Australia.

Williams, N.S.G., McDonnell, M.J. & Seager, E.J. (2005) Factors influencing the loss of an endangered ecosystem in an urbanizing landscape: a case study of native grasslands from Melbourne, Australia. *Landscape and Urban Planning* **71**: 35-49.

Predicting land cover change and avian community responses in rapidly urbanizing environments

J.A. Hepinstall[1], M. Alberti[2], J. Marzluff[3]

[1]Warnell School of Forestry and Natural Resources, University of Georgia, Athens GA, USA
e-mail: jhepinstall@warnell.uga.edu,
[2]Urban Ecology Research Laboratory and [3]College of Forest Resources, University of Washington, Seattle WA, USA.

Introduction

Predicting future landscape change is essential to inform the planning process and conservation efforts. Land transformation increasingly is a major threat to biological diversity in the USA and elsewhere in temperate regions of the globe (Sala et al. 2000). The influence of rapid urbanization is particularly evident in the western USA (Hansen et al. 2005). While we are beginning to understand how local urbanization processes influence biodiversity, we know much less about how these altered processes of extinction and colonization will play out through time.

Linking predictions from landscape change models to ecological models is generally accomplished by developing spatially explicit habitat models (Schumaker 2005). We build on such approaches by linking outputs from a sophisticated model of urban development (UrbanSim) to a Land Cover Change Model (LCCM) we developed that incorporates concepts central to landscape ecology in the prediction of land cover change 25 years into the future for the Seattle, USA, metropolitan region - a region undergoing rapid urbanization with 31% growth predicted (1 million people) in the next 25 years. Predicted land cover and land use are then used as input into avian diversity models to predict the influence of urbanization on biodiversity.

Methods

Land cover: The LCCM framework derives from the traditions of modelling landscape change as a dynamic interaction between socio-economic and biophysical processes (e.g., Wear et al. 1998). In the LCCM, transition probability equations are estimated empirically from observed land cover in 1991, 1995, and 1999 for ten land cover classes as a function of 65 potential explanatory variables. Transition probabilities for each 30-m pixel to change land cover class is hypothesized to be influenced by land use change and intensity of development predicted by UrbanSim, a set of local and attributes of the pixel, the spatial context of a site, and variables representing observed change.

Birds: Linear regression models were developed to predict both avian species richness (a total of 57 common species and three habitat guilds) and individual species relative abundance as a function of a series of landscape habitat metrics calculated for 139 1-km^2 field sites. Ten landscape variables describing land cover and land use patterns were developed for consideration. Land cover variables included: percent forest, percent urban, aggregation of forest, number of patches of forest, and number and mean patch size of urban patches. Land use derived from parcel data was used to calculate the percent, patch density, and aggregation of residential parcels, and mean year built of all parcels within each study site. Equations were applied to UrbanSim land use and LCCM land cover outputs to predict changes in avian biodiversity at two scales.

Results

Land cover: Predictions of land cover from 2003 to 2027 show a decrease in mature forest types (deciduous, mixed, and coniferous) from 60% of the study area to 38% and an increase in developed land (heavy-, medium-, and low-intensity urban classes) from 17% to

34%. Land in grass and agriculture use decreased from 14% to 10% of the area. Harvested and regenerating forest increased from 9% in 2003 to 18% in 2027. Most landscape change is concentrated in areas surrounding currently developed lands (i.e., expansion growth), with little infill or outlying new patches of development – the latter primarily occurring along lower elevations and up river valleys. Comparisons of land cover observed in 2002 and predicted for 2003 indicate higher agreement in the amount and location of change when considered at aggregate scales of $1km^2$, the scale of our avian models.
Birds: Mean total avian species richness for the study area is predicted to decline from 36 to 31. Within the region, urban and urbanizing zones are expected to see the greatest decline in total species. Changes in species richness are concentrated in those regions of the study area where land cover change is most dramatic – primarily in the urbanizing zone where forest loss and aging of developments cause the greatest changes in land cover. We expect future bird communities to be slightly less diverse and more vulnerable to future losses than they are at present. We expect native forest birds to become increasingly reliant on higher elevation forests as most low elevation forests will be converted to development too dense to support viable populations. High elevation bird populations may be less sustainable due to harsher winters and shorter growing seasons that may limit survival and reproduction.

Significance

Our results clearly indicate that landscape change in the Seattle metropolitan region is likely to be extensive over the next 25 years and that both landscape composition and configuration resulting from urbanization are important in determining avian species richness. By showing how birds generally respond to the amount, configuration and age of development we can provide planners with relevant tools to better understand how their decisions concerning zoning, housing density, and designation of conservation areas affect bird communities. With the increasing ubiquity of spatial data and GIS skills, even local planning offices can develop and apply such tools. Fostering ecosystem functionality is an important supplement to land use and land cover planning efforts requiring less manicured yards with minimal grass, letting trees die and rot, enabling native predators like coyotes to live in our neighbourhoods, and seeing the good that comes from natural disturbances. Tending to our lifestyle as well as our land cover will be increasingly important to future bird diversity if the changes we expect in the next 25 years occur.

We have shown how models of urban development can be translated into changes in land cover and how these changes can be projected to affect the abundance and diversity of birds in a rapidly urbanizing region. Models used and developed have been written in open source code (primarily Python) and are transferable and reuseable in other urbanizing regions.

References

Hansen, A.J., Knight, R.L., Marzluff, J.M., Powell, S., Brown, K., Gude, P.H. & Jones, K. (2005) Effects of exurban development on biodiversity: patterns, mechanisms, and research needs. *Ecological Applications* **15**:1893-1905.

Sala, O.E. et al. (2000) Global biodiversity scenarios for the year 2100. *Science* **287**:1770-1774.

Schumaker, N.H., T. Ernst, T., White, D., Baker, J. & Haggerty, P. (2004) Projecting wildlife responses to alternative future landscapes in Oregon's Willamette Basin. *Ecological Applications* **14**:381–400.

Wear, D.N., Turner, M.G. & Naiman, R.J. (1998) Land cover along an urban-rural gradient: implications for water quality. *Ecological Applications* **8**: 69-630.

2.4 Workshop on current and future research in urban ecology

Preservation of pastures as parts of the urban green infrastructure at Järvafältet, Stockholm: risk of damage caused by man?

C. Florgård

Swedish University of Agricultural Sciences, Department of Urban and Rural Development, Unit of Landscape Architecture, Box 7012, UPPSALA, Sweden
e-mail: clas.florgard@sol.slu.se

Introduction

As cities grow, they usually spread out into their rural surroundings. Lately, interest in preservation of the original vegetation in these surroundings (woodlands, meadows, pastures etcetera) as parts of the future green infrastructure has increased. This planning and design approach includes many functional, economic, biological, social and aesthetic advantages. In Sweden, the preservation of pastures in cities has often been combined with the preservation of ancient grave-fields. These grave-fields have often been used for grazing during centuries, and have become a grass and herb vegetation with high biodiversity, great beauty and great attractiveness to people (Hägerhäll 1999). In contrast to grazing in e. g. Africa and South America, where grazing often is a threat to the vegetation (Primack 1993), grazing is a prerequisite of the survival of these important vegetation types.

However, trampling might damage the vegetation. This might result in damage to the ground layer vegetation, which in turn can result in damage to the ground. The heritage authorities have claimed that the risk for erosion because of trampling is too high, and that the areas have to be excavated instead of preserved, with loss of biodiversity and amenity.

The aim of this paper is to elucidate the risk of damage of pastures preserved as parts of the urban green infrastructure.

Methods

Two pastures (called A and B) on ancient grave-fields in Stockholm have been studied. The surroundings were developed for residential houses in 1954-55 and in 1974-75, respectively. Area B was studied from the time before development, during development of the surroundings of the pastures, and during later use by the local inhabitants. Both areas are directly bordering on roads. The distances to residential houses and schools are 100 m (area A) and 7 m (area B).

The evaluation method used was triangulation according to Yin (1994). The following sub-methods were used: photographing from fixed points, analysis of aerial photos from the time before and after development, and for area B observations documented on sketches and vegetation analysis of fixed vegetation investigation plots. Area A was studied 1978-2006, and area B was studied 1972-1982, 1987 and 2003-2006. The results of the analyses were compared to the results of studies of areas where grazing has been abandoned.

Results

Grazing in both areas was heavy before development. After development, grazing in area A was abandoned. Area B was established as a grazing area for a “city farm” with horses and sheep. Grazing was assessed as heavy 1976, after that light, and in 2006 abandoned.

The intensity of trampling at area B and its surroundings has been presented in Florgård & Forsberg (2007). This so called border area at a distance of less than 100 metres from residential houses was not much used by the inhabitants, but nevertheless much more used than large recreation areas at a distance of 1000-2000 m from the built-up area. Area A was more used than area B. Damage caused by resident’s trampling and other wear and tear was found to be rare in area A and could not be detected in area B.

Both areas are now more or less overgrown with bushes, shrubbery and trees, concerning area A see Figure 1. Overgrowth has started from former forest edges, and has been spreading throughout the area. The vegetation development will be analysed further, but preliminary results imply that the species richness was lost and herbs were exchanged by grass.

Discussion and conclusions

The pattern of the overgrowth is the same as have been found in many studies where grazing was abandoned (see e. g. Bakker 1989, Glimskär & Svensson 1990). The conclusion is that the wear by the residents is much less than that formerly caused by the cattle. The trampling by the residents is so much less so these formerly open areas are overgrown by bushes and trees. This overgrowth is a severe threat to the areas in many ways. Firstly, the biodiversity will decrease and they will lose their biological value. Secondly, they will lose their amenity. And thirdly, if big trees grow on the graves, they can be damaged if the trees are felled and uprooted by wind. Instead of man’s wear being a threat, the lack of trampling becomes a threat. Management plans for the areas are needed.

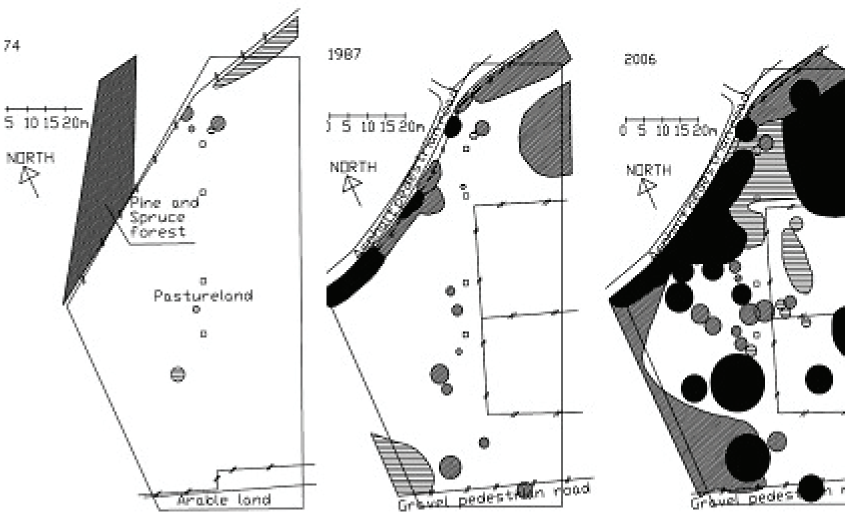


Figure 1. Distribution of bushes, shrubbery and trees 1974 (start of development), 1987 (13 years after development, and 2006 (32 years after development). = Bushes, shrubbery <2 m, = Bushes, shrubbery, trees 2-6 m, = Bushes, shrubbery, trees >6 m, = Fence, = Vegetation analysis plot.

References

Bakker, J. P. (1989) *Nature Management by Grazing and Cutting.* Kluwer, Geobotany 14, Dordrecht/Boston/London.

Florgård, C. & Forsberg, O. (2006) Residents’ use of remnant natural vegetation at the residential area of Järvafältet, Stockholm. *Urban Forestry and Urban Greening 5(2):83-92.*

Glimskär, A. & Svensson, R. (1990) *Vegetationens förändring vid gödsling och ändrad hävd.* Swedish University of Agricultural Sciences, Department of Ecology and Environment, Report 38, Uppsala.

Hägerhäll, C. (1999) *The experience of Pastoral Landscapes.* Swedish University of Agricultural Sciences, Agraria 182, Uppsala.

Primack, R. B. (1993) *Essentials of Conservation Biology.* Sinauer, Massachusetts, USA.

Yin, R. K. (1994) *Case Study Research. Design and Methods. Second Edition.* Sage, Thousand Oaks/London/New Delhi.

Urban semi-natural vegetation and the ecological functioning of urban green space at the landscape scale

A. Millard

School of Architecture, Landscape and Design, Leeds Metropolitan University, Hepworth House, Leeds LS2 8AE, UK
e-mail: a.millard@leedsmet.ac.uk

Introduction

It has long been recognised that urban habitats can support a higher diversity of plant species than the surrounding countryside (Gilbert, 1989). Two primary reasons suggested for this are the heterogeneity of the urban landscape and the relatively high number of alien (non-native) species available (Kowarik, 1995). The potential pool of native and non-native species is subject to a complex of natural and anthropogenic processes.
There is conflicting evidence as to how far urbanisation can increase native species diversity or the extent to which alien species are displacing native ones. However, there is mounting evidence for the importance of urban landscape heterogeneity in supporting greater species diversity overall (Waniaa *et al*., 2006). Roy *et al*. (1999), however, found no evidence that urban landcover increases overall plant species richness. Their data did suggest that complete urbanisation doubles the proportion of alien species and that the availability of urban habitats, together with high levels of disturbance, are important factors in maintaining the urban flora.
Roy et al. (*ibid*) looked at Britain as a whole, sampling tetrads (2km squares) from across the country and using the two categories of urban landcover from the Landcover Map of Great Britain, suburban/rural and urban development. This abstract reports on work in progess which also examines the relationship between species composition and urban land cover, but at a smaller scale and utilising a greater number of urban land cover categories.

Method

Plant species' records have been obtained from a survey of tetrads (2x2km squares) across a contiguous area of urban and peri-urban landscape in West Yorkshire, northern England (Abbott, 2005). Species have been categorised into native, archeophyte, neophyte and casual. The nature and extent of urban green space within a tetrad is being determined from GIS vector datasets, supported by examination of aerial photographs at a resolution of 12.5cm. Analysis of data is focusing on spatial variations in the relative abundance of the different categories of semi-natural flora in urban areas and how these might be related to variations in the extent and nature of urban green space.

Preliminary results

<u>Species richness and urban green space</u>
Analysis of the data is currently at an early stage but preliminary observations suggest no clear relationship between tetrad species richness and either the extent or the nature of urban green space. Neither is there a clear relationship between species richness and the distance of a tetrad from the city centre. However, three of the four richest tetrads do include the largest areas of open space that have been designated for their nature conservation value, within the built-up part of the study area

<u>Categories of species</u>

As with total species richness, the different categories of species (natives, archaeophytes, neophytes and casuals) show no obvious relationship between extent or nature of urban green space. However, the percentage of native species in those three species-rich tetrads encompassing significant designated nature conservation areas is very close to the mean for the study area as a whole. A combination of the additional archaeophytes, neophytes and casuals has contributed markedly to the relative species richness of these three tetrads.

Management of urban green space and plant biodiversity conservation

There is some suggestion from the data that management of urban green space for biodiversity conservation, implicit in the designation of particular areas, may have effects at the landscape scale. However, this is far from conclusive and it is by no means certain that further analysis of the available data will resolve this question convincingly. The complex of natural and anthropogenic factors operating on fully urbanised- and suburban/peri-urban areas is likely to mean that conservation management policies directed at particular sites will have very limited effects on urban plant species composition at the landscape scale.

References

Abbott, P. (2005) Plant Atlas of Mid-west Yorkshire. Yorkshire Naturalists' Union.

Gilbert, O. (1989) The ecology of urban habitats. Chapman & Hall, London.

Kowarik. I. (1995) On the role of alien species in urban flora and vegetation. In: Pysek. P. ct al. {eds). Plant invasions:general aspects and special problems, SPB Academic Ptibl.. pp, 85-103.

Roy, D.B.; Hill, M.O. & Rothery, P. (1999) Effects of urban land cover on the local species pool in Britain. Ecography 22: 507-515.

Waniaa, A..; Kühnb, I. & Klotz, S. (2006) Plant richness patterns in agricultural and urban landscapes in Central Germany—spatial gradients of species richness. Landscape & Urban Planning 75 (1-2): 97-110.

Can biological traits help to explain changes in plant communities along a rural-urban gradient?

J. Vallet[1,2], H. Daniel[1,2], V. Beaujouan[2], F. Rozé[3]

[1] Institut National d'Horticulture, UMR A462 SAGAH, 2 rue Le Nôtre, 49045 Angers France. E mail: Jeanne.Vallet@inh.fr
[2] Institut National d'Horticulture, UP Paysage, 2 rue Le Nôtre, 49045 Angers France.
[3] Université de Rennes 1, UMR 6553 Ecobio, Campus de Beaulieu, Avenue du Général Leclerc, Rennes France.

Introduction

The current growth of cities is regarded as one of the major threats to the conservation of biological diversity (Czech*, et al.*, 2000, McKinney, 2006). One important challenge in urban ecology is to better understand the relationships between biological traits of species which are more or less adapted to city environments and a defined set of environmental conditions found in cities. In our study we analysed the relationships between biological traits of spontaneous plants found in woodlands and a rural-urban gradient.

Material and methods

The study was undertaken in Angers, a city in western France. The Angers conurbation has about 270 000 inhabitants. Fifteen woodland plots of about 1 ha were surveyed along a rural-urban gradient stretching from the city centre to a distance of 10 kilometres. Plots were comparable in term of their geological substrate, canopy layer (deciduous trees, mainly oak) and their vegetation was dominantly indigenous (Florgard, 2000, Millard, 2004).
Data were in three tables (Fig. 1): R (environmental variables table), L (species composition table), Q (biological traits table).

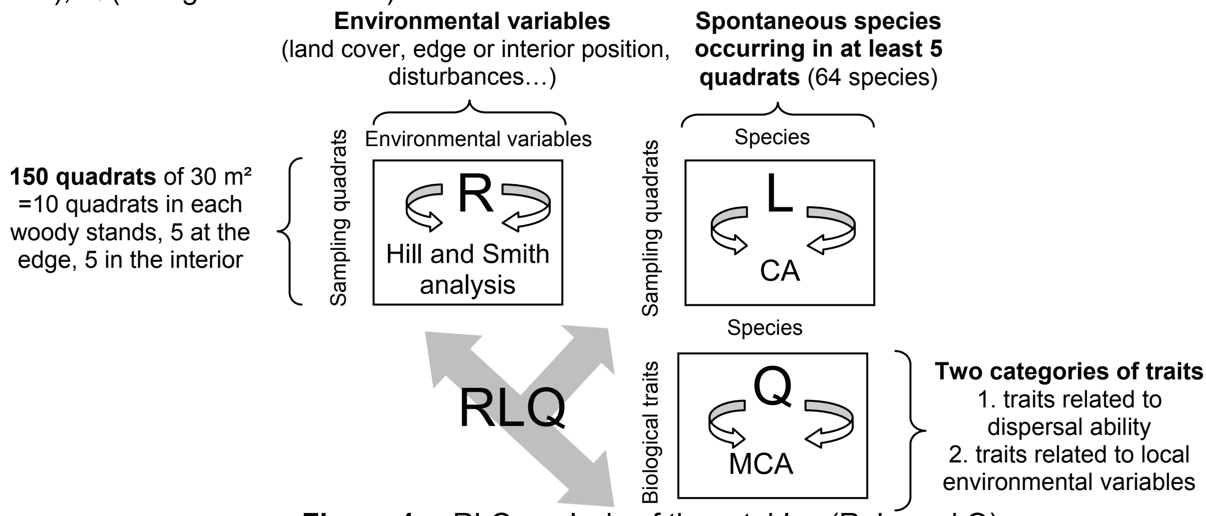


Figure 1. RLQ analysis of three tables (R, L, and Q)

Statistical analyses

Firstly, three separate ordinations were performed: a correspondance analysis (CA) on L, a Hill and Smith analysis on R (Chessel*, et al.*, 2006) and a Multiple Correspondence Analysis (MCA) on Q (Fig. 1). A three table ordination method (RLQ analysis) was subsequently carried out in order to link species traits directly with environmental variables (Dolédec*, et al.*, 1996). RLQ analysis combines the three separate analyses so as to maximize the co-variation between environmental variables and species traits.

Results and discussion

Three separate ordinations

The first ordination axis of environmental variable (table R) (explaining 59% of variance) is negatively associated with 'cover of roads and buildings' (r=-0.96 and -0.95 respectively) and positively with 'land under cultivation' (r=0.97). So it appears that the environment of different sites is predominantly determined by their position on the rural-urban gradient.

The analysis of vegetation (table L) shows the existence of a gradient with clear separation of ruderal species as *Geum urbanum, Geranium robertianum, Alliaria petiolata* and species more typical of forests such as *Deschampsia flexuosa, Pteridium aquilinum* and *Teucrium scorodonia* (Honnay*, et al.*, 1998).

The structure of biological traits (table Q) is more complex but some groups of species are distinguishable from other species principally on the basis of morphology and life-span.

RLQ analysis

The first axis of the three-table RLQ analysis explains 80% of the total variance. So we focus on this first axis for a first exploration of the results. This first axis of the RLQ analysis explains 90% of the inertia of R. Hence this axis is clearly related to the structure of the rural-urban gradient. The relationship between species traits and the environmental characteristics of their habitats is highly significant (p-value of Monte-Carlo permutation test<0.001). Differences in the distribution of traits along the rural-urban gradient involve morphological, phenological and physiological traits but not dispersal traits. Urban species are characterised by a short life-span, rosette growth forms, phenologies largely independent of seasonality and preferences for high pH and nitrogen levels. These characteristics of urban species are relatively well known (Hill*, et al.*, 2002) but have rarely been identified within a single habitat type, in particular as regards forest communities. The lack of a clear relationship between dispersal traits and landscape structure has often been noted with plants (Murphy and Lovett-Doust, 2004). One reason for this might be that plants respond to resource quality gradients which are difficult to analyse at landscape scales; secondly, plants rely on a range of other agents for dispersal of pollen and seeds.

References

EN.REFLIST

The role of the landscape on the distribution pattern of animals along a gradient of urbanisation

S. Croci [1,2], A. Butet [2], P. Clergeau [1]

[1] INRA SCRIBE, Campus de Beaulieu, Av. Général Leclerc, 35042 Rennes, France.
e-mail: solene.croci@rennes.inra.fr
[2] CAREN UMR CNRS 6553 ECOBIO Univ. Rennes 1, Campus de Beaulieu, Av. Général Leclerc, 35042 Rennes, France.

Introduction

The aim of our study was to evaluate the animal community responses to urbanisation. We focused on animal communities of woodlots to avoid any source of covariation potentially induced by the presence of different habitats within towns (Sadler *et al.* 2006). Urbanisation impacted woodlots environment along a rural-urban gradient especially at two scales (Clergeau *et al.* 2006): at the local scale (modifications of the vegetation of woodlots) and at the landscape scale (modifications of the composition and configuration of the surrounded landscape). These environmental modifications can affect animal communities differently according to their dispersion abilities.

Consequently, we investigated the response of three animal communities having different dispersion abilities to the urbanisation impacts on woodlots, the more common and natural habitat patch in French towns. Urban impacts on woodlots were considered at three different scales: local scale (within woodlots), close landscape scale (within 100m radius around woodlots) and wide landscape scale (within 600m radius around woodlots).

Method

Studied sites

Our study took place in 13 small woodlots distributed along a gradient of urbanisation extended over 10 km and ranging from the town centre of Rennes (Brittany, France) to its more rural adjacent landscape.

Environment's description

Using SIG and Fragstat v3.0, we investigated the landscape structure within 100m (close landscape) and 600m (wide landscape) radius around each woodlot. In parallel, we described the woodlot vegetation.

Animals' surveys

In each woodlot, we carried out a survey of bird, carabid beetle and small mammal communities during several months in 2004 and 2005. For each taxa, we took into account variations of species richness, Shannon's diversity index and Simpson's dominance index along the rural-urban gradient.

Statistical analyses

First, using PCA, we studied how the close and wide landscape and the vegetation of woodlots varied along the gradient. Second, we performed variance partitioning analysis to identify the environmental scale – local, close or wide- at which each animal community was the most sensitive. Second, using Spearman rank correlations, we describe the response of each taxa for its 'sensitive' scale.

Main Conclusions

Birds, carabid beetles and small mammals showed different responses to urbanisation. Birds were sensitive to urbanisation impacts at the local scale. Bird species richness increases with the richness and the diversity of woodlots vegetation which were higher in town than in rural landscape. Carabid beetle communities were sensitive to urbanisation impacts at wide landscape scale. Surrounded landscape of woodlots were more fragmented and characterized by mineral surfaces in town. This greater isolation of urban woodlots induced an impoverishment and a diversity decrease of the carabid communities in town. Nevertheless, about 50% of carabid beetle species were present both in urban and rural woodlots. Small mammals seemed to be adversely sensitive to urbanisation impacts at the local scale.

This study illustrated how important is to take into account 1) a single habitat type, 2) the dispersion abilities of animals and 3) the different environmental scales potentially influencing them to propose some assumptions on the mechanisms underlying the observed distributions of animal communities along rural-urban gradient. In addition, we suggest that urban woodlot is one of the urban habitats more prone to accommodate an important biodiversity within town.

References

Clergeau, P.; Jokimakï, J. & Snep, R. (2006) Using hierarchical levels for urban ecology. *Trends in Ecology and Evolution* **21:** 660-661.

Sadler, J.P.; Small, E.C.; Fiszpan, H.; Telfer, M.G. & Niemelä, J. (2006) Investigating environmental variation and landscape characteristics of an urban-rural gradient using woodland carabid assemblages. *Journal of Biogeography* **33:** 1126-1138.

Modelling bird species distribution and abundance in urban areas

C.H. Nilon[1],and P.S. Warren [2] .

[1] Department of Fisheries and Wildlife Sciences, University of Missouri-Columbia, USA.
e-mail: nilonc@missouri.edu
[2] Department of Natural Resources Conservation, University of Massachusetts-Amherst, Amherst, MA 01003, USA

Introduction

As co-investigators on a long-term urban ecology research project in Baltimore, Maryland, USA we want to understand how changes in the built areas of the city influence bird species distribution and abundance. We are particularly interested in changes that occur at a lot, street, and neighborhood scales that are initiated by residents and property owners. Our goal is to develop models that predict bird species distribution and abundance using variables from data that are used to measure changes in cities.

Methods

Study area

Our research takes places within the city limits of Baltimore City, Maryland. Baltimore is has a population of 637,000 residents and its city limits encompass an area of 216 km^2. Our census points are a sample of 80 of the 202 Urban Forest Effect Model (UFORE) points in Baltimore. The UFORE points represent the range of land uses found in residential census tracts in the city (Nowak and Crane 2000).

Bird data

Our protocol for conducting bird counts is similar to a procedure developed for the Central Arizona – Phoenix Long Term Ecological Research Project Grimm and Redman 2004). One trained observer visited each point between 05:30 and 09:30. The observer recorded the species and number of all birds seen or heard during a five minute counting period. Three counts were made at each point between May and July in 2005 and 2006. We averaged the number of detections on each count for each species and reported an index value of mean detections / count.

Lot – street- and neighborhood-scale data

Lot-scale variables are measures of bird habitat features that occur within a single residential lot and are under the control of a resident. We characterized lot-scale variables using tree cover, shrub cover, and ground cover data that were collected at each bird census point in 2001 as part of the UFORE analysis of Baltimore (USDA Forest Service Northeastern Research Station 2005). Street-scale variables reflect bird habitat features that are controlled by several residents and by local tree management and zoning decisions. Neighbourhood-scale variables are measures of bird habitat features that are controlled by local planning, zoning, and development decisions. We used data on building cover, building density, vegetation cover, tree cover, and tree density compiled by the Baltimore City Planning Department from 2000 LANDSAT imagery as measures of neighbourhood-scale habitat features. These variables were measured within a 200 m radius of each bird census point.

Models

The abundance of seven bird species (*Turdus migratorius, Thryothorus ludovicianus, Sturnus vulgaris, Passer domesticus, Cardinalis cardinalis, Columba livia, Hylocichla mustelina)* are correlated ($R^2 \geq 0.25$) with axes for a Bray-Curtis ordination of the bird census points. We are using these seven species as dependent variables in regression models based on lot, street, and neighbourhood –scale variables. We are using Krieging procedures and these species and lot and neighbourhood-scale variables to develop spatial models that predict species abundance values for all 202 UFORE points.

References

Grimm, N.B. & Redman, C.L. (2004) Approaches to the study of urban ecosystems: the case of Central Arizona-Phoenix. *Urban Ecosystems* **7:**199-213.

Nowak, D.J.& Crane, D.E. (2000) The Urban Forest Effects (UFORE) Model: quantifying urban forest structure and functions. M Hansen and T. Burke (Eds.) *Integrated Tools for Natural Resources Inventories in the 21st Century*. *Proceedings of the IUFRO Conference*. USDA Forest Service General Technical Report NC-212. North Central Research Station, St. Paul, MN. pp. 714-720.

USDA Forest Service Northeastern Research Station. (2005) *UFORE in action: Baltimore, Maryland.* Retrieved on 31 January 2007, from: http://www.ufore.org/action/02-00.html

Spatial variation of soils and vegetation structure in urban landscapes of the USA

R.V. Pouyat[1], I.D. Yesilonis[1], W.C Zipperer[2], K. Schwarz[3], D. Nowak[1]

[1]USDA Forest Service, Northern Research Station, c/o 5 Moon Library, SUNY-ESF, NY USA,
e-mail: rpouyat@fs.fed.us,
[2]USDA Forest Service, Southern Research Station, P.O. Box 110806, Gainesville, FL 32611, USA, [3]Institute of Ecosystem Studies, P.O. Box AB, Millbrook, NY 12545

Introduction

When land is converted from forest, grassland, and farmland to urban land use, novel management and disturbance regimes are introduced by humans. Most large-scale disturbances such as site grading and vegetation removal occur in the construction phase of urban development, while finer scale disturbances generally occur later. Horticultural management introduces even finer scale disturbances and includes the establishment and maintenance of lawns, shade trees, and planting beds on parcels of land that typically are smaller than the parcels that were managed in the previous forest or agricultural landscape. Horticultural management generally does not result in continuous physical disturbance of soil or plant communities, so it has less impact on ecological processes than management of agricultural systems, which continuously disturbs plant and soil systems throughout the year (or annually). Urban environmental factors that could affect ecological processes overlay these novel patterns of disturbance and management. These factors include the urban heat island effect; increased atmospheric concentrations of carbon dioxide (CO_2), and oxides of N and sulfur; atmospheric N deposition, heavy metal, and organic chemical contaminants; and the introduction of invasive plant and animal species. The net result of human disturbance, landscape management, and environmental change associated with urbanization is a mosaic of land patches that will vary in soil and vegetation conditions. In this presentation we will make spatial comparisons of soil properties and vegetation structure at multiple scales in an effort to characterize the urban patch mosaic. We use data mostly from the Baltimore Ecosystem Study, but include comparisons with other cities in the USA.

Results and Discussion

Depending on the soil property measured, measurements in Baltimore at the city scale showed that trace metals varied more by native parent material then proximity to potential polluting sources or land use and cover, while Cu, Pb, and Zn were related to automobile sources at both the city and regional scale regardless of vegetation structure. Vegetation structure and some soil properties (Ca, K, P, and bulk density) were related to land use and management regime. For example, land uses dominated by turf cover differed from tree dominated cover types in having higher soil P and K concentrations and higher bulk densities. Moreover, residential turf cover had more acidic soils and lower Ca concentrations than turf cover related to commercial, travel rights-of-way, and institutional land use.

There were over 2.8 million trees > 15 cm in diameter in Baltimore City with more than half of these trees established as volunteers (i.e., natural regeneration). Roughly a third of the trees were growing in natural stand conditions, mostly in public park lands. The percentage of area covered by tree canopies was 23.2%, which is roughly the same as other cities in the northeastern USA (e.g., Philadelphia and Boston), but also surprisingly similar to cities located in very different climates (e.g., Oakland, CA, USA, which was originally an oak savannah cover type). The most abundant non-native species at the city scale was *Ailanthus altissima*, which made up 5.2% of the tree population. The tree diversity index of Baltimore City was 3.52, which is slightly higher than other eastern cities in the USA and much higher than the range typically found in eastern deciduous forests (1.93-3.09).

At the neighborhood scale, invasive plant species and soil Pb and Cu contamination were associated with disturbed areas, such as vacant lots in inner city neighborhoods, while suburban areas had more formal horticultural landscapes with higher P levels in older aged turf managed soils. The most abundant tree species in high-density residential neighborhoods of Baltimore was *A. altissima*. Also in the suburban areas, organic matter showed an increasing trend with age but was not statistically significant at $P < 0.05$. In Baltimore, the number of tree stems (> 15 cm) per ha was 49 and 74 for high- and medium-density residential land uses, respectively. Additional relationships between soil properties, site factors (e.g., proportion of impervious surfaces), and vegetation structure are currently being investigated and will be reported at the IALE meetings.

These results suggest that both natural and urban factors affect the spatial variation of vegetation structure and soil properties at the city scale, while at finer scales urban factors are the most important. For example, at the city scale some soil properties of the native soil continued to persist. The continued strong relationship of these properties and the native parent material suggests that the transport of soil within the Baltimore landscape occurred at short distances. However, the fact that other soil properties did not vary by the native parent material, such as the variables shown to differ among land-use and cover types (pH, P, K, and bulk density), suggests that urban factors also had an affect on the spatial pattern of soil characteristics in Baltimore. Urban factors also played a key role at the neighborhood scale. For example, differences in heavy metals occurred between recently disturbed lots and grass covered lots in inner city neighborhoods. This relationship suggests that heavy metal contaminant sources may be more detectible at the neighborhood scale, e.g., deposition gradients from roads and the remains of Pb based paints from preexisting structures.

Rethinking urban waters from an ecosystem services perspective

D.G. Gledhill[1], P. James [2], D.H. Davies [3]

[1] Research Institute for the Built and Human Environment, School of Environment and Life Sciences, Peel Building, University of Salford, Salford, Greater Manchester, , UK.
e-mail: d.g.gledhill@pgr.salford.ac.uk
[2] Research Institute for the Built and Human Environment, School of Environment and Life Sciences, Peel Building, University of Salford, Salford, Greater Manchester, UK.
[3] Biomedical Research Institute, School of Environment and Life Sciences, Peel Building, University of Salford, Salford, Greater Manchester, UK.

Introduction

The use of the word green in phrases such as green space and green infrastructure may inadvertently deflect attention from the blue aspects of the urban environment i.e. the ponds, lakes, canals and rivers. Water plays an important part in modern cities e.g. sustainable urban drainage, flood control and, not least, providing an essential aesthetic component to everyday living and working environments.

Whilst freshwater habitats in rural settings have attracted research attention there is a dearth of data relating to ponds in urban settings. One aim of this research is to address this matter by a multidisciplinary evaluation of ponds within the Borough of Halton. Halton is situated between Manchester and Liverpool in Northwest England. This survey makes a contribution to addressing issues related to the ecological, social, cultural and economic value of ponds in an urban setting. The initial focus of this paper lies with the data collected on the ecological values and ecological services associated with these ponds. The authors go on to raises issues for consideration as part of a wider, multidisciplinary research agenda set within the context of sustainable urban development.

Urban pond ecosystems

There are an estimated 450 water bodies below two hectares within the 91 km^2 area occupied by the urban and industrial districts of Halton. Detailed ecological data from 30 of these ponds surveyed between 2004 and 2006, revealed a total of 119 species of aquatic invertebrates and 57 species of aquatic macrophytes. The median values per pond were 28 species of invertebrates and 10 plant species. The northern crested newt (*Triturus cristatus*), a UK priority species (English Nature, 1997) was found to be breeding in 20% of sites. A survey of 146 ponds in the City of Cardiff, Wales (Rich, 2000) found a median of 19.1 species of macrophyte per pond, a number significantly higher than the 9.6 species per pond reported by the National Lowland Pond Survey (Pond Action, 1998). Between 1995 and 1998 the Pond Life Project surveyed 1000 mostly rural sites in the northwest of England (Guest and Bentley, 1998). Median diversities of 32 species of invertebrates and 22 species of aquatic macrophyte per pond were recorded. The botanical diversity of Halton's ponds is comparable with the national average, but lower than that for either Cardiff or rural northwest England and compares favourably in terms of invertebrates with the Pond Life Project data.

Extrapolating from the mean area of ponds surveyed in Halton (581m2 ± 256 m2), it can be estimated that the 450 or so sites cover an area of approximately 26.15 ha. With approximately 10% of the total area of the Borough covered by the Mersey Estuary (and major canal arteries), ponds potentially account for 4% of the remaining area. Given that 15% of Halton is open water (ODPM, 2005) then pond ecosystems account for almost a third of that water area.

Discussion

Ponds and reed beds are designated as habitats of UK conservation importance (English Nature, 1997). Both the Halton and Cardiff studies illustrate the positive role that ponds have within the context of urban ecosystems, exhibiting biodiversity similar to rural sites. Urban habitats are frequently fragmented. Debate exists as to the relative merits of creating corridors or mosaics of habitats (English Nature, 1997a). Pond habitats are by nature fragmented, whether urban or rural and many pond species are adapted to living in a mosaic type landscape. An urban park, therefore, presents little more of a challenge to dispersal than open farmland. Nature conservation gains are not restricted to aquatic species. Nationally important species such as the English bluebell (*Hyacinthoides non-scripta*), song thrush (*Turdus philomelus*) and skylark (*Alauda arvensis*) have all benefited from land protected from built development and made available for nature conservation as part of urban drainage schemes.

While significant, biodiversity is not the only function of urban freshwater habitats. Ponds also provide the capacity to drain a sustainable area of land providing flood regulation and alleviation of heat island effects at the local scale. Surrounding edge habitats also increase the amount of permeable service for rain water infiltration and may compensate for the loss of soft surfaces in domestic front gardens (RHS, 2005). Blue/green infrastructure brings people often divorced from the countryside into daily contact with nature on their own doorstep (Miller and Hobbs 2002). This provides many of the social, cultural and, health and well-being services associated with a greener or bluer environment (Lee and Evans, 2003).

Meeting the needs of future development will require a paradigm shift in current management practices. Practitioners will have to move beyond single site strategies and single objectives in favour multifunctional landscapes incorporating nature conservation, sustainable development and human well being. In order to derive the maximum benefit from these landscapes questions surrounding the people-nature relationship still need to be answered. Questions such as; which groups of people utilise urban ponds? How they value them? And how best can good ecological practice be reconciled with human expectations? Addressing these questions will require closer engagement with stakeholders whose options are as yet, not well understood.

References

English Nature (1997) *The Urban Mersey Basin Natural Area: A nature conservation profile*. English Nature (now Natural England). Peterborough, England.

English Nature (1997a) A framework for the future: green networks with multiple uses in and around towns and cities. English Nature, Research Report No 256, Peterborough, England.

Guest, J.P. & Bentley, D. (1998) *Critical Pond Biodiversity Survey*. Pond Life Project. Liverpool John Moores University, Liverpool, England. Unpublished survey report.

Lees, S. & Evans, P. (2003) *Biodiversity's contribution to the quality of life*. A research report for English Nature, No 510. Environmental impacts team, English Nature. February 2003.

Miller, J.R. & Hobbs, R.J. (2002) Conservation where people live and work. *Conservation Biology* 16, No 2 pp 330-337. April 2002.

ODPM (2005) *Generalised land use data (GLUD) statistics for England*. Office of the Deputy Prime Minister, February 2005. London England.

Pond Action (1998) *National Lowland Pond Survey 1996*. Pond Action Oxford Brookes University, England.

RHS (2006) *Are we parking on our gardens? And do driveways cause floods*? Garden Matters, Urban Series, Royal Horticultural Society, May 2006. London, England.

Rich, T. (2000) *A comparison of the ponds in the County of Cardiff with the national statistics from the Lowland Pond Survey*. In Pond Action (2000). Proceedings of the Ponds Conference 1998. Pond Action, Oxford.

Understanding everyday urban biodiversity – interpreting the 'intrinsic value' of biodiversity through human perception and mutualism

M. Gyllin

Swedish University of Agricultural Sciences,
e-mail: Mats.gyllin@lpal.slu.se

Background

Positioning human beings in relation to biological diversity is a difficult but important task, particularly considering the 'everyday biodiversity' that we more or less subconsciously perceive and respond to when performing our daily routines. However, it is rather unclear to what extent this 'background biodiversity' is actually perceived by different groups of the public, to what extent it is believed to be beneficial and to what degree different organisms can be identified and appreciated by the public, i.e. the perceptive resolution of biodiversity experience. It could be argued that basic perception is the foundation for human interactions with other life forms, that this connection is so important that it could probably be considered a mutualistic relationship, and thus makes the idea that biodiversity has an intrinsic value less controversial.

The perception of biological diversity

Although biological diversity has been defined 'officially' (UNEP, 1992), this definition is too vague for scientific purposes, and several other definitions have been proposed more or less *ad hoc* (Delong, 1996). The actual use in everyday life is a more intuitive practice, involving values, feelings and professional background (Gyllin, 2004). Thus, what we spontaneously regard as aspects of biodiversity probably differ very much among individuals. How much detail we can perceive – the 'biodiversity resolution' – also varies with a number of factors, most importantly perhaps our knowledge about plants, animals and ecological relationships. In terms of 'affordances' (Gibson, 1986, 127-143), the number and quality of affordances connected to biological objects would be different among individuals. To catch the inner core of biodiversity as it is empirically experienced and valued by people, it is necessary to establish in what way and to what extent it is perceived.

The intrinsic value of biodiversity and mutualism involving people

Decisions, planning policies and opinions regarding nature conservation often imply that biodiversity has an intrinsic value, which is explicitly stated in the convention on biological diversity (UNEP, 1992). Philosophically, this is difficult to defend (Randall, 1994; Oksanen, 1997), at least in its biocentric version, but to some extent it could be answered by acknowledging that man is part of an integrated network of mutualistic relationships, involving a large number of organisms that are somehow interconnected with humans, i.e. a more holistic, ecocentric approach (Oksanen, 1997; Stenmark, 2000). In other words, what is beneficial to (some aspects of) biodiversity is beneficial to man and vice versa. Evidence for the existence of such relationships may be drawn from environmental psychology (Ulrich, 1986; Kaplan et al., 1998), and possibly explained by the biophilia hypothesis (Kellert & Wilson, 1993). Thus, conservation and development of everyday urban biodiversity could be motivated through general human well-being issues and the difference between the intrinsic value and instrumental values of biodiversity would be less distinct.

The peri-urban environment

The peri-urban environment is an important, but largely underrated, interface between man and nature. Particularly in densely populated and highly productive agricultural areas, such as the southernmost parts of Sweden, the peri-urban areas provide some of the most visited recreation areas, sometimes ephemeral and doomed to be built (Qviström & Saltzman, 2006), but sometimes made permanent owing to their popularity. Since they are often unplanned and initially not intended for any particular purpose, and because accessible green areas in such regions are limited, they may be heavily used for a number of different recreational purposes. Experiencing biodiversity may be an important, however rarely explicit function, and the peri-urban landscape provides an important refuge to a number of species that do not fit in either the urban landscape or the sometimes even more hostile agricultural landscape. It is reasonable to conclude that a substantial proportion of the encounters between humans and other organisms in the agricultural landscape takes place in the peri-urban environments.

Methods and expected results

Some of the aspects mentioned above are tested in an ongoing project, involving expert groups as well as different groups of visitors, among them immigrants, local people, and visitors. The main aim is to clarify the extents of biodiversity perception, and to relate this to the subjects' cultural, professional and social background, gender and age, and to the actual vegetation structure and species composition regarding plants and animals. The study is based on semantic questionnaires, simple questions and focus-group interviews. The subjects are asked to identify as many species as they can, and to identify structural variation in the surrounding vegetation, in motion as well as standing still at certain points in the area. The study site is a newly established recreation area, Lake Arrie, an abandoned quarry that has been used for a multitude of purposes, mostly spontaneous recreation, such as horseback riding, fishing and bathing, but also more planned activities like paintball and swimming lectures for small children. The area also has some biological qualities and potential, and there is an ambition to integrate these qualities with recreation. Results of the investigation are expected to provide new insights concerning the nature of human perception and preferences regarding biological diversity, and also to deepen the knowledge about the empirical meaning of biodiversity as such.

References

Delong, D. C., Jr. 1996. Defining biodiversity. *Wildlife Society Bulletin* **24**(4): 738-749.

Gibson, J. J. 1986. *The ecological approach to visual perception*. Hillsdale, New Jersey, Lawrence Erlbaum Associates.

Gyllin, M. 2004. Biological Diversity in Urban Environments - Positions, values and estimation methods. *Department of landscape planning*. Alnarp, SLU.

Kaplan, R., Kaplan, S. & Ryan, R. L. 1998. *With People in mind: design and management of everyday nature*. Wahington, D.C., Island Press.

Kellert, S. R. & Wilson, E. O., Eds. 1993. *The Biophilia Hypothesis*. Washington D.C., Island Press/Shearwater Books.

Oksanen, M. 1997. The moral value of biodiversity. *AMBIO* **26**(8): 541-545.

Qviström, M. & Saltzman, K. 2006. Exploring Landscape Dynamics at the Edge of the City: Spatial Plans and Everyday Places at the Inner Urban Fringe of Malmö, Sweden. *Landscape Research* **31**(1): 21-41.

Randall, A. 1994. Thinking about the value of biodiversity. *Biodiversity and landscapes - A paradox of humanity*. Kim, K. C. & Weaver, R. D. Cambridge, Cambridge University Press**:** 271-286.

Stenmark, M. 2000. *Miljöetik och miljövård*. Lund, Studentlitteratur.

Ulrich, R. S. 1986. Human responses to vegetation and landscapes. *Landscape and Urban Planning* **13**: 29-44.

UNEP 1992. *Convention on biological diversity*, UNEP.

Applicability of metapopulation theory to biodiversity conservation efforts in Greater Manchester

A.E. Kazmierczak[1], P. James[2]

[1]Research Institute for the Built and Human Environment, School of Environment and Life Sciences, Peel Building, University of Salford, Salford, M5 4WT, UK
e-mail: A.E.Kazmierczak@pgr.salford.ac.uk
[2]Research Institute for the Built and Human Environment, School of Environment and Life Sciences, Peel Building, University of Salford, Salford, M5 4WT, UK

Introduction

Natural and semi-nature habitats within urban areas are becoming increasingly fragmented, isolated, disturbed and homogeneous (McKinney, 2006; Ahern, 1995). Fragmentation and habitat loss are considered to be major causes of the decline in wildlife numbers and diversity. Hence, to prevent further decline it is important to preserve and/or develop areas that are large enough for populations of wildlife species to persist (Jongman, 1995). It is also necessary to recognise that conservation actions have to be taken outside designated reserves (Walker, 1995) so that possibilities for exchange of individuals, and hence genes, between sites are maintained and enhanced (Jongman, 1995).

An ecological network is a planning tool that can help maintain both structural and functional connectivity in the landscape (e.g. Bouwma *et al.*, 2002; Alterra, 2003) as it forms an interconnected spatial framework of areas of high nature value. An ecological network provides the physical conditions necessary for ecosystems and species populations to survive in a human-dominated landscape (Jongman and Pungetti, 2004). One of the rationales for grouping habitats into an ecological network of high connectivity is to provide for the specific needs of species forming metapopulations which depend on exchange of individuals for the survival of individual populations (Jongman, 2004). However, this rational can be questioned with regards to its applicability in urban areas and with respect to the observation that increased connectivity in the landscape may be unnecessary (Hobbs, 1988), ineffective (Henein and Merriam, 1984) or in some cases even detrimental to species not forming metapopulations (Simberloff *et al.*, 1992). Addressing these issues leads, in turn to questions about the application of metapopulation theory in urban areas, and about the feasibility of directing conservation efforts into creating ecological networks in the wider environment around designated areas.

Metapopulations and Ecological Networks in Greater Manchester – a case study

The authors report on a case study of the metropolitan area of Greater Manchester, UK. Greater Manchester is a densely populated conurbation (19.4 people per hectare) in the Northwest of England (National Statistics, 2007; ODPM, 2005). In this conurbation the identification and enhancement of an ecological network is being championed by the local planning authorities and promoted by ecological advisory bodies.

Following a critical review of the availability and relevance of data on the distribution and dispersal behaviour of species of special conservation importance in Greater Manchester the authors of this paper identify that there is a lack of empirical data relating to the occurrence of metapopulations for these species. The implications of these findings are considered within the context of the relevant wildlife conservation legislation and the planning process currently operational in England. In particular local authorities may not be justified in requiring a developer to conduct a protected species survey in the absence of a record for a particular species in a particular place. Further, local authorities also experience difficulties when trying to design and implement plans for an ecological network in the absence of empirical data.

There is, however, considerable evidence that structure and diversity within the green space of cities is of greatest importance in determining the species diversity of these areas (e.g. Smith *et al.*, 2005; Sandström *et al.*, 2006). The authors provide an analysis of amount, distribution and ecological quality of publicly and privately owned green space within Greater Manchester. Combining this analysis with information on the dispersal potential of the species of conservation importance in Greater Manchester allows the authors to propose a framework by which the ecological processes can be sustained and the biodiversity can be maintained in densely populated conurbations.

References

Ahern, J. (1995) Greenways as a planning strategy *Landscape and Urban Planning* **33** 131-155.

Alterra (2003) *Ecological areas: linking protected areas with sustainable development* Alterra, Wageningen.

Bouwma, I.M; Jongman, R.H.G. & Butovsky, R.O. (2002) *The indicative map of the Pan-European Ecological Network for central and eastern Europe. Draft version* European Centre for Nature Conservation, Tilburg.

Henein, K. & Merriam, G. (1984) The elements of connectivity where corridor quality is variable. *Landscape Ecology* **4** 157-170.

Hobbs, E.R. (1988) Species richness of urban forest patches and implications for urban landscape diversity. *Landscape Ecology* **1** 141-152.

Jongman, R.H.G. (1995) Nature conservation planning in Europe: developing ecological networks. *Landscape and Urban Planning* **32** 169-183.

Jongman, R.H.G. (2004) Context and concept of ecological networks. IN Jongman, R.H.G.and Pungett, G. *Ecological networks and greenways. Concept, design, implementation*_Cambridge University Press, Cambridge 7-33.

Jongman, R.H.G. & Pungetti, G. (2004) Introduction: ecological networks IN Jongman, R.H.G. & Pungetti, G. *Ecological networks and greenways. Concept, design, implementation*. Cambridge University Press, Cambridge 1-6.

McKinney, M.L. (2006) Urbanization as a major cause of biotic homogenization *Biological Conservation* **127** 247-260.

National Statistics (2007) *Census 2007 – Greater Manchester* Retrieved on 23 Jan 2007, from: http://www.statistics.gov.uk/census2001/pyramids/pages/2a.asp.

ODPM (2005) *Generalised land use data (GLUD) statistics for England* Office of the Deputy Prime Minister, London.

Sandström, U.G; Angelstam, P. & Mikusiński, G (2006) Ecological diversity of birds in relation to the structure of urban green space *Landscape and Urban Planning* **77** 39-53

Simberloff, D; Farr, J.A; Cox, J. & Mehlman, D.W. (1992) Movement corridors: conservation bargains or poor investments? *Conservation Biology* **6** 493-504.

Smith R.M; Gaston K.J; Warren P.H. & Thompson K. (2005) Urban domestic gardens (V): Relationships between landcover composition, housing and landscape. *Landscape Ecology* **20** 335-253.

Walker, B.H. (1995) Conserving biological diversity through ecosystem resilience. *Conservation Biology* **9**(4) 747-752.

Modelling, assessing and monitoring urban socio-ecological systems: The new challenge of shrinkage and perforating cities for urban green and nature conservation.

D. Haase

UFZ-Centre for Environmental Research Leipzig-Halle, Department for Computational Landscape Ecology, Permoserstr. 15, D-04318 Leipzig, Germany,
Email: dagmar.haase@ufz.de

Problem

Demographic transitions and individualisation as well as economic decline produce novel pattern, densities and modified dynamics of urban land use along the rural-urban gradient. Compared to the beginning of the 90ies right after the societal transition in East Germany, today massive shrinkage and vacancies in both the housing and commercial sector, followed by demolition and perforation, occur. Such processes of urban decline are known from UK and the US in the 80ies and 90ies but did not face whole regions (most parts of East Germany) in a tremendous short time interval (less than 15 years). Moreover, shrinkage is at the same time interfered with splintered growth processes of the late transition phase from the socialist to the market economy system.

Objectives

In consequence of the above mentioned processes, scientists and planners have to state a massive surplus of urban brownfields and open space in the core city and at the periphery which was never expected to become real in such quantity and, what is more, that have to be "prepared" for the future. Normally, concepts and indicators of urban green aim in increasing area and quality of greenery up to a target far away. Here, in case of shrinkage, common urban landscape planning and monitoring systems enter "undiscovered terrain". A series of questions were asked, eg., should these areas be developed or to be left for natural succession? Do such amounts of shrinkage have influence on normative targets of urban ecological and human recreational values or targets?

Methodology

To find answers on the above asked questions, structural and land use changes related to demolition and following perforation had been detected and quantified. Here, field mapping, remote sensing and GIS-based data compilation had been applied. Further, urban waste land remaining from vacancies and demolition had been analysed concerning their species distribution and abundance related to (i) age and (ii) substratum of the land.

In consequence of the field work, a multi-criteria indicator matrix had been developed to quantify environmental and ecological effects of urban open land and greenery for their environments. Seen from both sides, the ecosystem species and the urban inhabitant, different scenarios of urban shrinkage and perforation had been evaluated concerning ecological and QoL related target values determined in the indicator matrix. Finally, the FLAG multi-criteria evaluation model had been applied to produce a quick-"ample"-view to select the best scenario depending on a pre-defined objective function.

Results

For the case study of Leipzig, situated in East Germany and representing a "fore-runner" in terms of massive shrinkage processes and housing vacancies, results for the coming 10 years are presented and discussed. For two test areas, the prefabricated GDR-time housing areas of "Leipzig-Grünau" and an old built-up district near the city centre "Leipzig-East" recent demolition processes and planning framework are the base of the 3 scenarios.

In particular, existing target values for urban green per inhabitant and data of urban biodiversity under growth conditions had been set against the data explored from the shrinkage and demolition context (Figure 1)

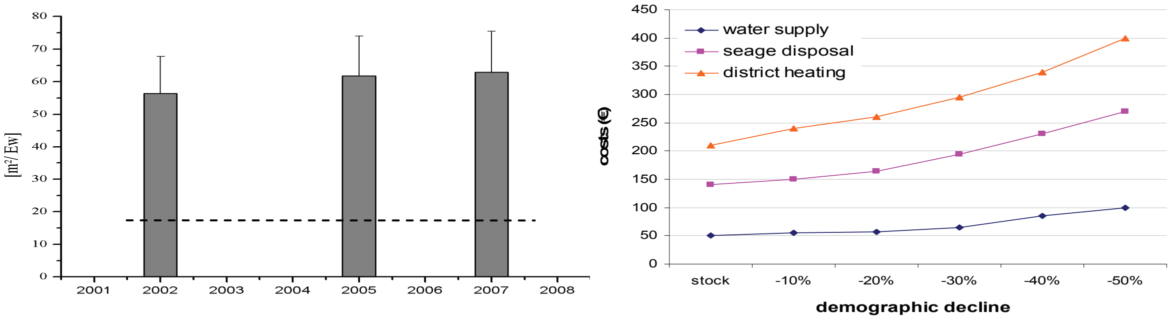


Figure 1. Left: Share of public accessible urban green in Leipzig-Grünau. 2002 – Residential vacancy >25%. 2005 and 2007 describe a demolition rate of 6 and 20% (broken line = target value of 7.5m^2/inh.). Right: Cost development of urban infrastructure under conditions of shrinkage (modified according to Koziol, 2004).

Conclusions

What did we learn? The example of Leipzig gave evidence that firstly, East German cities possess a "for-runner role" in urban restructuring processes such as shrinkage and perforation arising from demographic change, secondly, a surplus of urban greenery offer considerable positive effects for both man and nature, thirdly, that simultaneously costs of marinating urban infrastructure has to be set against this positive environmental development and endanger the development of green perforated districts, an, finally, urban planning is not prepared to handle "too much" green or open space and therefore it needs methodological input from science to cover these recent challenges. Last but not least, the results of this study underline that urban landscape ecologists are able to valuably contribute to the debate on urban shrinkage, a discussion originally and oftentimes exclusively driven by architects and planners.

References

Haase D, Nuissl H, 2006: Spatial consequences and environmental impact of long-term land use change. A case study for Leipzig (Germany), Landscape and Urban Planning (*in press*).

Haase D, Haase A, Bischoff P, Kabisch S, 2006. Guidelines for the 'Perfect Inner City' Discussing the Appropriateness of Monitoring Approaches for Reurbanisation. Landscape and Urban Planning (*accepted*).

Haase D, Seppelt R, Volk M, Lautenbach S, 2006. Landscape consequences of demographic change – Insights from urban regions in Eastern Germany. Müller F, Zurlini G, Petrosillo I, eds. Use of landscape sciences for the assessment of environmental security. Springer (*in press*).

Koziol M, 2004. The consequences of demographic change for municipal infrastructure. DfK 44 (1), online publication.

Nijkamp P, Ouwersloot H 2003. A decision support system for regional sustainable development. The FLAG Model. Amsterdam.

Schetke S, 2006. Multikriterielle Bewertung von Freiraumkonzepten und –szenarien in einer schrumpfenden Stadt. Das Beispiel Leipzig. Diploma thesis, University of Leipzig, Department of Geography (*typescript*).

The New Zealand urban ecology problem and some resolutions

C.D. Meurk

Landcare Research, PO Box 40, Lincoln 7640, New Zealand.
e-mail: meurkc@landcareresearch.co.nz

Introduction

Basic urban ecology in New Zealand lags behind Europe. New Zealand ecologists have preferred to study 'pristine' mountain, subantarctic and rain forest ecosystems, usually in national parks. These systems are biased towards inhospitable environments (Kelly and Park, 1986) remote from the experience of most people. Urban studies are increasingly reductionist, generic or engaged with stormwater, waste and energy management. But in New Zealand a healthy physical environment may not equate with biodiversity and so we become further divorced from our highly endemic natural history (Conservation International, 2007). It must be accessible, identifiable and desirable for it to be relevant to sense of place; enculturated nature is more likely to be protected (Fig. 1). This is taken for granted in older densely populated nations where regulation generally prohibits removal of habitat. But an easy link between indigenous nature and culture is thwarted in post-colonial New Zealand by the overwhelming dominance of introduced species in cultural landscapes. The biogeographic context and historic legacy, and the consequences for both our biota and culture, are documented elsewhere (Meurk and Swaffield, 2000; Meurk and Hall, 2006).

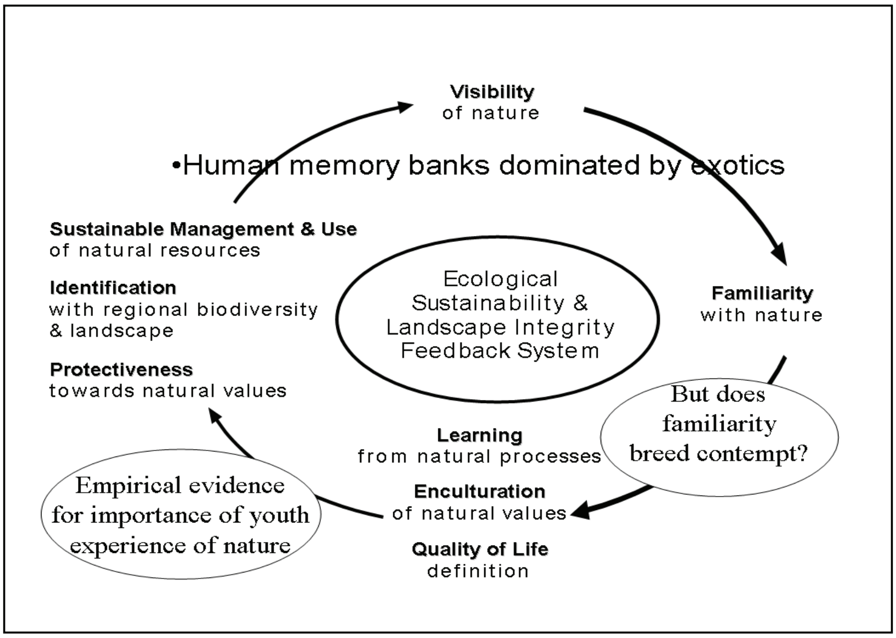


Figure 1. The reinforcing cycle of visibility, familiarity and protectiveness - at least towards that which is deemed useful (adapted from Meurk and Swaffield, 2000).

Reversing the Trends at a Cost

Conservation in New Zealand is achieved by seemingly endless killings of pests. This is exacerbated by a culture out of tune with its natural history; that continues to spread biosecurity risks. Although the calamaties facing our special biota (Wilson, 2004) are publicised, this is often received with indifference and decision-makers continue to permit removal of primary habitat. The replacement cost of this folly, even without factoring in the complexities of mature foodwebs, etc., is *ca.* € 50 000/ha. Meanwhile, a pond ecosystem may be restored in Europe by digging a hole, letting succession take place and translocating non-vagile species. The same project in New Zealand requires painstaking planting then fighting back the exotic smothering sward grasses that dominate seed banks. There are thus severe ecological and cultural barriers to rebuilding sustainable indigenous lowland habitats.

The Role of the Urban Environment

New Zealand cultural landscapes have comparable species richness to National Parks, but considerably higher numbers of naturalised species (Table 1). The statistics however hide the important representation of lowland, often poorly protected, species in the cities. Louv (2005) makes the empirically supported observation that the human relationship with nature is paramount to a healthy, intelligent, and globally street-wise community. Exposure to (indigenous) nature is therefore vital to not only understanding ecological processes (for survival) but also to maintaining points of difference. This has to happen in towns as much as anywhere. New Zealand is being introduced to this message but resistence to change comes from influential people with attachment to a colonial past and often an extreme intepretation of property rights, exacerbated by inadequate compensatory measures. As such, there is a race to see if a maturing culture, with a sense of its unique place in the world, will evolve before its underpinning indigenous biota dwindles below the point of no return. Gaining a deeper appreciation of urban natural history in New Zealand, through information, online recording of observations, and promoting innovative ways of integrating nature into living landscapes (Meurk and Hall, 2006), is contributing to biodiverse futures that moreover support the indigenous Maori people and their customary use aspirations.

Table 1. Summary floristics (±SE) of (all) New Zealand, National Parks or Reserves, and Cities or Cultural landscapes (adapted from Given and Meurk, 2000)

	NZ	National Parks	Cities
Indigenous Vascular spp	2500	583±76	491±65
Adventive Vascular spp	2500	148±21	475±120
Indigenous spp/000 ha	0.07	7±5.8	6±3.7
Indigenous spp as % of NZ	100	23±3	20±2.6

References

Conservation International (2007) *Biodiversity Hotspots*, Retrieved on 5th February, 2007, from: http://www.biodiversityhotspots.org

Given, D.R. & Meurk, C.D. (2000) Biodiversity of the urban environment G.H. Stewart & M.E. Ignatieva (Eds). *Urban biodiversity and ecology as a basis for holistic planning and design.* Proceedings of a workshop held at Lincoln University, 28-29 October, 2000. Lincoln University International Centre for Nature Conservation Publication 1. Wickliffe Press Ltd, Christchurch, pp. 22-33.

Kelly G. C. & Park G. N. (1986) *The New Zealand Protected Natural Areas Programme: A Scientific Focus,* Department of Scientific and Industrial Research, Wellington.

Louv, R. (2005) Last child in the woods: saving our children from nature deficit disorder. Algonquin Books of Chapel Hill, North Carolina.

Meurk, C.D. & Hall, G.M.J. (2006) Options for enhancing forest biodiversity across New Zealand's managed landscapes based on ecosystem modelling and spatial design. *New Zealand Journal of Ecology 30*: 131-146.

Meurk, C.D. & Swaffield, S.R. (2000) A landscape ecological framework for indigenous regeneration in rural New Zealand-Aotearoa. *Landscape & Urban Planning 50:* 129-144.

Wilson, K-J. (2004) *The flight of the huia.* Canterbury University Press, Christchurch, New Zealand.

Social functionality of urban green on the example of Karachi/Pakistan

M.M. Anwar

COMSATS Institute of Information Technology, Department of Environmental Sciences, Division of Urban Landscape Ecology, University Road, Tobe Camp, Abbottabad, Pakistan.
e-mail: mmushahid@ciit.net.pk

Problem:
The impact of urbanization on the social function of green open spaces in the mega-cities of South Asia, with special reference to Karachi/Pakistan. It is well recognized that urban green space plays an important role in the social and natural sustainability of a city. However, urban green spaces are one aspect often disregarded in the urban ecological studies. The increased urbanization, associated with social-environmental degradation, has generated a debate on what important role urban green spaces can play in social life of urbanities.

Objective:
To seek an answer to this question, this research hypothesized that urbanization and development within the metropolitan regions in Karachi/Pakistan, are aimed only towards accelerating economic growth. To test the main hypothesis, the study was carried out with the following main objectives:
1. A comparison of two regions in Karachi, which have different socio-economic status.
2. Urbanization trend in metropolitan regions lead to loss of urban green space, and an increase in environmental problems. Therefore, it is necessary to investigate the current condition of urban green space.
3. The relationship between urban green space and environmental condition was investigating by evaluated the ecological function of greenery and social functionality.

Methodology:
Beside theoretical linkages and approaches, the case study of a major city, Karachi, in Pakistan was carried out to find out answers on the above mentioned hypothesis. On the example of selected regions of the city, the significance and applicability of the above mentioned questions will be discussed. The main idea of this paper is to show how much urban green space is important for social needs in the megacity of Karachi/Pakistan.

Expected results:
The expected results can be used for development of urban green spaces for social functionality for future generation. It is also important for the improvement planning strategies identified.

Wild in the city: urban lakefill becomes nature's refuge. A case study of Tommy Thompson Park, Toronto, Canada.

K. Landman, Y. Cardoso, W. Kehm

University of Guelph, Guelph Ontario Canada N1G 2W1.
e-mail: klandman@uoguelph.ca

Redman *et al.* (2004) argue that scientists can no longer study social systems and ecological systems as separate activities. Redman *et al.* (2004) and others (Grimm *et al.* 2000) argue for an integrative ecology that expressly integrates cultural institutions, policy and economics. The study of urban ecosystems especially requires knowledge of the social influences that act on ecosystems, as they generate diverse configurations of development and land use (Alberti *et al.* 2003) and manifest obvious and subtle influences on ecosystem processes both directly and indirectly, or remotely (Pickett *et al.* 2001). While humans play a significant role in structuring landscapes, the structure tends to be the focus of ecological research rather than the human behaviour that produced it (Nassauer 1995). Understanding the spatial organization of urban ecosystems requires understanding hierarchically scaled linkages of both spatial ecological heterogeneity and social organizational hierarchies (Pickett *et al.* 1997).

Urban wild is the antithesis of the cultivated landscape, the opposite of a sterile green park (Rink 2005), and is a concept that is gaining attention for studying urban ecology. Typically, urban wild is a patch of nature set within a greater urban context. This patch may be a remnant of a degraded ecosystem or a spontaneous, particular expression of conditions in a brownfield (Urban Wild Group 2004). For this expression to occur, change is the norm, history is important, and local conditions depend on what happens elsewhere and at other times (Pulliam and Johnson 2002). To better understand the temporal and spatial linkages, this research is set within the conceptual framework set out by the Long-Term Ecological Research Network (Redman *et al.* 2004), and more specifically employs a single-unit, longitudinal case study (Francis 2001).

This paper presents a case study of change, both in landscape structure and public policy, on the Tommy Thompson Park (TTP) lakefill on Toronto's waterfront. The current configuration of the TTP extends 5 kilometres from the north shore of Lake Ontario. It is comprised of a total land base of approximately 160 hectares and a water surface area of 100 hectares composed of embayments and disposal cells. TTP was created of construction rubble and dredged material over the last half of the 20^{th} century, with an ultimate end-use as an outer-harbour headland and an urban waterfront airport. Engineers designed the human-made spit to protect the Toronto harbour in response to increased shipping traffic. It is, however, this spit formation that has contributed to this industrial site becoming important for urban wildlife habitat.

Over the past five decades, significant ecological colonization has taken place at TTP, resulting in an internationally-significant stepping-stone for migratory birds and a concomitant public demand for a nature reserve on this site. Plans for the airport have long been scrapped, and the care and management of TTP has been handed to the Toronto Region Conservation Authority (TRCA). The TRCA is now grappling with wildlife habitat design and species management, as well as the urban planning issues of a multi-cultural metropolitan city which contributes to more than 300,000 TTP visitors each year, all of whom embody conflicting views of nature. While conservation design and wildlife management is the paramount mandate for the TRCA at TTP, success can only be achieved by integrating an on-going participatory planning process.

Wildlife management and urban planning can contribute to the sustainability of urban species by using the principles of conservation design, maintaining flexibility in response to unforeseen habitat successes and failures, and offering opportunities for advocacy groups and lay people to participate along with scientists in shaping policy and practice. The TTP case study offers place-based, integrative findings that address both societal concerns and scientific questions about processes that change over the long term, and thereby an opportunity for comparison with other urban wild sites.

References

Alberti, M.; Marzluff J.M.; Shulenberger, E.; Bradley, G.; Ryan, C. & Zumbrunnen, C. (2003) Integrating humans into ecology: opportunities and challenges for studying urban ecosystems. *Bioscience* **53**(12):1169-1179.

Francis, M. (2001) A case study method for landscape architecture. *Landscape Journal* **20**(1):15-29

Grimm, N.B.; Grove, J.M.; Redman, C.L. & Pickett, S.T.A. (2000) Integrated approaches to long-term studies of urban ecological systems. *Bioscience* **70**:571-84.

Nassauer , J.I. (1995) *Placing Nature: Culture and Landscape Ecology* Island Press, Washington D.C.

Pickett, S.T.A.; Cadenasso, M.L.; Grove, J.M.; Nilon, C.H.; Pouyat, R.V.; Zipperer, W.C. & Costanza, R. (2001) Urban ecological systems: linking terrestrial ecology, physical and socioeconomic components of metropolitan areas. *Annu Rev Ecol Sys* **32**: 127-157.

Pickett, S.T.A.; Burch, W.R. Jr.; Dalton, S.E; Foresman, T. W.;Grove, J. M.; & Rowntree, R. (1997) A conceptual framework for the study of human ecosystems in urban areas. *Urban Ecosystems* **1**: 185-199.

Pulliam, H.R. & Johnson, B. (2002) Ecology's new paradigm: what does it offer designers and planners? B. Johnson and K. Hill (Eds). *Ecology and design: frameworks for learning.* Island Press, Washington, D.C., London.

Redman, C.L.; Grove, J.M. & Kuby, L.H. (2004) Integrating social science into the long-term ecological research (LTER) network: social dimensions of ecological change and ecological dimensions of social change. *Ecosystems* **7**(2): 161-171.

Rink, D. (2005) Surrogate nature or wilderness? Social perceptions and notions of nature in an urban context. I. Kowarik & S. Korner (Eds). *Wild urban woodlands: new perspectives for urban forestry.* Springer, Berlin, New York. pp 67-80.

Urban Wild Group (2004) What is urban wild? Retrieved September 13, 2006. http://wwwurbanwild.blogspot.com/.

2.5 Open session 23: urban ecology and greenspace

Shifting the urban landscape paradigm – the ecosystem engineering and design approach

A. Stokman

Institute for Open Space Planning and Design, Faculty for Architecture and Landscape Sciences, Hanover University, Herrenhäuser Str. 2a, 30419 Hannover, Germany.
e-mail: antje.stokman@freiraum.uni-hannover.de

Introduction

Due to economic growth combined with more and more refined technologies in the 20th century humans were able to overcome the restrictions of natural environments. The destruction of the "wild" nature in favour of a man-made, controlled image of nature has led to standardized, costly and high-maintenance urban landscapes – environmental damages related to it are being pushed downstream. Can we afford these urban landscapes in the future? Challenges of modern urbanization trends and increasing environmental risks require different forms of planning, design and management of urban landscapes. A discourse between different disciplines is emerging, exploring on the design of urban landscapes by linking design, engineering and ecological strategies (Mossop, 2006).

<u>Design versus engineering versus ecology: segregated understanding of urban landscapes</u>

Contemporary landscape and urban design still look at urban landscapes with mainly aesthetic considerations, constrained by an attachment to the picturesque. The predominant methods and techniques are based around an architectural paradigm of "final form" or a static outcome which should be kept by maintenance and prevent wilderness to "invade" and destroy the design (Yu, 2006). Engineers are designing the vital urban infrastructure – built forms that manage movement, water, power and waste - judged against the only criterion of technical efficiency of isolated systems (Picon, 2005). They generate huge structures related to human settlements and yet do not meet broader human, aesthetic and ecological objectives. Landscape ecology with its concern for the protection of landscape ecological functions is closely related to biological sciences (Ahern, 2005) and often lacks an integrated perspective considering the benefit also for people and economy rather than only nature.

This separation leads to isolated aesthetic, technical and ecological solutions creating static systems that require a high level of control and maintenance and are unable to adapt to changing conditions. However society, the environment and nature are complex dynamic, changing and evolving systems. The underlying processes and overall spatial dimensions of global simultaneous development trends are very hard to manage, control and foresee.

<u>Challenges of today's changing and dynamic urban landscapes</u>

The first challenge is related to expanding, low-density urban territories blurring the difference between the city and the countryside. More and more people follow the trend towards living in a low-density, attractive green and watery environment outside the city centres, longing for the presence of a different kind of landscape than what the dense urban environment can offer. The expensive urban infrastructure has to be extended to serve the same amount of people distributed in a larger area. The proportion of open space in urban agglomerations is becoming higher as the cities are maximising their edges. How can these extensive landscape and infrastructure systems still be afforded to be created and maintained? How can these landscapes be made accessible for a large number of people without destroying their ecological landscape functions?

The second challenge is related to shrinking cities. Due to the declining density there is an over dimensioned technical infrastructure within the cities for too few people needing extra high maintenance and also not functioning well because it not used within the limits of its ideal capacity anymore. Also there is less money to maintain more and more open space to prevent it from becoming neglected derelict land which makes the urban environment even less attractive. Can the existing kind of urban landscape and infrastructure really be maintained to keep the urban environment functioning and attractive in the future?

The third challenge is related to the fast growing and dense megacities where the infrastructure development can't keep pace with the rapid process of building construction. There are technical obstacles of existing technologies being too expensive, not being flexible enough to adapt to different circumstances and being quite susceptible to disturbances and failures if they are not constructed, operated and maintained in the right way. At the same time the sealing of huge areas leads towards big problems of groundwater subsidence and increasing floods. While the ornamental landscape beautification of cities is increasing very fast the ecological conditions within the urban environment are deteriorating even further. What kind of infrastructure is flexible, efficient and feasible in this situation and how can the urban landscape contribute to the sustainable urban development?

The integrated ecosystem engineering and design approach

Considering these challenges the existing models of urban design, infrastructure and ecology have to be reassessed and integrated, using a transdisciplinary type of knowledge production, a "mode 2" approach (Gibbons *et. al.*, 1994). By the examples of projects in Germany and China a transdisciplinary approach was developed to overcome the distinction between natural and artificial systems towards integrated hybrid typologies. In these projects the landscape contains a higher degree of ecological stability, making use of its dynamics for urban infrastructure functions which require less intervention and technical control while still offering attractive landscape experiences. These projects apply methods combining both analytical and logical thinking with intuitive and creative thinking to gain a comprehensive understanding of the landscape on a regional scale: its structure, organizational and financial frameworks, natural and socio-economic dynamic processes, elements and functions. The process of designing becomes at the same time a process of understanding towards a recognition of locally appropriate, sustainable landscape patterns. This understanding shifts the urban landscape paradigm: from a landscape that the society can bear the cost for beautification or ecology towards an understanding where landscape becomes an inevitable and constituent part of the cities infrastructure.

References

Ahern, Jack (2005): Theories, methods and strategies for sustainable landscape planning. In: *From Landscape Research to Landscape Planning.* B. Tress et. al. (Ed.), Springer. pp. 119-131.

Gibbons, M.; Limoges, C.; Nowotny, H.; Schwartzman, S.; Scott, P. & Trow, M. (1994): *The New Production of Knowledge*. Sage Publishers, London.

Mossop, E. (2006): Landscapes of Infrastructure. In: Waldheim, Charles (Ed.): *The Landscape Urbanism Reader.* Princeton Architectural Press, New York. pp. 164-177.

Picon, A. (2005): Constructing Landscape by Engineering Water. In: Institute for Landscape Architecture, ETH Zurich (Ed.): *Landscape Architecture in Mutation*. Gta Verlag, Zurich. pp. 99-114.

Yu, K. (2006): *Position Landscape Architecture. The Art of Survival.* China Architecture and Building Press, Beijing.

Escaped plants from garden into fallow lands in urbanizing rural area: influence of local versus landscape factors

A. Marco [1], S. Oliveau [2], T. Dutoit [3], M. Deschamps-Cottin [1], J-F. Mauffrey, V. Bertaudière-Montes[1]

[1] UMR 151 UP/IRD Laboratoire Population-Environnement-Développement, Université de Provence Centre Saint-Charles, 3 place Victor Hugo, 13331 Marseille CEDEX 3, France.
e-mail audrey.marco@up.univ-mrs.fr
2 UMR 6012 ESPACE, UFR des Sciences géographiques et de l'aménagement, 29 avenue Robert Shuman, 13621 Aix en Provence CEDEX, France ;
3 UMR 406 INRA-UAPV "Ecologie des Invertébrés", IUT Site Agroparc, Domaine Saint-Paul, 84914 Avignon CEDEX 9, France ;

Context of the study

Over the last thirty years, rural areas of French Mediterranean countryside have been subjected to a strong pressure of urbanization (Julien, 1999). Houses have spread, essentially isolated residential houses and highly crowded housing estates, have reorganized landscape mosaics in creating new ecological interfaces. The gardens of residential houses, represent areas of voluntary introduction of native and alien horticultural species which are in contact with a diversity of habitats (woodlands, fallow lands and fields under cultivation…) which might be colonized by introduced species. Horticultural species, which are well-adapted to mediterranean climatic and edaphic constraints, are able to escape, reproduce, and become established outside gardens (Sukopp, 2004). They participate therefore in the development of alien flora and are able to modify the floristic diversity and the ecosystem functioning (biological invasions, hybridization, interspecific relations…) (Vitousek *et al.*, 1997). Considering the absence of recent anthropic perturbation on fallow land and the increase of their cover in rural landscapes, following the abandonment of agricultural land since 1950, fallow land offer suitable sites for the establishment of escaped plants.

Aim of the study

The aim of this work is to understand the mechanisms leading to floristic patterns of alien species in urbanized landscapes in order to give information to urban planners to preserve biodiversity in these areas. More precisely, we identified the explanatory factors of the presence of escaped garden plants in the Mediterranean post-cultural fallow lands and their relative importance with a spatial analysis on two hierarchical levels: the local structure of fallow land and its surrounding landscape.

Methods

The study was carried out in the village of Lauris, in south-east France, in the Mediterranean Basin region. It is located in the Natural Regional Park of Luberon, bordered in the north by the watershed of the Petit Luberon and in the south by the Durance River. This rural area consists of 53% of woodland, 37% of agricultural land and 10% of urban land and is within meso-mediterranean bioclimate. It is in the zone of influence of two big towns Aix-en-Provence and to a lesser extent of Marseille where urbanization has been spreading into the surrounding agricultural land and natural countryside since 1975. In thirty years, the population of Lauris has doubled, rising from 1,620 inhabitants in 1975 to 3,143 inhabitants in 2005.

During June and July 2006, 180 fallow land parcels were visited. In each parcel, we sampled all the perennial escaped plants from gardens and noted on a scale plan their abundance, using a reasonably consistent search effort depending on areas of fallow land.

We assessed the relative importance of 34 predictor variables for alien species richness in the fallow land sampled. They were divided in three groups: 12 variables related to gardens (introduction sites of horticultural species), 10 variables related to fallow land characteristics (establishment site of horticultural species) and 12 variables related to the surrounding landscape of fallow land. They were collected from the land near homeowners, or estimated with GIS.

Data analysis

General Linear Modelling (GLM) was used to determine the combinations of independent variables that best predicted the richness of escaped garden plants.

Results and Discussion

Overall 27 perennial from garden escapes, essentially ornithochorous species, were found on the fallow land with highly variable abundances. We found that higher alien species richness was mainly associated (73% of the variation) with 7 predictor variables related to the introduction site, particularly with proximity and density of gardens around the fallow parcels, but also establishment depended on the structure of vegetation of the parcel. These results show therefore that both surrounding landscape and local factors are important drivers for alien species richness. Firstly, the surrounding landscape determines condition dispersal process of escaped garden plants. The closest juxtaposition between gardens and fallow land, but also the highest density of gardens around fallow land, increase the risks to colonization by escaped plants from a garden to a neighbouring habitat. The dispersal process occurs mainly over short distance. Secondly, the local factors with the structure of woody vegetation of fallow land may favour the establishment of ornithochorous species by offering perching places for birds.
This study thus shows that the hierarchy theory applied in landscape ecology operates in urbanized landscape and can be used to understand ecological process in these new environments (Burel and Baudry, 1999).

References

Burel, F. & Baudry, J. 1999. ***Écologie du paysage. Concepts, méthodes et applications*, Paris, TEC & DOC.**

Julien, P. 1999. Au-delà de l'urbanisation, l'étalement urbain caractérise la région, SU*D INSEE l'essentiel* 23, 1-4

Sukopp, H. 2004. Human-caused impact on preserved vegetation. *Landscape and Urban Planning* 68, 347-355.

Vitousek, P.M.; D'Antonio, C.M.; Loope, L.L.; Rejmanek, M. & Westbrooks, R. 1997. Introduced species: a significant component of human caused global change. *New Zealand Journal of Ecology* 21, 1-16.

Towards strategies for the development of urban green spaces

C. Smaniotto Costa, J. Mathey, B. Edlich

Leibniz Institute of Ecological and Regional Development (IOER), Weberplatz 1,
01217 Dresden / Germany.
e-mail: c.smaniotto-costa@ioer.de

Introduction

Urban green spaces are crucial elements of all cities. They shape the character and the image of a city. They provide ecological diversity and form essential structural and functional elements that make cities more liveable places for their citizens. Thus they assume a key role of improving the quality of urban life not only because of their ecological functions but also of their relevance for healthy citizens, societal well-being, economic benefits and the central role that they perform for sustainable ideals. But frequent deficits in quantity and quality all over Europe require appropriate management strategies for developing and improving urban green systems (URGE-Team 2004). Backed on these premises IOER carries out some international research projects on urban green spaces. Our contribution presents and discusses the findings from the European research projects “URGE – Development of Urban Green Spaces to Improve the Quality of Life in Cities and Urban Regions” and “GreenKeys – Urban Green as a Key for Sustainable Cities” . Within these projects networks with different European cities were established in order to obtain an overview on green situation, development strategies and planning frame conditions as well as to identify successful green development strategies and good practice examples.

Interdisciplinary instruments for analysing the performance of urban green systems

The traditional approach for the evaluation and development of green spaces is often characterised by a rigid splitting up into sectoral analysis. The different departments of a city’s administration gather green-related data in their own field of interest, which are later analysed and evaluated. Based on this type of analysis, strategies for the development of urban green spaces are often built upon a limited number of criteria related to a single discipline where, generally, the opinions of other disciplines are not taken into account. This process results typically in only quantitative targets (e.g. “create more green spaces”) with little consideration being given to the needs of the local population, economic factors, wider planning targets or even the qualitative aspects of green spaces (e.g. biodiversity). As a consequence, the emerging strategies for urban green spaces are not in harmony with the local circumstances. This effect is further compounded when other aspects of urban development (housing, infrastructure etc.) displace green space planning and development (URGE-Team 2004).

To solve this problem URGE developed an interdisciplinary approach, where criteria from the four disciplines of ecology, economics, sociology and planning were selected and integrated into a set of instruments called “The Toolbox”. With the application of the tools it is possible to analyse and evaluate urban green systems and individual green spaces in a more multi-dimensional way, which can support practitioners in achieving most favourable development and management strategies for green spaces. The tools included in the Toolbox are: 1) City Profile, 2) Interdisciplinary Catalogue of Criteria (ICC) and 3) Evaluation Methods. The City Profile is a questionnaire designed for the compilation of general information about a city’s urban green conditions. As a starting point for any necessary improvement, it enables the user (e. g. municipalities, planning authorities) to carry out a self-assessment, to identify existing strengths and weaknesses in policies and in provision of green spaces. The Interdisciplinary Catalogue of Criteria (ICC) is a complex tool set which integrates ecological, economic, social and planning aspects to assist practitioners in the interdisciplinary assessment, development and management of urban green spaces. It contains criteria and indicators and operates at two levels: The *City Level* deals with cities as geographical units and aims to support the analysis the structure of green spaces of a city, and the *Site Level* focuses on the evaluation of an individual green space. These two levels are not entirely the same, since the different levels of interpretation require different questions, but they are complementary. To support the analysis and the interpretation of the data collected by the application of the ICC the URGE project suggests two evaluation methods: the Polyfunctional Assessment Method (PFAM) and the FLAG Method. The URGE Manual provides a detailed description of both methods, as well as their theoretical background.

Challenges for an urban green space strategy

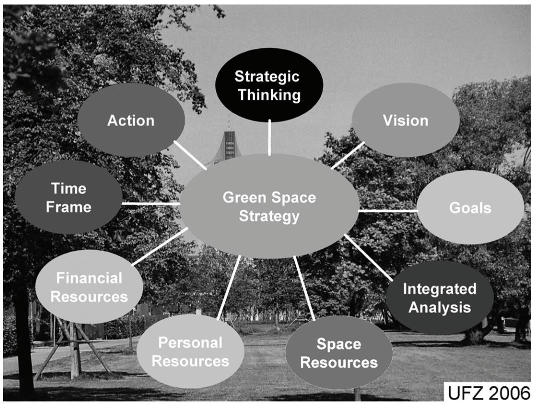


Figure 1 The components of the GreenKeys Strategy approach

As a result of the cross analysis within the cities network in URGE Project we can state that one challenge to be tacked is the low recognition of green spaces as an indispensable component of the urban infrastructure. This lack of recognition is maybe a result of the low awareness about the benefits offered by a good green space structure. Green space development in many cases is not linked with other planning activities. This affects at the same time the improvement of the urban social and economic environment. The challenge means also putting green space development high in the political agenda. An intensive exchange and reflexion of urban issues underpin the need for a Strategy for Developing Urban Green Spaces, which shall set out a collective vision for improved green spaces, meet community needs and provide a reference point for allocating resources and plans of action. In many cities there is a lack of a methodology to work out a green space strategy. A target set by GreenKeys project is to develop a green strategy for all 12 participating cities and based on the experiences made, build and disseminate a pool of green space strategies.
GreenKeys aims at developing and applying together with the city partners a strategy approach, this based on a literature review and on the exchange of practical experiences, methods and measures for initiating and strengthening the strategy development process with different features and under different conditions (e.g. demographic trends, economic transformation, land-use pressure, stage of development, structural policy).
This contribution aims at providing an analysis and an appraisal on the current situation on the development of these strategies. As the project is still running the results represent an interim situation, which is worth to be close assessed, then the problems and challenges faced by GreenKeys cities network should be also the same posed to other cities.

References

Greenkeys-Team (2006) 'Guideline for the General Procedure of Developing and Implementing an Urban Green Space Strategy'. http://www.greenkeys-project.net/media/files.
Smaniotto Costa, C. et al. (2005) 'Good Practice Examples for Green Space Development in European Cities'. Life in the Urban Landscape. International Conference for Integrating Urban Knowledge and Practice, Gothenburg, Sweden.
URGE-Team (2004) 'Making Greener Cities – A Practical Guide'. UFZ-Bericht. Nr. 8 (Stadtökologische Forschungen Nr. 37). Leipzig.

Landscape Ecological Indicators to Evaluate Urban Greenland

W.-C. Su, C.-Y. Chang

Landscape Architecture Group, Department of Horticulture, National Taiwan University, 138 Keelung Rd. 10673 Taipei, Taiwan
e-mail: d95628011@ntu.edu.tw

Introduction

How do people judge the correctness of the development and improvement of urban greenlands toward the ecological way? For example, Ong (2003) offers an ecological measure of the green plot ratio. Although it is proved effective in the evaluation of the greenery in urban areas, this measure adopts a humanistic ecological perspective.

Land use and land cover changes associated with urbanization significantly affect the composition of plant communities. Species are not only removed but also introduced (Wu & David, 2002). In other words, vegetation composition and structure affect the habitat capability directly (McComb *et al*., 2002). Based on biodiversity, it is reasonable to assess the ecological quality through spatial pattern analysis, i.e. the landscape structure (Luck & Wu, 2002; Kong & Nakagoshi, 2006; Abdullah & Nakagoshi, 2006). This research aims to develop an indicator to assess the spatial character and ecological quality of a specific urban greenland.

Method and material

This study was carried out in the eastern part of the main campus of National Taiwan University (NTU). The analysis of landscape structure was based on aerial photographs. The landscape elements were classified into seven classes: pavement, buildings, trees, shrubs, grass, farm, and water with the software eCongnition version 4.0. The scale parameter in multiresolution segmentation was set as 100 while shape factor as 0.1, compactness 0.9, and smoothness 0.1.

In ArchView 3.2, the 200 $\times$ 200 m^2 girds were applied on the digital data to defined the landscape metrics. To detect the landscape patterns, the metric was computed using FRAGSTATS (McGarigal *et al*. 2002). We chose the area-weighted mean shape index (AWMSI), which was the key point because it contained the area and shape.

Results and discussion

In Figure 1, we learn pavement is the dominant patch in NTU campus, especially in the main axis Palm Boulevard (grid 17, 18, 19, 20). Besides, it also happens to some of new buildings with lager paved open space (grid 7, 8, 11, 25, 26). The AWMSI values of pavement have a negative impact on bird populations (Chiang & Chang, 2006). It makes sense because the human activities are relative intensive in these locations.

On the other hand, the AWMSI values of trees could be an indicator of bird habitats and food sources. In the west side, named Black Forest, grid 9 and grid 15 have a better performance than others. However, the other parts of Black Forest, grid 8 and grid 16, have low AWMSI values because they are close to parking lot and dormitory.

Not only pavement but also the artificial grasses results in the isolation of patches. Similarly, the woods and ponds are not connected. Because the farms have educational function, the usage is very frequent. Therefore, the ecological quality is limited.

Data quality and accuracy assessment are both important points in landscape analysis (Luck & Wu, 2002). In this study, we applied aerial high-resolution photographs taken in 2004 and detailed classification. Our results should be robust.

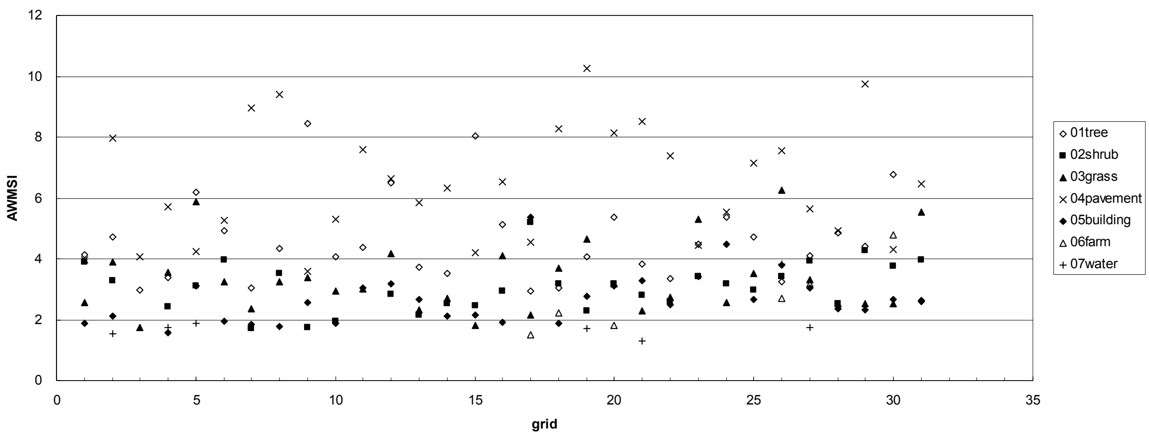


Figure 1. Landscape metrics-the AWMSI values of landscape classification in each grid which is 200 × 200 m^2

Conclusion

One of the most ecological functions is to afford wildlife species food and habitats in the urban environment (Attwell, 2000). However, the isolation of patches limits these functions in ecific areas. The new development in NTU campus should avoid to destruct the existing patches and corridors. Furthermore, since it is difficult to add new habitats, the more positive way is to enhance the connection between patches.

Besides the spatial dimension, to adjust the density and strength of usage is another way to reduce the impact. These analysis is helpful to assess the ecological quality and make new strategy to improve the urban greenland.

Reference

Abdullah, S. A. & Nakagoshi, N. (2006) Changes in Landscape Spatial Pattern in the Highly Developing State of Selangor, Peninsular Malaysia. *Landscape and Urban Planning* **3**: 236-275.

Attwell, K. (2000) Urban Land Resources and Urban Planting - Case Studies from Denmark. *Landscape and Urban Planning* **2-3**: 145-163.

Chiang, Y. –C. & Chang, C. –Y. (2004) Exploring the Sustainable Environment Based on Landscape Ecology and Landscape psychophysiology. *Landscape Cognition and Preference,* The Outdoor Recreation Association of ROC, Taipei, pp. 153-167. (in Chinese)

Kong, F. & Nakagoshi, N. (2006.) Spatial-temporal Gradient Analysis of Urban Green Spaces in Jinan, China. *Landscape and Urban Planning* **3**: 147-164.

Luck, M. & Wu, J. (2002) A Gradient Analysis of Urban Landscape Pattern: a Case Study from the Phoenix Metropolitan Region, Arizona, USA. *Landscape Ecology* **17**: 327–339.

McComb, W. C., McGrath, M. T., Spies, T. A. & Vesely, D. (2002) Models for Mapping Potential Habitat at Landscape Scales: An Example Using Northern Spotted Owls. *Forest Science* **2**: 203-216.

McGarigal, K., Cushman, S.A., Neel, M.C. & Ene, E. (2002) FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps. Computer Software Program Produced by the Authors at the University of Massachusetts, Amherst. Available at the following website: www.umass.edu/landeco/research/fragstats/fragstats.html.

Ong, B. L. (2003) Green Plot Ration: an Ecological Measure for Architecture and Urban Planning. *Landscape and Urban Planning* **4**: 197-211.

Wu, J. & David, J. L. (2002) A Spatially Explicit Hierarchical Approach to Modeling Complex Ecological Systems: Theory and Applications. *Ecological Modelling* **1-2**: 7–26.

Floristic patterns and mediterranean exurban landscapes: Relative importance of economic geography and landscape structure in functional diversity

E. Dumas[1], C. Napoleone[1], G. Geniaux[1], T. Tatoni[2]

[1]INRA. Ecodéveloppement, Site Agroparc Domaine St Paul, 84914 Avignon France.
e-mail: Estelle.Dumas@avignon.inra.fr
[2]Institut Méditerranéen d'Ecologie et de Paléoécologie (IMEP, CNRS UMR 6116), Université Paul Cézanne, Europôle de l'Arbois, Bâtiment Villemin, BP 80, F-13545 Aix-en-Provence

Introduction

Due to demographic growth over the last few decades, urban development and its impacts on wildland areas (diversity loss, fire risk) has become a major concern in developed communities in Mediterranean France. Especially, during the last decades, urban spread around the city of Marseille (a large employment pole in the area), has extended over agricultural and post-agricultural lands. Thus, urbanization and forests (results of abandoned agricultural grounds) constitute two intermingling systems in interaction, linear and surface urban configurations around or within forest islands, having recently re-structured the landscape: Wildland and forested areas in the Mediterranean region are popular and influence residential location choice. In this context, single houses answer a demand for space that urban areas cannot offer. Mutually, urbanization adjacent to or within forested areas modifies the structure and state of forest vegetation by increasing spatial fragmentation. At a local scale, urbanization and the associated human activities modify the composition and the structure of forest understorey and could then influence the functioning of the urbanized forest ecosystems in the long term.

Thus, urban and wildland area relationships drive landscape dynamics and generate various urban-forest interfaces. We therefore constructed research questions focused on urban-forest interfaces and hypothesize that forest states can be explained by urban impact via vegetation analysis at the landscape level. We tested this interdisciplinary landscape level by comparing plant responses in urban-forest interfaces from ecological landscape and socio-economic perspectives. This work was able to be made because of the approach of the landscape proposed by landscape ecology and which answers a demand of economic geography. With this goal in mind, we carried out floristic surveys in urban-forest interfaces. We performed multivariate analysis to test the influence of landscape pattern and socio-economic variables. Moreover, we built a Floristic Competitive Index (FCI), based on plant functional traits to test which variables may explain the presence of more or less closed forest (diversity, simplification of strata).

Floristic Competitive Index (FCI)

A Floristic Competitive Index (FCI) was derived from plant traits. Plant species are appropriate indicators of environmental parameters (Lavorel and Kramer, 1999). Growth-forms (Raunkier, 1934), adaptative stategies (Grime,2001) and seed dissemination (Muller and Molinier, 1938) were chosen to describe functional diversity in urban-forest interfaces. We used these plant functional traits because they are a means by which we can characterize system function. This conceptual framework assumes that functional groups are composed of species with shared responses to ecological processes. Every trait was weighted by a coefficient. The FCI index is defined as follows:

$$\mathbf{FCI} = \left(\sum_{i=1}^{n} \alpha\, C_{ij} / R \right) * \sqrt{N}$$

where α is the coefficient, Cij is the coefficient of species i at site j, R is species richness and N the total species richness (298 species). The square root was used to dampen the effects of species richness (Wilhem and Ladd, 1988). The disturbance index was limited between 0 and 1.

Regressions involving the disturbance were built from socio-economic, ecological and landscape variable groups. Local and regional levels were used in the model because both local and regional factors influence ecological processes. Socio-economic variables were recorded at the municipal level, ecological variables were recorded at local levels and landscape variables were calculated from the local to landscape levels.

References

Grime J.P. (2001). Plant Strategies, Vegetation Processes, and Ecosystem Properties John Wiley & Sons Ltd (Eds) Chichester

Lavorel, S. & Kramer, W. (1999). Functional analysis of plant response to disturbance. *Journal of Vegetation Science* **10:** 603–730.

Molinier, R. & Müller, P. (1938). La dissémination des espèces végétales. *Revue Générale de Botanique* **50**: 1–178.

Raunkiaer C. (1934). *The life-forms of plants and statitical plant geography*. Claredon Press (Eds), Oxford

Wilhem, G. & Ladd, D. (1988). Natural area Assessment in the Chicago region. Pages 361-375 *in Transactions of the 53rd North Marican Wildlife and Natural Resources Conference (Louisville, Kentucky)*, Wildlife Managment Institute (Eds), Washington, D.C.

The use of herbaceous vegetation to promote biodiversity in urban parks

J.C. García-Albarado[1], N. Dunnett[2]

[1] Colegio de Postgraduados - Campus Córdoba. Km. 348 Carr. Fed. Córdoba- Veracruz. Apdo. Postal 143, C.P. 94500. Córdoba, Veracruz, México.
e-mail: jcruz@colpos.mx
[2] University of Sheffield – Department of Landscape. 3rd Floor Arts Tower. Sheffield England.

Introduction

Public parks have great potential in promoting biodiversity in towns and cities. Traditionally, nature conservationists have concentrated on semi-natural habitats within a park, and the wilder areas of a site as a focus for biodiversity enhancement. However, the more intensively used and more ornamental areas also have much potential. This paper addresses this potential, concentrating particularly on two key issues: public perceptions of nature-like vegetation in high-visibility locations, and the positive role of non-native species in ornamental contexts. The paper focuses on a study carried out in a well-used park in the city of Sheffield, UK that investigated public responses to conventional and naturalistic plantings at the entrance to the park.

Methodology

Two different plantings were established in two adjacent beds of a similar size in a highly visible location. Planting 1 was a formal colourful summer bedding scheme of exotic (non-native) species whilst planting 2 was a sown meadow containing both native and exotic species (similar to natural vegetation), (Figure 1). The use of exotics for the latter was to extend the flowering season and increase the structural complexity of the planting, when mixed with native. 300 park visitors were interviewed about their level of preference, as well as their likes and dislikes of each planting during summer 2002

Figure 1. Formal colourful summer bedding scheme (right) and a sown meadow (left) at Endcliffe Park, Sheffield, UK during summer 2002 in the vicinity of the study plantings.

The evaluation of the beds was made using a questionnaire in which respondents were able to point out their level of preference according to a Likert scale as well as their likes and dislikes. The data obtained were processed using the SPSS version 11.0 software package.

The qualitative responses relating to respondents likes and dislikes were sorted into a number of response categories. For example, all responses that related to the colour of any of the plantings were assigned to the variable 'colour'. Spearman correlations were used to identify tendencies of respondents. These tendencies are presented in the main findings.

Main findings

According to the results, various characteristics were identified in both plantings to be key aspects to consider as barriers and opportunities for promoting biodiversity in the more intensively used areas of public parks: 1) Regardless the type of planting (formal or informal) the public tends to be enthusiastic about the more creative use of colour of flowers. Especially warm colours should be included in the composition of designed vegetation, a fact that has been also documented by other studies (e. g. Atha, 2003). 2) The natural, wild and informal appearance of the meadow was also valued not only for its overall visual effect but also for the opportunity it offers in experiencing a sense of freedom, being in touch with the natural world, etc. 3) The greater diversity of plant species and their dynamic processes were also identified as positive characteristics. Its effect on the promotion of niches is created by the multi layers of vegetation. Meadow type plantings provide shelter and food for a great variety of insects, birds, and small mammals (Dunnett, 2004). 4) Height of plants was also highlighted by respondents in the meadow. Tall herbaceous vegetations were usually disliked, and especially when the plants are all tall and uniform, the preference decreases dramatically. Therefore a good mixture of species of different heights is likely to enhance people's preference.

In the case of bedding, the public tends to perceive this style as being too formal, an aspect that was liked as well as disliked. There were people who tend to like its formality but also to see it as dull. However, it was found that whilst both plantings were positively received, a significantly greater number of respondents indicated that they would wish to see more examples of the meadow in the future, compared with the formal planting type in the park. There was also a tendency to have the meadow planting on a larger scale and separated from the formal plantings within the park. It has been suggested by other research (e.g. Hitchmough, 2004, Nassauer 1995) that the scale and location of ecological plantings are likely to be very much related to the context of the place.

Finally, this research contradicts much of the perceived wisdom amongst public landscape managers and suggests that there is a possibility of public acceptance for change in the appearance and management of public parks to a less formal and more natural aesthetic appearance. The research informs that both plantings, natural and formal may have potential in any urban park that fulfils demands of its users.

References

Atha, J. (2003). Public perception of naturalistic herbaceous vegetation in urban environments: Colour combination and distribution pattern. Unpublished MA dissertation. Department of Landscape, University of Sheffield, UK.

Dunnett, N. (2004). The Dynamic Nature of Plant Communities. Pattern and Process in designed plant communities. In: N. Dunnett and J. Hitchmough (Eds.). The Dynamic Landscape. London: Spon Press. Pp. 97-114.

Hitchmough, J. (2004). Naturalistic herbaceous vegetations for urban landscapes. In: N. Dunnett and J. Hitchmough (Eds.). The Dynamic Landscape. London: Spon Press. Pp. 130-183.

Nassauer, J. (1995). Messy ecosystems, orderly frames. *Landscape Journal*, **14** (2): 161-170.

Effects of land-use intensity and forest patch complexity on avian diversity in an urbanized tropical island landscape

M. Suárez-Rubio[1], J.R. Thomlinson[2]

[1] Conservation and Research Center, National Zoological Park, 1500 Remount Road, Front Royal, VA 22630, USA.
e-mail: suarezm@si.edu
[2] California State University, Dominguez Hills, 1000 E. Victoria Street, Carson, California 90747, USA.

Introduction

Human population growth and the expansion and intensification of human land use are among the most pressing environmental challenges of the 21st century (McKinney 2002). Urban development in Puerto Rico has an accelerating and widespread pattern and deforestation is causing the loss and fragmentation of its forests (Ramos-González 2001). Only 1.2 % of the moist evergreen forests on the island are protected (Helmer *et al.* 2002), generally, these forests occur at the lowest elevations where rates of land-cover conversion to urban areas are highest. Puerto Rico provides a unique opportunity to assess how the spatial arrangement of urban forest patches and the interior patch structure influence the bird communities within a range of urbanization intensity.

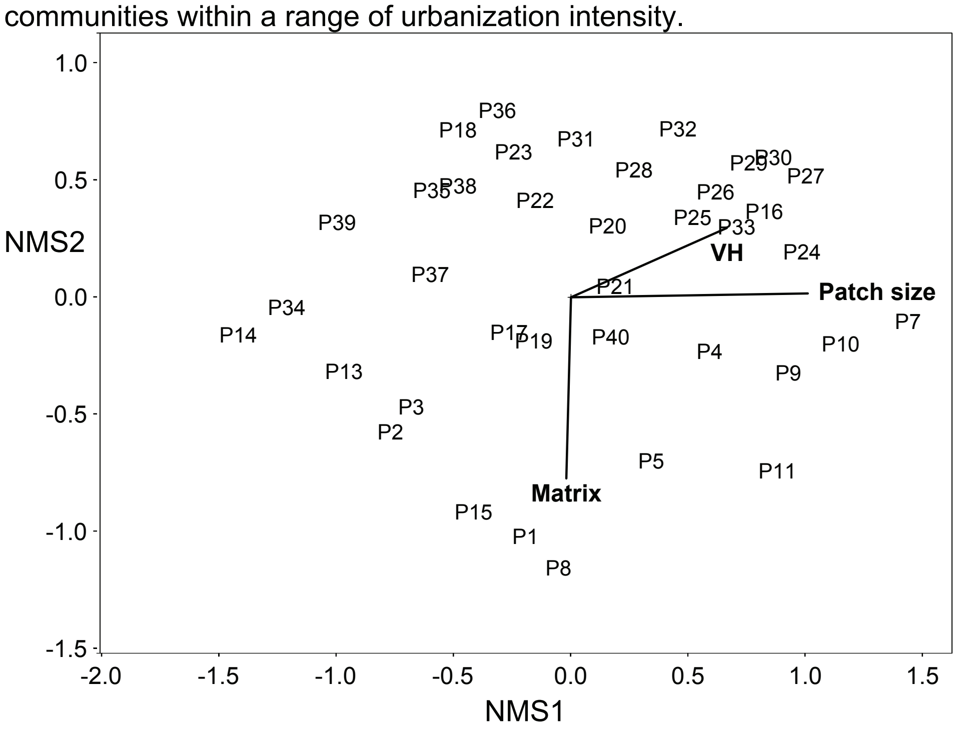


Figure 1. Joint plot of NMS scores of forest patches scores with patch size, matrix, and vertical heterogeneity (VH). The first and second NMS axes represent 44.0% and 22.6% of the variance, respectively.

Methods

We randomly selected 40 forest patches in the San Juan metropolitan area, Puerto Rico using IKONOS satellite images from 2002. To characterize the forest patches, we calculated patch size, patch perimeter, boundary configuration index (using the shoreline development index), matrix index (percent of constructed land in the matrix surrounding each forest patch), isolation coefficient (Thomlinson 1995), and texture analysis (measured as the coefficient of variation in normalized difference vegetation index (NDVI; Millward and Kraft 2004). In each of the 40 forest patches, we censused birds thrice: in 2004 and 2005, and we determined the foliage height profile in the 20 m radius plots centered at each bird census point.

Results

Both landscape and the interior patch structure are influencing the bird communities. Bird assemblages differed along the urban-suburban gradient in Puerto Rico: some species were relatively unaffected by urbanization, while several increased in abundance with increased urbanization and some were sensitive to even minor urban disturbances. It is important to understand the sensitivity of bird species to habitat degradation in the urban-rural interface, areas that in Puerto Rico are used by both endemic and neotropical migrant species. Identifying the importance of forest patches for these groups of birds will aid conservation. We are also identifying species sensitive to fragmentation.

Table 1. Species identified as indicators of matrix urbanization, and vertical heterogeneity. All indicator values (IV) were significantly larger than random values based on Monte Carlo tests (1000 permutations, $p < 0.05$).

	Indicator value		
Species by landscape and vegetation variables	*Observed*	*Random*	*SD*
Low-level urbanization matrix			
Todus mexicanus	*62.2*	*36.5*	*6.32*
Columba squamosa	*58.1*	*36.3*	*6.14*
High-level urbanization matrix			
Zenaida asiatica	*56.8*	*31.3*	*6.28*
Mimus polyglottos	*47.7*	*23.1*	*6.41*
Myiopsitta monachus	*40.2*	*15.8*	*5.84*
Spindalis portoricensis	*49.1*	*26.1*	*6.5*
High vertical heterogeneity			
Todus mexicanus	*56.9*	*36.4*	*6.17*
Loxigilla portoricensis	*52.5*	*28.9*	*6.38*
Low vertical heterogeneity			
Tiaris bicolor	*32.3*	*18.9*	*5.9*

References

Helmer, E.H.; Ramos, O.; López, T.d.M.; Quiñones, M. & Diaz, W. (2002) Mapping forest type and land cover of Puerto Rico, a component of the Caribbean biodiversity hotspot. *Caribbean Journal of Science* **38**: 165–183.

McKinney, M.L. (2002) Urbanization, biodiversity, and conservation. *BioScience* **52**: 883-890.

Millward, A.A. & Kraft, C.E. (2004) Physical influences of landscape on a large-extent ecological disturbance: the northern North American ice storm of 1998. *Landscape Ecology* **19**: 99-111.

Ramos-González, O.M. (2001) Assessing vegetation and land cover changes in northeastern Puerto Rico: 1978-1995. *Caribbean Journal of Science* **37**: 95–106.

Thomlinson J.R. (1995) Landscape characteristics associated with active and abandoned Red-cockaded Woodpecker clusters in east Texas. *Wilson Bulletin* **107**: 603-614.

The evaluation of the vegetation component of the urban landscape of Milan

V. Ingegnoli, S. Bresciani

Natural Sciences, University of Milan, 26 via Celoria, 20133, Milan (Italy)
e-mail: v.ingegnoli@virgilio.it

Introduction and methodological criteria

Ingegnoli (2002, 2006) directs his efforts towards the comprehension of the landscape and of its main component -the vegetation mosaic- as a proper biological system. Landscape ecology has been revised according to new scientific paradigms, ranging from the Principle of Emerging Properties to the 'order through fluctuation' processes, proposing new concepts (e.g. ecocenotope, ecotissue), new functions (e.g. biological and territorial aspects of vegetation, BTC) and new applications (e.g. evaluation of vegetation, etc.).

The method utilised here, *named LaBISV* (Landscape Biological-Integrated Survey of Vegetation), is able to integrate three different criteria (a biotic one, an environmental one and a configurational one) with different temporal and spatial scales. It uses a *parametric standard form*, a proper one for each type of vegetation, for the analysis and evaluation of a vegetated tessera (Ingegnoli, 2002; Ingegnoli & Giglio, 2005). It helps in the definition of the so called "*normal state"* for each specific type of tessera. The most important function involved in this method is the BTC.

The biological territorial capacity or BTC (Ingegnoli 1991, 2002) is a synthetic function, referred to the vegetation of an *ecocoenotope* (i.e. the integration of ecosystem, community and microchore). It expresses the flux of energy an ecological system must dissipate during a year to maintain its degree of organization and metastability. It is based on: (1) the concept of resistance stability (Odum 1971); (2) the principal types of ecosystems of the ecosphere (Whittaker 1975); (3) their metabolic data (biomass, gross primary production, respiration, R/PG, R/B) (Duvigneaud 1977, Piussi 1994, Pignatti 1995).

All this improves vegetation science (Ingegnoli, 2005), allowing its capacity to analyze and evaluate even an urban landscape.

The vegetation of the urban landscape of Milan

At this purpose, we present the case study of Milan and its hinterland. This landscape is extended 1.103 km^2 where Milan (municipality) covers only the 16,5% of this territory, and vegetation is mainly concentrated in few remnant patches of woods (4,1%), in few urban parks and gardens (4,2%) and in the remnant rural hedgerows (2-3%).

The vegetation summing only 11% of a so large landscape represents a big environmental problem for 3.400.000 inhabitants of the "Great Milan", which environment is quite degraded, as shown in Table 1. Remember that with the same characters of the sample average, a good ecological state of an oak forest can easily reach BTC = 8,00. Moreover, the ratio BTC/BTC* which gives the level of maturity of a forest patch is less than 50%! On the other hand, in the city of Milan (1.300.000 inhabitants) the ecological state is worst: only 5% of urban green, 1,5% of woods, 1% of rural hedgerows! Let us see the reported figure 1. The large horizontal line in the figure represents the regional BTC: note that all the urban parks have lower BTC values (about 1.2-1.5 Mcal/m^2/year), while a remnant patch of natural forest in Cusago reach 7.5. The decrease of the water table under the town and the increase of the temperature forming a "thermal island" enhance the degradation of the urban environment.

Table 1. *Some examples of forest tesserae in the hinterland of Milan, demonstrating their low ecological condition.*

Forest tesserae	*Q.T*	*Q.F*	*Q.E*	*Q.U*	*BTC*	*BTC/BTC**	*H*	*PB*
					Mcal/m2/yr		*m*	*m3/ha*
A-Quercus rubra, *Monza Park*	*53*	*84.9*	*31.4*	*32.8*	*5.33*	*52.2*	*29.2*	*649*
B-Oak mixed wood, Monza Park	*43.9*	*59.1*	*32.7*	*49*	*4.57*	*44.7*	*24.4*	*300*
C-QuercusCarpinetus, *Monza Park*	*53.8*	*59.1*	*39.1*	*52*	*5.08*	*49.7*	*22*	*280*
D- Oak mixed wood, Monza Park	*53.8*	*53*	*37.7*	*36.4*	*4.53*	*43.2*	*20.5*	*290*
E-Quercus-Carpinetus, *Parco Ticino, Robecco*	*61.4*	*54.6*	*58.6*	*57.6*	*6.41*	*62.7*	*23*	*439*
F- Oak mixed wood Parco Ticino, Robecco	*46.2*	*43.9*	*47.3*	*47*	*4.95*	*48.4*	*19.6*	*315*
G-Robinietum *B.Riazzolo, Cisliano*	*18.9*	*53*	*35*	*47*	*3.48*	*34.1*	*9.5*	*120*
Sample average					4.9	48	21.2	300

BTC/BTC = ratio to the threshold of maturity of a forested tessera;*

QT= tessera quqlity; OF=quality of the phytomass; QE= quality of an ecocoenotope (sensu *Ingegnoli 2002); QU= quality of landscape unit characters; PB = plant biomass volume.*

References

Duvigneaud P. (1977), Ecologia. in *Enciclopedia del Novecento*. Vol. **II**, Enciclopedia Italiana Treccani, Roma.

Ingegnoli, V. (1993) *Fondamenti di Ecologia del Paesaggio*. Cittàstudi. Milano.

Ingegnoli, V. (2002) *Landscape Ecology: A Widening Foundation*. Springer. Berlin, New York.

Ingegnoli, V. & Giglio E. (2005) *Ecologia del Paesaggio: Manuale per conservare, gestire e pianificare l'ambiente.* Sistemi Editoriali Se. Napoli.

Pignatti S. (1995) *Ecologia vegetale.* UTET, Torino

Piussi P. (1994) *Selvicoltura generale.* Torino, Ute

Managing feral exotic pets: decision-making process revisited

V. Servais[1], P. Teillac-Deschamps[2], R. Lorrillière[2], V. Delmas[2], A.C. Prévot-Julliard[2]

[1] Département des Sciences et de la Communication. Université de Liège. Place du 20 Août, Bât. A1. 4000 Liège. Belgium;
e-mail: v.servais@ulg.ac.be
[2] UMR 8079 Laboratoire Ecologie, Systématique et Evolution. Univ Paris-Sud bat 362. 91405 Orsay Cedex. France.
mailto:

Exotic pets released in the wild occupy a particular position among human-driven introductions: They are mostly introduced in urban areas, where human densities are the highest and where habitats are no more natural. Moreover, in addition to being potential invaders, these species are well known and appreciated by the general public. These contradictory arguments may lead to potential conflicts between stakeholders in decision-making process concerning management actions.

Slider turtles *Trachemys scripta elegans* have been introduced in urban wetlands since 1980's, after massive pet trade from United States. They are notably present in managed urban parks, where people use to go for walking or recreation goals. Despite naturalists' fears and conviction that slider turtles have a great impact on natural communities, no scientific studies supported this assertion.

As a part of a general project on slider turtle in Paris area (France), we studied the impact of this exotic species on natural pond communities and human perception of slider turtles in the urban context. In this talk, we propose a way to mix these biological and anthropo-social questions through companion modelling and multi-agent system. We suggest how this research process can be used as a guideline for decision-making, in order to integrate all points of view and sensibilities, in other conservation programs in urban areas.

We studied the impact of slider on aquatic communities; through an experimental protocol we weekly surveyed water composition and several compartments of the aquatic communities of 12 semi-natural ponds (algae, vascular plants, zooplankton, arthropods, gastropods and amphibians). These ponds contained 0, 1 or 3 adult female turtle respectively. Preliminary results indicate that turtles impact the functioning of local communities, but without decreasing neither species richness nor species abundance (Teillac-Deschamp et al. in prep).

When asking the general public about their feelings on turtles, many people who spent time hiking commented that they liked seeing turtles during their walks. For some urban people, this exotic species is one of the few representations of nature to which they are exposed in urban parks. This non-intuitive result is contrary to the conservationist's beliefs that every exotic species is a problem.

Finally, we studied the decision-making process of any turtle private owner wanting to get rid of the pet. We found that the decision (releasing ii in nature or in recovery centre) strongly depends on the general environmental perception of the owner.

Managers of public areas have generally both conservation and education aims. However, the education tools they propose are only efficient for volunteers that are already environmentally concerned. Nevertheless, many citizens go to urban parks for other reasons than just nature-based and are not receptive to education messages. These users maybe attracted to urban parks for aesthetic reasons, including the presence of exotic species in these areas. In this context, the presence of slider turtles in urban parks could be associated with a higher number of visitors and thus of a higher potential impact of nature-based education tools developed by managers.

These results show that slider turtles present in urban parks should be considered not only as a (potential) biological problem, but also as an element of a social-ecological urban system. Our research findings will thus be used to propose management strategies for Slider

Turtles in urban wetlands. In particular, we ask whether it is worth systematically removing turtles, considering the balance between impact, spreading potentialities and public

The fact that exotic species could attract people towards nature should be taken into account in decision-making process, in the same way that the potential impacts of this species on environment should also be considered.

Acknowledgements

This program is funded by the Regional Council Ile de France, the Direction de l'Environnement Ile de France, the General Council Seine et Marne, the General Council Essonne, the General Council Hauts de Seine, the General Council Seine Saint Denis. The collaboration between the laboratory ESE (University Paris-Sud, France) and the Dept of Communication (University of Liege, Belgium), is founded by CNRS and FNRS/CGRI (n° 18 220).

2.6 Open Session 24: The urban Landscape

The Crisis And Rehabilitation Opportunities Of Urbanization In Urban Fringe Rural Settlements - A Case Study Of Taoyuan Region, Taiwan

M. Kuo

Chinese Culture University, 2F., No.1-8, Jinsi St., Jhongshan District, Taipei City 104, Taiwan (R.O.C.).
e-mail:epdc2000@ms42.hinet.net

Recently the rapid growth of global population and its concentration in limited urban areas have resulted in the changes of land use patterns and the fuzzy boundaries of urban and rural areas. Regional economy, ecology, and culture affected by rural changes are complex and diversified. The factors affecting the aforementioned rural agricultural settlements are also connected to the global environment, politics, economics, and societal changes.

In terms of large-scale national land development, the aforementioned changes can be identified. However, due to the diversity and variation of these factors, the feedback of changes to the intrinsic quality and formation of landscape ecological structures on a regional scale is related to the value of resource changes, land capacity, and management policies towards the environmental and ecological rehabilitation.

Taiwan is an island with 58.8% of high slope mountain areas covered by forests. The flatlands are limited. The rapid population growth, 77% of the population concentrated in urban areas (Yang, 2005), industrialization, and urbanization in the past 50 years have significant impact on the ecological structure of lowland agricultural landscape. The urban sprawl destructed agricultural wetlands and threatens river corridors. In addition, the globalization in the last 20 years has resulted in a vast transformation in the agricultural landscape. The internal structure of ecological systems in the existing farmland also faces dramatic changes.

The Taoyuan Tableland area is the most distinct example of urbanization in Taiwan farming settlements. It is located in the plains of northwestern Taiwan with only 40km from the Taipei metropolitan area. Prior to 1949, the economic focus has been on the agriculture. However, after 30 years of industrialization and the construction of freeways and international airport, since 1980 the area economy has been rapidly converted to high-tech industries and recreational tourism. Additionally, with the completion of the Taiwan High Speed Railway system in 2006, it begins a fourth wave of revolutionary change in city and country spatial development.

The Taoyuan Tableland possess a globally unique irrigation pond and canal system which is an important lifeline of agricultural development in the past. In the recent years, the irrigation ponds have been reduced from over 10,000 to 3,345, while the irrigation canal system has been expanded to 2,184 km. The ecological habitat and water resource conservation along with the rural landscape structure play an important role in developing the cultural landscape in the area. The value of cultural landscape has reached the level of the conservation of world cultural heritage.

This paper utilizes satellite images and GIS to explore the effect of urbanization on special massive irrigation pond systems, the growth and decline of irrigation canal networks, and the overall landscape ecological structure in the period of past 50 years. The landscape ecology theory will be applied as a basic platform to examine past studies and collected data, and utilize the spatial change history to explore and analyze the current states of regional scale landscape ecology changes, to analyze the factors and driving forces behind the landscape ecology change of the Taoyuan Tableland, to understand the pressure and impact of urbanization on the life-support system, ecological system, and rural settlement ecological system. Finally, the result of the aforementioned analysis will be used to examine the responses and strategies of national land management policy implementation towards the repair of the Taoyuan Tableland landscape ecology system.

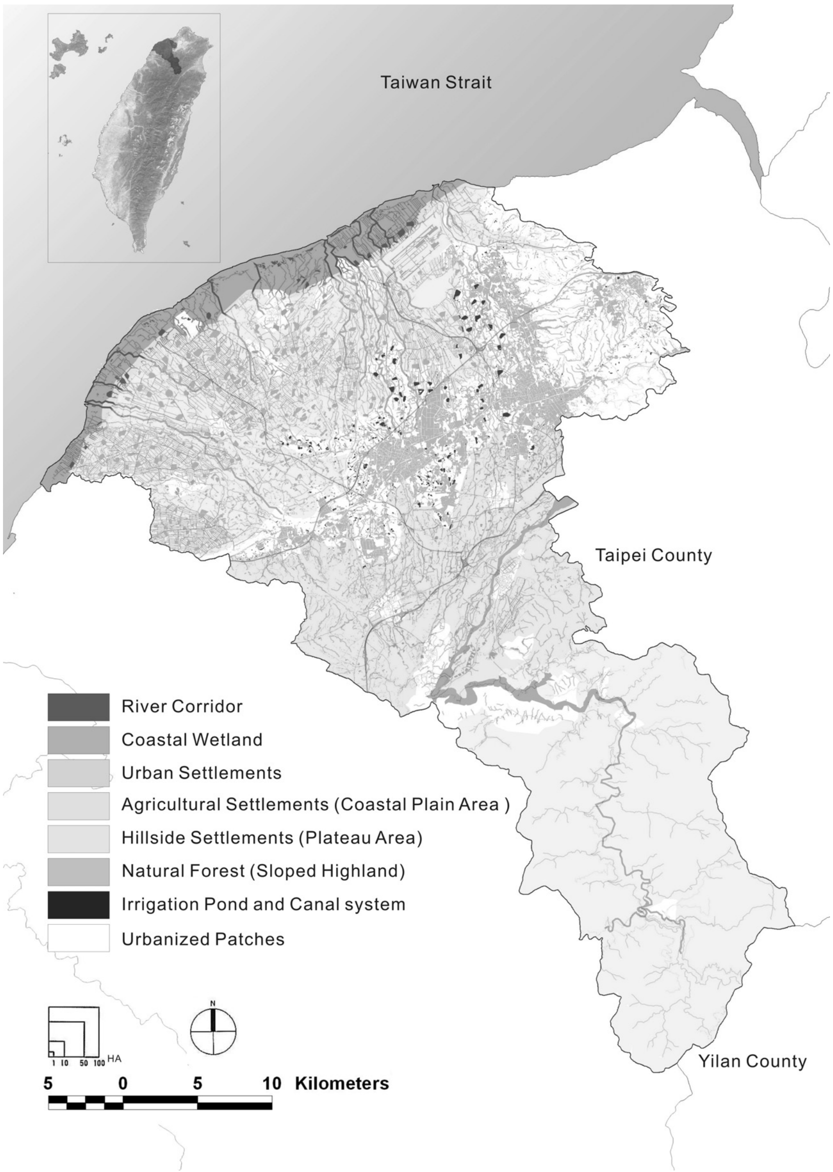


Figure 1. Landscape ecological structure of current Taoyuan rural settlements, Taiwan

Investigating the relationship between the tree cover connectivity of the metropolitan regions across the eastern United States and the number of breeding occurrence of the three forest bird genera

S. Kato

University of Massachusetts/Amherst, Department of Landscape Architecture and Regional Planning, 109 Hills North, University of Massachusetts, Amherst, MA 01003, USA.
e-mail: skato@larp.umass.edu

Introduction

In urban areas, even though greenspaces are often small and fragmented, they have a potential to support important ecological as well as social functions. Thus, strategic planning of urban greenspaces is important for those—human and non-human species—that benefit from their services. This study focuses on the spatial configuration, especially connectivity, of urban/suburban greenspaces and its effect on the number of occurrence of certain forest bird species that could benefit from the increase in tree cover connectivity. By using certain bird species that can act as the indicators of ecological health, the study hopes to claim that their presence suggests an environment that can support related ecological functions.

Objective and Research Questions

The objective of the study is to investigate the relationship between the degree of connectivity of tree cover of major metropolitan regions across the eastern United States and the number of occurrence of breeding oriole species (*Icterus* spp.), tanager species (*Piranga* spp.), and thrush species (*Hylocichla* spp.). Specific questions asked include: Can structural connectivity metrics predict the target breeding bird abundance/occurrence in metropolitan regions? Can they be surrogates for functional connectivity metrics? What is the range of connectivity that best supports the breeding birds? Is there a generalizable relationship between the appropriate degree of tree cover connectivity and the breeding bird abundance/occurrence across different geographic/climatic regions?

Study Area and Land Cover Data

The study area will be the Eastern United States (i.e., the states east of the Mississippi River). The study area contains the New York-Washington, D.C. megalopolis corridor—the most densely populated region in the United States. Metropolitan Statistical Areas (MSAs) as defined by the U.S. Office of Management and Budget will be used as the metropolitan regions of interest (i.e., my samples). A MSA consists of one or more core urban area with the population of at least 50,000 and neighboring areas with strong economic and social ties to the core(s). Within the study area, I will compare the metropolitan regions with varying tree cover connectivity. Land cover data will be acquired from the National Land Cover Database 2001, which includes other potentially useful data including a 30 m DEM, slope, aspect and a positional index, and per-pixel estimates of percent imperviousness and percent tree canopy. Per-pixel (30 x 30 m) estimate of percent tree canopy is of primary interest.

Bird Data

Three genera of bird species (i.e., *Icterus* spp., *Piranga* spp., and *Hylocichla* spp.) will be chosen as target genera since they have a wide distribution across the eastern United States and they are neither too rare nor to common in urban areas. The most important criterion of choosing these genera is that they are forest birds expected to respond to changes in forest structure (both composition and configuration) in urban areas. My assumption is that they would increase in number if tree covers and their connectivity increase. Tanager species are reported to be a good indicator of forest fragmentation (Rosenberg *et al*., 1999).

The bird data will be acquired from the Breeding Bird Atlas. It provides a listing of species known to be breeding or suspected of breeding in each survey block at the time of the survey. Each state is divided into 5 x 5 km survey blocks within which trained volunteers count the evidence of breeding (“possible,” “probable,” or “confirmed”). To account for yearly fluctuations in breeding occurrence, the number of breeding occurrence for each species will be averaged over the past five years (2001-2005) and the average will be used as the response variable.

Variables and Data Analysis

The number of breeding occurrence of the three bird genera is a response variable. The degree of tree cover connectivity in each metropolitan region serves as a predictor variable. A regression analysis will be conducted. Other predictor variables that may be included in a stepwise regression model are: elevation, average annual temperature, and average annual precipitation. The Akaike Information Criterion will be used to select the best fitting model (Akaike, 1974).

Merit of the Study and Expected Results

It is important to characterize landscape heterogeneity in a way that is relevant to how forest birds respond to the increase/decrease in tree cover connectivity. By using a continuous explanatory variable (i.e., percent tree canopy), the study intends to capture the effect of small patches and/or rows of trees that may provide a valuable food source and/or serve as rest stops for forest birds to increase in number in urban settings. The traditional patch-mosaic model (Forman, 1995) is not suited to represent these small patches of trees at a coarse resolution. Since I hypothesize that forest birds would respond to these small forest patches, there is a merit of using continuous explanatory variables that can relate to continuous response variables such as organism abundance and occurrence (McGarigal and Cushman, 2005).

The results will have implications for planning an appropriate degree of tree cover connectivity in metropolitan regions to support breeding forest birds. The findings would lead to the planning of urban greenspaces to support ecological as well as social functions. To plan future urban greenspaces, it is crucial to consider their interrelatedness: both horizontal (lateral) and hierarchical connections. The study will shed light on the important environmental variables to predict the occurrence of the forest birds and suggest an appropriate degree of tree cover connectivity in the metropolitan regions in the eastern United States to sustain the breeding of these forest birds.

References

Akaike, H. (1974) A new look at the statistical model identification. *IEEE Transactions on Automatic Control* **19:** 716-723.

Forman, R.T.T. (1995) *Land Mosaics: the ecology of landscapes and regions.* Cambridge University Press, Cambridge, UK.

McGarigal, K. & Cushman, S.A. (2005) The gradient concept of landscape structure J.A. Wiens & M.R. Moss (Eds). *Issues and Perspectives in Landscape Ecology.* Cambridge University Press, Cambridge, UK, pp. 112-119.

Rosenberg, K.V.; Lowe, J.D. & Dhondt, A.A. (1999) Effects of forest fragmentation on breeding tanagers: a continental perspective. *Conservation Biology* **13:** 568-583.

The spatial relation between "urban green" and "surface sealing" in semi-urban areas

S. Meeus, H. Gulinck

Division of Forest, Nature and Landscape Research
K.U.Leuven, Department of Land Management and Economics
Celestijnenlaan 200E, 3001 Leuven, Belgium
e-mail: steven.meeus@biw.kuleuven.be

Urbanization is generally considered as a process of soil-sealing, fragmentation and reduction of green elements and biomass. This presentation focuses on the spatial interaction between the process of "hard" urbanization and the emergence of new green elements and structures such as gardens and parks, green verges etc.

Measuring simultaneously urban green and surface sealing and investigation their spatial co-occurrence can lead to the definition of indicators that not only help to deepen the insight in landscape-ecological conditions of urbanization, but also to help in giving more land cover and structural insight in urbanizing areas, which may eventually stabilize in semi-urban landscapes. Semi-urban landscapes, however difficult to define or demarcate, deserve much more attention as specific landscape settings next to rural, urban or natural.

Using various statistical techniques such as multivariate analysis, clustering and non parametrical statistics, the relationships between (geographical) location of the site where the indicators are measured and the distance to urban cores, as well as the effect of the cultural landscape and scale effects are analyzed for a study area (Mechelen) located in the centre of Flanders and two smaller study areas in more rural parts of Flanders.

For measurement of the properties of semi urban areas, a conceptual model based on a possible range of combinations of properties of three main landcover / landuse classes (sealed surfaces, urban green structures and agricultural land) was designed. This model was successfully used to define "urban cores" in the semi urban area, using class area per sample, these cores being different from dense city cores. The results were used for radial proximity analysis.

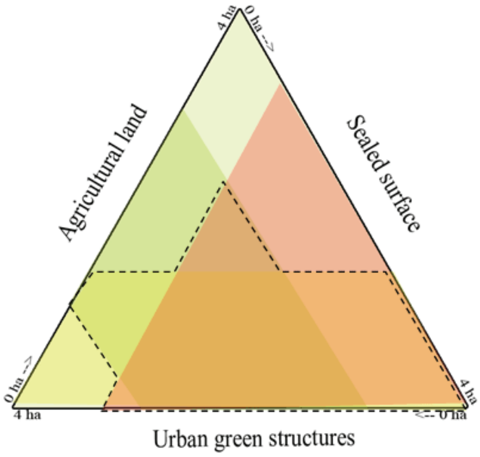
The properties uses in the conceptual model are based on landscape metrics (as in the FragStats applications), such as Class Area, Patch Size, dynamics and diversity measures.

As source data a very detailed landuse/landcover raster was used with resolution one meter, based on the topographic Land Use maps on scale 1:10000 and compared, where necessary with orthographic photos taken between 1990 an 2005.

The upper and lower boundaries for these specific properties for sealed surfaces, urban green structures and agricultural land were statistically determined with a random sample of sample areas covering the targeted population of 'landscape type' inside an assumed semi urban area – for example "urban cores" or "hybrid agriculture". For every sample area, 50 different extents were used and compared statistically, resulting in an "optimal extent" for the sample size – 4 hectares in case of the urban cores analysis for example.

Combining the constraints for a landscape metric, for a given landuse/landcover class and for the specific landscape type analysed, the multidimensional space of all possible combinations of this property for the three landuse/landcover classes can be determined.

This conceptual model (recently called the ASU model) can be expanded with other (main) landcover classes, proven to be found in semi urban areas, such as forest fragments or water bodies. In addition to this, a wide range of properties, patch and landscape metrics, can be included in this model.



Repeating the analysis as described above, but for different properties, show that for a big number of metrics, these combinations of their values for different landuse/landcover classes can be investigated and used to describe typical landscape configuration as found in semi urban areas.

Combining these results in a proximity analysis (with for example the distance to the main city in the center of the study area as key measure, the proximity of other urban cores, the density of rural activity, demographic features or other ‘global’ properties), the dynamics of the semi urban area can be investigated.

Results show that there are specific relationships between urban green and surface sealing, that the location of the sample sites in relation to urban cores exist but are sometimes less significant than the influence of the underlying older rural substrate – even in denser semi-urban areas – and that surface sealing, as well as urban green are very dynamic variables or indicators in the semi urban area.

Results will be presented for several semi urban areas in Flanders, a region know for a high degree and diversity of semi urban areas.

Land-cover classification of Chongqing City and its surroundings using Landsat data

Y. Zhao[1], M. Tomita[1], K. Hara[1], M. Fujihara[2], Y. Yang[3], L. Da[4]

[1] Department of Environmental Information, Tokyo University of Information Sciences, 1200-2 Yato-cho, Wakaba-ku, Chiba 265-8501, Japan,
e-mail:zhaoyisoul24@yahoo.co.jp
[2] Awaji Landscape Planning & Horticulture Academy/Institute of Natural & Environmental Sciences, University of Hyogo, Japan.
[3] Key Lab of Three Gorges Reservoir Region's Eco-Environment (Chongqing University)Ministry of Education, Chongqing / Faculty of Urban Construction and Environmental Engineering, Chongqing University, China.
[4] Department of Environmental Sciences, East China Normal University, China

Introduction

Chongqing is a mega-city located in the southwest part of China along the Yangtze River. Numerous endangered species are found in and around the city, and the region includes rich water and biological resources. Since 1997, however, Chongqing is being redeveloped as the nucleus of an economic program designed to rejuvenate the inland region, which includes the Three Gorges Dam. This development is suspected of having a strong impact on the local biodiversity and ecosystems.

Remote-sensing is an effective tool for understanding landscape structure over a wide scale, as well as changes in spatial patterns over time. This study utilizes Landsat ETM+ 2001 data to establish a land cover classification for evaluating ecological conditions and trends in and around Chongqing.

Study Area

Chongqing Municipality is situated on the upper reaches of the Yangtze River. The total area of the municipality is 82,300km^2, and the population 31 million. Chongqing has a subtropical humid monsoon climate with four distinct seasons. Annual average temperature is 18.4 centigrade and annual precipitation 1182.1mm. The local topography features a river basin surrounded by mountains and hills, with elevations ranging from 150~3,000m. Rural villages and mountainous areas account for 80% or more of the municipality.

Methods

The research employed Landsat ETM+2001/5/22 data, Path 128 & Row 39, obtained from the Global Land Cover Facility of the University of Maryland. Eighty photographs taken in August 2006 using a digital camera with GPSMAP 60CS GPS, were utilized to establish ground truth. Based on this ground truth data, 7 classes of land cover were established, and classification was implemented using the Maximum Likelihood Method by ERDAS IMAGINE (Leica Geosystems GIS & Mapping, LLC).

Results and Discussion

The results of the land cover classification are shown in Figure.1 and Table 1. As can be seen, cultivated (non-irrigated fields) land (35.2%) and rice paddy (13.4%) together accounted for almost half of the total study area, showing that the land resources of Chongqing are heavily used for agriculture. Cultivated land, as well as forest (18.3%), scrub (24.2%) were concentrated at higher altitudes. Rice paddies were found mostly in the valleys, but in some cases terraced paddies were built into the slopes. This land-use pattern of closely following the local topography was evident even from the field observations, and in this sense resembles the traditional land-use patterns in many areas of Japan. In contrast to the agricultural valleys and hillsides, the level areas in and around the city, was mostly urban, with development reaching as far as the foot of the mountains. The combined area of forest and scrub accounted for 42.5% of the total. It is possible, however, that this substantial area may at least in part be the result of a national policy for converting agricultural land to forest. Stretches of forest along the higher slopes formed a continuous habitat corridor, which can be expected to play an important role in conserving biodiversity in the study area.

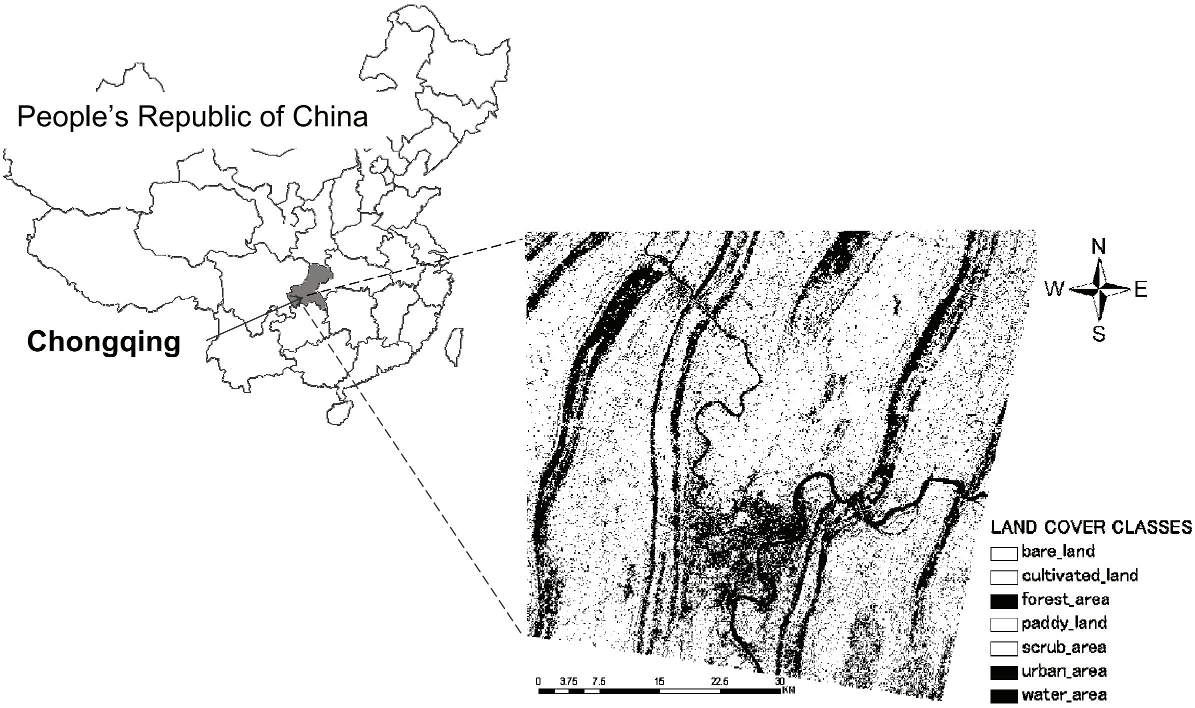


Figure 1. Results of land cover classification

Table 1. Results of land cover classification

Land cover class	(%)
Bare land	1.5
Cultivated land	35.2
Forest area	18.3
Paddy area	13.4
Scrub area	24.2
Urban area	5.0
Water area	2.4

References

M. A. Alrababah & M. N. Alhamad (2005) Land use/cover of arid and semi-arid Mediterranean landscapes using Landsat ETM. *International Journal of Remote Sensing* 27: 2703-2718.

Linking physical landscape character with open space aesthetics

Z. Wang, J.I. Nassauer, D. Brown

School of Natural Resources and Environment, University of Michigan.1550 Dana Building, 440 Church Street, Ann Arbor, MI 48109-1041,USA.
e-mail: zhifangw@umich.edu

Introduction

Ecological effects of exurban development are a growing global concern(Liu *et al.* 2003), and American landscapes epitomize residential sprawl(Burchell *et al.* 2002). Aesthetic preferences are one driver of sprawl in America, and preference for living near open space has been identified as a driving factor for people moving to exurban areas (Kaplan and Austin 2004; Vogt and Marans 2004). Yet, both the ecological health of exurban areas and the long term availability of open space experiences there depend on planning to maintain open space patterns even as more exurban development occurs. To help managers incorporate both open space aesthetics and ecological concerns into planning, we investigated the link between exurban residents' preferences for open spaces and the physical landscape character of their surroundings, as measured from mapped data.

Methodology

Our data about open space preferences were drawn from our web survey of 494 exurban home owners in southeast Michigan. The web survey was conducted for a large research project about spatial land use and ecological effects at the rural-urban interface. In this paper, only open space preference data were drawn from the survey. Open space preference was measured on a seven-point Likkert scale by asking respondents to indicate how much they would value open space directly adjacent to their property.

To investigate the links between open space preferences and physical landscape character, three aspects of nearby physical landscape character were explored. For landscapes directly adjacent to survey respondents homes, we measured landscape composition (the amount of thirteen landscape cover types), the shape of each landscape cover type (core area index, shape index), and overall landscape configuration (core area index, landscape evenness, landscape shape index). These indices were selected as they have been indicated as relevant to individual perception or individual experience of their surrounding environment from literature(Kaplan and Kaplan 1989; Palmer 2004; Zube *et al.* 1974). Home addresses of respondents were physically located in a GIS data layer. 468 respondents were used in this study since some of them did not provide valid addresses. Physical landscape character was generated from 2001 landcover data at a 30-meter resolution (State of Michigan). The amount of each landscape type adjacent to each home address was generated from a circle with a radius of 400 meter and a center at each respondent's home location. 400 meter was used because of its acceptance in planning literature as a comfortable walking distance (Atash 1994; Calthorpe 1989).

Statistical relationships between open space preference and the three types of landscape character were examined using SPSS 13.0. Descriptive statistics and correlations were the primary techniques executed to investigate the relationships.

Results and discussion

The respondent sample (n=468) reflects US Census of population descriptions of our study area in most ways, including age, income, education and number of kids. In the study, our respondents have tended to highly value open space adjacent to their homes with a mean rating of 6.1(Min=1; Max=7).

Our research found that people living in areas dominated by urban built-up landcover have significantly lower preferences for open space adjacent their home than do those living in less built up areas. Those who living nearby deciduous forest, agricultural land or shrub land have significantly higher preferences for nearby open space. However, coniferous woodland within walking distance is linked negatively with exurbanites' open space preference, and those living near water do not have significantly different preferences than others for adjacent open space.

Configuration of each surrounding landcover type strongly affected open space preference. Larger core area and more complex shapes of agriculture, deciduous forests and shrub link to significantly higher open space preference. For wetland and parks, their complex shapes have significantly positive correlation with open space preference but not their core areas. Cluster of roads and high density residential development have significant negative relationships with people's evaluation of their adjacent open spaces. Landscape characterized larger patches of low density residential development had significant positive correlations with resident open space preference while the complex shape of low density development of had the opposite effect.

Our investigation of the surrounding landscape configuration suggests that exurbanites tend to value more homogenous surroundings. Nearby landscapes that are characterized by larger patch sizes (more core area) were significant positively related to resident open space preference. In comparison, complex shape of nearby landscape links negatively with people's value of their adjacent open spaces. Landscape diversity is negative but not significant to open space preference.

Our research revealed that open space landscape character is strongly related to open space aesthetics of exurban residents. We conclude that the landscape character of nearby open spaces is linked with residents' preferences In addition, residents prefer to live in areas with more complex shapes of open spaces. Planning to maintain woodland character and agricultural land as a part of exurban landscapes while providing good access may help to satisfy residents' preferences and to enhance ecological quality.

References

A**tash, F. (1994)** Redesigning suburbia for walking and transit: emerging concepts. *Journal of Urban Planning and Development* **120**, 48-57.

Burchell, R., Lowenstein, G., Dolphin, W., Galley, C., Downs, A., Seskin, S., Still, K., and Moore, T. (2002) Cost of Sprawl-2000. National Academy Press, Washington, DC.

Calthorpe, P. (1989) Pedestrian pockets: New strategies for suburban growth. In The pedestrian pocket book: A new suburban design strategy (D.Kelbaugh, ed., pp. 7-20. Princeton Architectural Press, New York.

Kaplan, R., and Austin, M. E. (2004) Out in the country: sprawl and the quest for nature nearby. *Landscape and Urban Planning* **69**, 235-243.

Kaplan, S., and Kaplan, R. (1989) *The Experience of Nature: A Psychological Perspective*. Cambridge University Press, New York.

Liu, J., Daily, G. C., Ehrlich, P. R., and Luck, G. W. (2003) Effects of household dynamics on resource consumption and biodiversity. *Nature* **421**, 530-533.

Palmer, J. F. (2004) Using spatial metrics to predict scenic perception in a changing landscape: Dennis, Massachusetts. *Landscape and Urban Planning* **69**, 201-218.

Vogt, C. A., and Marans, R. W. (2004) Natural resources and open space in the residential decision process: a study of recent movers to fringe counties in southeast Michigan. *Landscape and Urban Planning* **69**, 255-269.

Zube, E. H., Pitt, D. G., and Anderson, T. W. (1974) Perception and Measurement of Scenic Resources in the Southern Connecticut River Valley, pp. 1-191. University of Massachusetts, Amherst.

Applying a landscape ecological approach in the analysis of prospective development for low-rise housing in Tyumen suburbs (Tyumen region, Russia)

N.R Rakhimova

Tyumen State University, Department of Ecology and Geography, ul. Semakova 12, Tyumen 625003, Tyumen region, RUSSIA

Introduction

It is increasingly recognized that in the second part of twentieth century the acceleration of urban population growth, city development, urban sprawl, and megalopolises leads to the spreading of urban life-styles to rural areas or the movement of urban populations to suburban areas, i.e. suburbanization. Suburbs first appeared in the big cities of the USA from the end of nineteenth to the beginning of twentieth century (Varivonchnik, 2004). The reason for this was the arrival of new types of transportation like automobiles and electric trains. This phenomenon then spread to Europe (Antrop, 2000), at first to the west and then to the east. It was associated with the advantages of having a privately-owned home, independence and a high standard of living.

Tyumen suburbanization

Post-perestroika Russia too experienced the effects of suburbanization. The initial boom in country house building involved the central regions of Russia. Later this process became more popular not only in the European part of country but in peripheral regions as well. Tyumen region is one of them. However, it was only in recent years that real legislation regulating land use in suburbs came into force. In response to the growing demand for out-of-town housing, the city administration made a decision to assign relevant areas for low-rise housing.
Now planning aspects are regulated by the Architectural Code of the Russian Federation, and issues of suburban planning fall within the purview of regional planning. So far there is not enough attention to ecological aspects in these official documents. Unlike in developed countries, debates about the use of landscape ecological approaches in planning procedures are not seen as germane to this process in Russia. Nevertheless, in this research I would like to apply some existing approaches of landscape ecology to Tyumen.

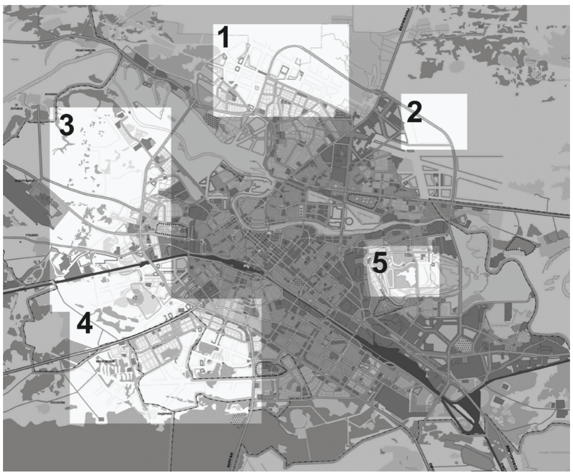


Figure 1. Areas of prospective development for low-rise housing (Tyumen general layouthttp://multitran.ru/c/m.exe?a=sa&t=217432_2_1&sc=0)

Assessment of the attraction of the developing landscape

Based on the general layout of Tyumen I have picked out five prospective areas (Figure 1). These areas have been chosen because they reveal more potential in terms of sustainable landscape planning. I have chosen two parameters to assess landscapes in prospective areas for low-rise housing: sustainability and value. These parameters are more important for residential area planning: sustainability is the ability of the landscape (landscape complex) to maintain its rate of functioning and spatial structure under changing external influences (Kurbatova, 2004); and value is the aggregate of aesthetic attractiveness, uniqueness, comfort and recreational resources of the landscape (Drozdov et al., 2006). I have composed a matrix of these parameters and identified an integral coefficient for the attraction (κ_i) of the developing landscape in order to offer a more opportune comparative assessment and for further application of this data in suburbs planning.

Table 1. Matrix of integral coefficient for the attraction of the developing landscape (κ_i)

Value / Sustainability	Highly valuable	Valuable	Not valuable
Highly sustainable	9	8	6
Sustainable	7	5	3
Unsustainable	4	2	1

Having defined the integral coefficient for the attraction of each developing landscape for individual suburban housing, I suggest using this formula to assess the attraction of some areas comparatively:

$$K_m = \frac{\sum_1^i S_i \times \kappa_i}{S_c},$$

where K_m – average coefficient of attraction for area, κ_i – integral coefficient of attraction of particular landscape, S_i – square area of landscapes with the same value of κ_i, S_c – total square area of land under assessment.

Having taken into account this research, area number 4 is the most felicitous for low-rise housing in Tyumen suburbs in terms of sustainable landscape planning. But if we want to get a complex assessment, we should take into account other factors in these areas, such as pollution, accessibility of communication, transportation and so forth.

Different level plans with landscape ecological approaches like this can form one of the axes of a sustainable development strategy, both for individual districts as well as for the country as a whole over the long-term period. My research is just one of the attempts to apply the landscape ecological approach to a real Russian city where there are challenges about developing low-rise housing in order to create a sustainable interconnected natural and man-made system for comfortable living.

References

Antrop, M. (2000). Changing patterns in the urbanized countryside of Western Europe. Landscape Ecology 15: p.257-270.
Drozdov, A.V. (2006). Landscape planning with engineering biology elements. Association for scientific publications, Moscow.
Kurbatova, D.S. (2004). Landscape ecological basis of town planning structures forming. Madzhenta, Moscow-Smolensk.
Varivonchnik, I.V. (2004). Country of suburbs: "American dream" today. USA – Canada. Economics, politics, culture 7: p.72-85.

2.7 Posters

Change analysis for planning sustainable landscape in the Urban Biosphere Reserve of Rome

C. Blasi, M. Marta , G. Capotorti, M. Marchese

Department of Plant Biology, University of Rome “La Sapienza”Piazzale Moro 5, Rome, Italy.
e-mail: blasilab@uniroma1.it

The extent that urban growth affects the local ecosystems can be controlled by high quality land management, an essential ingredient in all urban growth yet in most cities there have been virtually no effective measures to control land development. This is the case of Rome where master plans, including guidelines on land development and the future directions for urban growth, have rarely been realised. The most rapid growth of built up areas happened from the mid 1950s to the late 1960s, during the mass movement of population from country to the city. In the following decades, the population growth slowed down, while the urban spread still continued affecting the high biodiversity and landscape diversity characterizing Rome municipality. These trends underscore the urgent need to support the capacity of local governments to manage urban development. In this framework, the project of Rome as Urban Biosphere Reserve promotes the increase of environmental quality and the improvement of urban sustainability. The Urban Biosphere Reserve, encompasses representative areas of the variety of Rome landscapes defining areas with different functions and conservation of Rome ecosystems.

Knowledge of land cover transitions derived from three temporal data sets (1954; 1980; 2001) assessed the efficiency of the UB Reserve zoning and provided valuable information for understanding the effects of changes in land uses. The emphasis was given to the transition zones, more affected by significant changes in land uses. Between 1954 and 2001 about 30% of agricultural lands were transformed in built up areas. In addition to the incredible growth of built up areas, about 80% of discontinuous urban fabric were converted to continuous urban fabric. Core areas, representing the best conservation areas, and buffer zones, contiguous to the core and outstanding for specific landscape components, showed less changes in land use even if there was a significant increase in landscape fragmentation. It is worth noting that a positive effect of land use change was the little but significant increase of natural areas, mostly happened between 1954 and 1980.

The information derived from the three temporal data sets allowed to define the guidelines for a sustainable urban development, mostly based on the protection of sites of conservation interest, the increase of ecological connectivity between natural areas, the implementations of urban requalification actions, the safeguard and increase of traditional and low intensive agricultural practices. Strategic priorities and actions were identified for each of the 15 areas of the Urban Biosphere Reserve, giving attention to the specific landscape components characterising the different areas.

References

Blasi C., Capotorti G., Di Pietro R., Ercole S., Filesi L., Fortini P. & Celesti-Grapow L. (2002) Natural landscape in the area of Rome. **EuroMAB 2002 Meeting,** Rome, 2002.

Blasi C., Capotorti G., Di Pietro R. Filesi L. & Fortini P. (2002) Natural landscape in the area of Rome and a new proposal for the urban biosphere reserve. **EuroMAB 2002 Meeting,** Rome, 2002.

Capotorti G., Marta M, Marchese M. & Blasi C. (2005) Programma MAB per la definizione di Roma come Riserva Urbana della Biosfera. *Informatore Botanico Italiano*, vol. 37: 122-123.

Capotorti G., Marta M, & Blasi C. (2005) Vegetation and landscape diversity for defining the Urban Biosphere Reserve of Rome. **European IALE Congress, 2005:** 62-63.

Woody biomass in semi-urban landscapes

S. Meeus, H. Gulinck

Division of Forest, Nature and Landscape ResearchK.U.Leuven, Department of Land Management and Economics Celestijnenlaan 200E, 3001 Leuven, Belgium
e-mail: steven.meeus@biw.kuleuven.be

As semi-urban landscapes form the transition area between densely urbanized areas and much less urbanized rural areas, they enclose land cover types from both the urban as the rural landscapes. In particular the 'green' land cover classes, such as urban green (roadsides, parks, gardens, …) linear landscape elements (wooded banks and verges, hedgerows,…) and non-linear and mostly non-defined green structures such as various forms of thicket and shrubs, fallow grounds with green elements and smaller natural patches whether managed as a natural area or not. The semi-urban area is assumed to be an important carrier of biomass and its associated cycles. In order to develop further the ecological role of these green components, the actual amount of biomass in the semi-urban areas needs to be known.

Measuring biomass for these highly hybrid green structures is, however, very complex. The biomass of herbacous and grassy vegetation, as well as high and woody structures (trees) can be estimated and calculated relatively easy and with good accuracy, for shrublike green structures – such as hedges and verges, biomass analysis is very difficult and assessment can only give a very rough picture of the amount of biomass.

As alternative measure – with a specific landscape morphological goal as background – an estimate of the volume used by these green structures can provide interesting information.

The method consists of a planimetric and if possible volumetric measurement of the green structures, a comparison with a classification algorithm and a statistical assessment of the biomass amount.

The 'closeness' of an area is an important property for viewshed analysis and results show an important influence of the urban green in this landscape analysis for semi urban areas and is related to the geographical location of these green structures.

Plant trait patterns: differences between urban and rural areas?

S. Knapp, I. Kühn, S. Klotz

UFZ, Helmholtz Centre for Environmental Research – UFZ, Dep. of Community Ecology – Theodor-Lieser-Str.4, 06120 Halle, Germany.
e-mail: sonja.knapp@ufz.de

Introduction

Cities differ from rural landscapes: human densities peak in urban areas. Pollutants, waste, energy and nutrients concentrate there. Temperatures and precipitation are higher, air moisture is reduced. Foreign species are more frequent, land-use is often more heterogeneous. With some of these aspects, cities anticipate probable future conditions under global change. We hypothesize that the differences between urban and rural areas act as environmental filters resulting in different plant trait patterns.

Methods

We tested our hypothesis at national scale (Germany, urban, agricultural and forested grid cells of 10' latitude x 6' longitude) and at regional scale (city of Halle and rural surroundings, Central Germany). The latter was differentiated into protected areas and randomly selected 250m²-plots (Wania *et al.*, 2006). We analysed the proportions of trait states per study unit for several leaf traits, floral traits, reproductive traits and whole plant traits (Klotz *et al.*, 2002). As all states of a trait add to 100%, the decline in one proportion causes the increase of at least one other proportion. Therefore, we used log-ratios of proportions. To correct for the effects of environmental parameters, we used multiple regression with the log-ratios vs. environmental parameters. We compared the resulting residuals of urban and rural study units using t-test and z-values. Due to differences in sample size ($n_{urban} = 59$, $n_{agricult} = 1365$, $n_{forest} = 312$), we used a resampling technique for the national scale (59 grid cells, 999 times).

Results and conclusions

Most traits show significant differences between urban and rural areas at national scale but not at regional scale. Urban areas have for example more plants pollinated by wind than by insects, less plants with hygromorphic leaves, more annual but less biennial plants, more therophytes, more plants reproducing by seed instead of vegetatively and more stress-tolerant ruderals (*sensu* Grime, 1979). These results reflect the patchiness and climate of urban areas, disturbance regimes and the high proportion of ruderal habitats in cities. As the protected and randomly selected areas at regional scale do not differ in plant trait patterns, an effect of nature protection does not seem to exist. This might be different at other scales. The different reactions of plant trait patterns on different scales shall be further investigated.

References

Grime, J.P. (1979) *Plant strategies, vegetation processes, and ecosystem properties.* Wiley, Chichester.

Klotz, S.; Kühn, I. & Durka, W. (2002) *BIOLFLOR – Eine Datenbank zu biologisch-ökologischen Merkmalen der Gefäßflanzen in Deutschland.* Schriftenreihe für Vegetatiosnkunde 38, Bundesamt für Naturschutz, Bonn.

Wania, A; Kühn, I. & Klotz, S. (2006) Plant richness patterns in agricultural and urban landscapes in Central Germany – spatial gradients of species richness. *Landscape and Urban Planning* **75:** 97-110.

Landscape change in the municipality of Rome (1954-2001)

R. Frondoni, B. Mollo, C. Blasi

Department of Plant Biology, University of Rome "La Sapienza", Piazzale A. Moro 5, 00185 Rome, Italy.
e-mail: blasilab@uniroma1.it

Introduction

Knowledge of land cover and land use change is crucial for assessing the stability and dynamics of landscapes and for gaining options and suggestions for management and conservation activities. In this context, an analysis of land cover transitions in the Municipality of Rome (about 128,700 hectares) has recently been carried out, with the objective of understanding the significance and spatial extent of change processes in the last 50 years.

The analysis employed the overlay of three 1:25,000 land cover layers within a GIS environment. These data were gained by the interpretation of multi-temporal aerial photographs (years 1954, 1980 and 2001), and were iteratively checked for thematic and spatial consistency (Kayhko & Skanes, 2006). Land cover change was analysed over the whole Municipality area and also within ecologically homogeneous land units, defined by a hierarchical land classification process (Blasi *et al.*, 2005).

Results and discussion

Important transformations occurred in the study area, with significant magnitude and rate particularly in the 1954 -1980 period. In the 1980 -2001 interval, change processes maintained the same direction but generally occurred at a slower pace and with smaller spatial extent (affecting only 16% of the territory).

Urbanisation is by far the major process of change: artificial areas cover today about 32% of the study area versus 11.6% in 1954. Most of the gained surface derives from pre-existing artificial areas. There was also an expansion of urban areas and industrial units over coastal habitats (which have declined by 60% since 1954) and agricultural land (declined by 27%), particularly heterogeneous agricultural areas.

A major change is represented by the natural dynamics of vegetation, which led to a constant increase in woodlands and to a significant expansion of scrub over abandoned agricultural areas and quarries.

Despite these changes, at the landscape level results show a significant relative stability of landscape composition between 1954 and 2001, which is mainly due to: an urbanisation model largely based on the compaction of pre-existing urban areas; the overall conservation of natural and semi-natural habitats (except in coastal areas); and the maintenance of agricultural activities (agricultural land still represents the major land cover type).

Analysis of landscape change within land units in the 1954-2001 period identified ecologically relevant areas characterised (when compared with the average situation over the Municipality as a whole) by severe urbanisation processes or by considerable natural dynamics towards mature vegetation. This approach is helpful for providing planning guidelines and detecting particularly vulnerable areas that require special protection and restoration measures.

References

Blasi, C; Capotorti, G. & Frondoni, R. (2005) Defining and mapping typological models at the landscape scale. *Plant Biosystems* **139(2):** 155-163.

Kayhko, N. & Skanes, H. (2006) Change trajectories and key biotopes – Assessing landscape dynamics and sustainability. *Landscape Urban and Planning* **75:** 300-321.

Apomictic species, apophytes and anecophytes as elements of phytodiversity of urban-industrial regions and their applicability as indicators

G.H. Loos

Biological Station of Western Ruhrgebiet, Ripshorster Str. 306, D-46117 Oberhausen, Germany.
e-mail: Goetz.H.Loos@bswr.de

By studies of phytodiversity and ecology of the compartments of the diversity (genera, species and lesser ranked taxa) in the old urban-industrial region Ruhrgebiet (Germany, Northrhine-Westphalia), it was pointed out that a lot of the apparent native species are neogenic (anecophytes, so called "Indigenophyta anthropogena", see Sukopp & Scholz 1997) or occurred at new habitats (apophytes). A quantitative and qualitative overview of these taxa in relation to the other taxa could be given (see also Keil & Loos 2005). On the one hand, there are obvious anecophytes like primary hybrids and hybrid derivatives with stable characters (hybrids especially in genera *Epilobium, Populus* and *Salix*), on the other hand, there may be only differences in genotypes while the phenotype is identical (probably many species which are recognized as native in general). Apophytes grow in natural landscapes especially at river banks and its surroundings. An important migration way of them were railways (with similar ecological conditions as stony river banks). From these habitats further dispersal took place, without dependence on line structures.

A lot of taxa of both status types are apomicts (and within this group in most cases agamospermous taxa). In cultural landscapes apomictic species as well as other anecophytes and apophytes were generated by farming. In urban-industrial ecosystems, the ecological factors are partly different from agricultural landscapes (e. g. higher grade of fragmentation), but at part these factors are very similar, too (different niches in more or less small areas). The apomictic species of *Taraxacum* sectio Ruderalia (Asteraceae, Cichorioideae) are preferably inhabitants of grasslands, some species are most frequent in urban-industrial habitats – but the grassland species are also present in settlements and the urban-industrial species can be found in wet meadows in some cases.

Present studies show that there are some possibilities to use such taxa as indicators. Indicator attributes concern land-use intensity, primarily succession stadiums, soil types, hemerobic stages and therefore the conservation value. A detailed overview of the significant indicator species was ascertained and their indicator attributes were pointed out. The occurrence of not apomictic anecophytes and apophytes together with apomictic species leads to the reflection that in a phase of an unsteady and ambiguous Global Change evolution processes provide for all contingencies.

References

Keil, P. & Loos, G.H. (2005) Anökophyten im Siedlungsraum des Ruhrgebietes – eine erste Übersicht. *Conturec* **1**: 27-35.

Sukopp, H. & Scholz, H. (1997) Herkunft der Unkräuter. *Osnabrücker Naturwissenschaftliche Mitteilungen* **23**: 327-333.

Development of trees and soils of the forested area in Expo'70 Park 30 years after reclamation

T. Sasaki[1], Y. Morimoto[1], J. Imanishi[1]

[1]Graduate School of Agriculture, Kyoto UniversityKitasirakawa Oiwake-Cho, Sakyo-ku, Kyoto, Japan 606-8502
e-mail: sasakita@kais.kyoto-u.ac.jp

Introduction

The Expo'70 Commemorative Park was constructed at the site where a world exposition in 1970 was held. It is located in Suita city in Osaka Prefecture, Japan, and belongs to warm-temperature zone and lucidophyllous forest zone. The exposition site was made by large scale reclamation; therefore, the original surface stratum was perfectly lost. After the exposition, the site was mounded with imported local soils from the neighbouring hills. Then, revegetation with mainly evergreen broad-leaved trees was conducted. Intensive studies about vegetation and soil were conducted in 1982 and 1995-97.

In this study, we selected twelve sample plots in the forested area where the previous studies were conducted, and surveyed about trees and soils to reveal the effect of revegetation for 30 years.

Materials and Methods

In each plot, tree height and DBH were investigated for all trees (DBH ≥ 1cm). In addition, a pit was excavated in each site, and undisturbed and disturbed soil samples were taken from 0-5, 20-25, 50-55 cm depth for investigating physical and chemical properties.

Results and Discussion

The canopies reached over 10m and most of canopy species were evergreen broad-leaved trees. Regeneration of the canopy dominant species did not successfully occur.
Tree density has declined; indicating self-thinning has occurred but seemed insufficient.

The soil physical properties were improved in most of the plots, to the level that the root system was not affected. The yield per hectare was maximum at the plot where trenches were dug for improvement of drainage after the monitoring in 1982. It was suggested that appropriate management after revegetation can lead to satisfactory forest development even under difficult soil environmental conditions.

References

Njoroge, J. & Morimoto, Y. (2000) Studies on Soil Development as Influenced by the Method of Large Scale Reclamation of a Sub-urban Forest. Journal of the Japanese Society of Revegetation Technology 25(3):184-195

Morimoto, Y & Kobashi, S. (1985) On the pedogenic process in the forest areas of the Commemorative Park of Expo'70. Journal of the Japanese Institute of Landscape Architecture 48(5):115-120

Vegetation cover where there is none: the third dimension of trees over sealed surfaces and their influence on the city environment

A. Walz

Department of Geography, Marshall University, Huntington, WV 25755, USA.
e-mail: walz@marshall.edu

Introduction

In most climates cities are warmer than surrounding areas (urban heat island, Arnfield, 2003). Sun-exposed pavement absorbs radiation and releases it overnight; keeping the neighbourhoods warmer than if the surface was vegetated or shaded. Mature large-growing road-side trees overlap streets to a degree where a large proportion of the pavement is shaded, intercepting radiation before it reaches sealed surfaces. Existing literature recognizes the cooling effect of trees in urban areas (Oke, 1989, Rosenzweig et al., 2006). No reports exist on the specific influence of road-side trees.

Land cover in cities is generally highly fragmented with small patches of vegetation interspersed with buildings, roads, parking lots, and other features. Coarse scale satellite information does not pick up these details (Lo et al., 1997). In this study high resolution satellite images are used to map vegetation in a city.

The Study

In a twelve-block neighbourhood trees' canopy width and height were measured manually and pavement temperatures collected at locations of various levels of sun exposure. Analysis revealed that before sunrise on mornings after hot summer days the surface temperatures in exposed locations were still two degrees warmer than in shaded sites (Walz, 2006).

The above mapping technique is time consuming and only suitable for small study areas. A new procedure to map the canopy that overlaps with roads was tested using high resolution satellite images. The difference in spatial distribution of high fractional vegetation cover between spring images (green lawns but bare canopies) and summer images (canopy fully developed) indicates the location of tree canopies over sealed surfaces. This method of determining tree cover over roads simplifies canopy mapping, and much larger areas in cities can be processed. In future steps thermal infrared data will be used to examine the relationship between the proportion of exposed sealed surfaces and temperature. This technique could be adapted by city planners in order to ameliorate the environmental quality in cities, and to identify gaps in urban forests.

References

Arnfield, A. J. (2003) Two decades of urban climate research: a review of turbulence, exchanges of energy and water, and the urban heat island. *International Journal of Climatology* **23:** 1-26.

Lo, C. P.; Quattrochi, D. A. & Luvall, J. C. (1997) Application of high-resolution thermal infrared remote sensing and GIS to assess the urban heat island effect. *International Journal of Remote Sensing* **18**: 287-304.

Oke, T. R. (1989) The micrometeorology of the urban forest. *Philosophical Transactions of the Royal Society of London Series B* **324:** 335-349.

Rosenzweig, C.; Solecki, W.; Parshall, L.; Gaffin, S.; Lynn, B.; Goldberg, R.; Cox, J. & Hodges, S. (2006) Mitigating New York City's heat island with urban forestry, living roofs, and light surfaces. 86th American Meteorological Society Annual Meeting, Jan. 31, 2006, Atlanta, Georgia.

Walz, A. (2006) The Influence of Trees in Residential Neighborhoods on Pavement Temperature. Annual Meeting of the Association of American Geographers, March 7-10, 2006, Chicago, IL.

Landscape ecological study on urban green spaces in Hanoi, Vietnam

U.D Pham, N. Nakagoshi

[1] Graduate School for International Development and Cooperation, Hiroshima University, 1-5-1 Kagamiyama HigashiHiroshima City, Hiroshima 739-8259, Japan
e-mail: ducanhy2000@yahoo.com

Urbanization is a vital process and is increasing rapidly throughout the world, and consequently is one of the main causes of ecological fragmentation, which is a serious threat to biodiversity. Urban green spaces are an important component of urban ecosystems, providing urban dwellers with many benefits such as environmental, aesthetic, recreational, and economic values. However, as a result of increased building density, green spaces in urban areas are reduced in both area and the quality of ecological services. It is found that methods and principles of landscape ecology are useful and especially suitable for studying urban green spaces.

This study aims at assessing the status and the temporal change of green spaces based on landscape metrics in Hanoi in the period from 1996 to 2003; by applying the graph theory and gravity model to study connectivity and eco-network of these green spaces. This will assess the fragmentation of urban green spaces; and then we apply suitability analysis based on GIS to identify appropriate sites for green spaces and landscape ecological principles in planning a comprehensive green structure in Hanoi up to 2020. We implemented this study by using Erdas 8.6 software for processing satellite images and Arc GIS 9.0 for doing the GIS work. Assessing the temporal changes of green spaces was then based on landscape ecological metrics by using Fragstats 3.3. In this period, the most significant potential network for biodiversity conservation in Hanoi will be identified. It is a basis for building an inner greenbelt in Hanoi planning up to 2020. Application of landscape ecological principles and land suitability analysis also shows that green structure, including green wedges, greenways, greenbelts, green fingers, green hearts and other green spaces, is considered as a network of green elements and is more than the sum of these green spaces. It expresses the connectivity and network or the inter-connection of green spaces in the urban area instead of separate green spaces. Thus, comprehensive green structure planning is proposed at two scales. At the city scale, an inner greenbelt and three green wedges surrounding peri-urban have been proposed to enhance a skeleton of green structure. At the neighborhood scale, greenways and other green spaces are planned to allow nature to permeate into in the built-up area. The green network of this study will not only help slow the extension of the urban sprawl process, but also improve urban environment and maintain biodiversity in Hanoi City, Vietnam. Finally it will also provide a basis for building a garden city or an eco-city in the near future.

Settlement and urban areas along motorways: Changes in area and composition

K. Müller[1], C. Steinmeier[1], M. Küchler[1]

[1] Swiss Federal Research Institute WSL – Zuercherstrasse 111, Birmensdorf, Switzerland.
e-mail: kalin.mueller@wsl.ch

Landscapes in Central Europe are constantly undergoing changes due to different land use claims. It is expected that the landscape is and will be influenced more by the increasing traffic, especially apparent in the proportion of the settlement and urban areas (Steinmeier and Müller 2007).

The purpose of the present investigations is to quantify the changes of the settlement and urban areas along the main motorways through the Swiss Alps. Since changes in developed land usually run in only one direction – it expands and does not revert to other land use classes (Turner *et al.* 2001) – we are interested in its composition, e.g. which sub-classes of it are expanding.

For the analyses we used two surveys of the Land Use Statistics of Switzerland (LUSS) from 1985 and 1997. These statistical data sets consist of sample points which are regularly spaced over Switzerland on a hectare grid and which are classified into land use categories. In this study we used the major class settlement and urban areas, as well as its sub-classes building areas, industrial areas, transportation areas and special areas. We divided the landscape according to the five ecoregions of Switzerland, as they vary in terms of natural and cultural preconditions. We further divided them into distance zones to the motorway exits of 1km width and used relief characteristics as the outermost boarder. In these sub-regions we then calculated the indicators, e.g. change of proportion of building area, and made significance tests for every indicator in every sub-region.

The main findings are that the zones close to the motorways show a higher growth of the settlement and urban areas, as well as their sub-classes building areas, industrial areas and transportation areas. We can find this distance trend in all ecoregions. However, the analysis of the relative area-changes, which means changes compared to the previous proportion of the land use classes, only confirms a significant distance trend for the overall class settlement and urban areas, and only in the ecoregions Northern Alps, Central Alps and Southern Alps. In these regions the distance correlates strongly with the relief. If this is considered, the variation explained by the distance diminishes even more.

Overall, these analyses allowed us to reveal a distance trend in the changes of the settlement and urban areas and its sub-classes within the first few kilometres of the motorway exits. By analysing the relative changes, such a trend can also be confirmed for the settlement and urban areas as a whole in the mountain regions. However, further analysis shows that a great part of the changes is explained by the relief. Therefore the relief is an important factor, which should not be neglected in Switzerland, especially in the mountain regions.

References

Steinmeier, C. & Müller, K. (2007). *Monitoring of Supporting Measures - Environment (MSM-E).* 27.01.2007,http://www.wsl.ch/forschung/forschungsprojekte/monitoring_flankierende_massnahmen2/index_EN

Turner, M.; Gardner, R. H. & O'Neill, R.V. (2001). *Landscape Ecology in Theory and Practice: pattern and process.* New York, Springer.

Ecological research on Riga city street greenery

G. Čekstere[1], A. Osvalde[1], O. Nikodemus[2]

[1] Laboratory of Plant Mineral Nutrition, University of Latvia Institute of Biology, Miera 3, Salaspils, LV-2169, Latvia.
e-mail: guntac@inbox.lv;
[2] Faculty of Geography and Earth Sciences, University of Latvia, Alberta 10, Riga, Latvia.

The street greenery is a very significant landscape's design element with important ecological value in the high building density area of the Riga City central part.

The first planned street trees in the city's green structure appeared during the 18th century as alleys connecting the old city's gates with the recreation area. The street greenery currently compiles 39 % from the overall street length (90 km) of the city's central part. The spatial arrangement of the street greenery is irregular and not completely corresponds to the historical planning. The smallest amount of the street trees has been found in the Old Town due to the highest building density.

Out of 16 tree species occurring in Riga's street greenery nowadays *Tilia x vulgari*s and *Tila cordata* are the most frequent. *Tilia x vulgaris* is avowed as the most appropriate species for the urban environment in Riga.

The elimination of the greenery as the result of the carriageways expanding or trees decaying has been stated in comparison to the beginning of the 20th century. The decrease in the total amount of the street trees has been observed since 1979. The strongest street trees decrease (more than 10 trees per street section) has been stated in 5 main streets. Reconstruction of some green areas recently has been done in separate street's sections. Currently trees in the containers have become a new street landscape's element as well.

The results of the bioindication research of the street greenery in Riga reveal that the ecological status of *Tilia x vulgaris* could be characterized as seriously injured. The damage to the deciduous trees typically appears as a necrosis of leaves. During the latest years, the defoliation of leaves has been already observed at the beginning of August.

The investigation demonstrates that the physiological status of the trees has been negatively affected due to systematic use of de-icing agents on the streets during the winter period, as well as soil compaction, air pollution and probably alteration of the city's microclimate. As concluded from the research results, for the visual observation of the necrosis of *Tilia x vulgaris* leaves the critical level concentration for Na is 0.18 % to 0.24 % and for Cl - 0.62 % to 0.66 %.

Restoration of multifunctional forests in north-west suburban area of Milan: scenario and proposals

E. Padoa-Schioppa, A.B. Digiovinazzo, L. Bottoni

[1] Università degli Studi di Milano-Bicocca, Department of Environment and Landscape Sciences Piazza della Scienza 1 – 20126 Milano Italy.
e-mail: Emilio.padoaschioppa@unimib.it

Suburban area of Milan (1.982 Km2, with about 3.869.037 inhabitants) represents one of the most important European metropolitan area. That is, agricultural land use represents 49% of the territory, urbanisation 38%, natural vegetation and uncultivated fields 11%, pits and redevelopment areas 1%, streams 2%.

The aim of this study is the identification of a green belt ("MetroBosco project") around the city of Milan, to improve woods and forest patches that already exist.

The functions of these restored woods should be: i) mitigation of roads impact; ii) CO2 absorption; iii) fruition; iv) increase of forest biodiversity; v) ecological network.

We carried out some scenarios, each of them maximizing one of the mentioned functions. The term "scenario" is used to describe different situations in the future as well as a series of events lead from the current state to the future state (Van Den Berg & Veeneklaas F.R. 1995 in Tress B., Tress G. 2003). By this definition, our scenarios are all realistic the same, depending on the specific function maximized.

We used D.U.S.A.F regional maps to calculate different land uses (ArcView GIS 3.2 software): these are layers that cover all suburban area of Milan, with a meaning similar to Corine Land Cover. We also overlapped aerial images to correct possible mistakes.

Then we used fuzzy logic method to carry out each scenario. This approach is a logic, in which membership functions are graded from 0 to 1 (Zadeh 1965). This method allows us to better describe ambiguous concepts that are not well modelled by traditional logic.

The approach of scenarios can help the stakeholders during the planning processes, because it shows different images of a possible future depending on their decisions.

References

Tress B., Tress G., 2003. Scenario visualisation for participatory landscape planning-a study from Denmark. *Landscape and Urban Planning* **64:** 161 – 178.

Zadeh L.A., 1965. Fuzzy sets. *Information and Control* **8:** 338 – 353.

Urban influence in bird communities. A case in three neighbourhoods of Buenos Aires city, Argentina

P.V. Perepelizin [1], A.M. Faggi [1,2]

[1] Universidad de Flores, Facultad de Ingeniería – Av. Nazca 274, , Buenos Aires, Argentina.
e-mail: afaggi@uflo.edu.ar
[2] Museo de Ciencias Naturales Bernardino Rivadavia, CONICET – Av. Ángel Gallardo 490, (C.P. C1405DJR), Buenos Aires, Argentina

Introduction

Studies about the effects on urbanization on bird communities in Latin America and, particularly in Argentina, are almost inexistent, knowledge essential for sustainable urban planning and management tending on the conservation of their communities.

This paper, based mainly in two dominant ecological theories: urban gradients and spatial-structuring analysis, compared bird richness and abundance with local habitat characteristics of green spaces and land use of each neighbourhood. Bird habitat preferences are linked to habitat structures inside the urban matrix.

Methods

In 3 neighbourhoods: “San Telmo”, near down town; “Almagro”, in the geographical center of the city; and “Versalles”, in the West limit, land use was characterized through satellite images for assessing the habitat quality. The existing green areas were classified in five categories: Forest, Park, Savannah, Grassland and Artificial. Bird abundance in the green areas was assessed in 34 visit point counts of 0.33 ha each. Richness in the rest of the neighbourhoods and presence of nests were considered as well. Species were categorized in: Urban-exploiters, Undetermined and Urban-avoiders. In addition, indexes for richness, diversity, similarity and Reciprocal Average ordination were used for data analysis.

Urban impacts on bird communities

Twenty four bird species have been registered; 85 % were native from the pampean ecoregion and nesting in the city. The exotic birds counted were *Sturnus vulgaris, Aratinga leucophthalma, Passer domesticus* and *Columbia livia*.

The neighbourhood “Versalles”, with moderate levels of disturbance, has high presence of breeding species, lower influence of exotic, higher richness and abundance of Undetermined birds and Urban-avoiders and the highest level of richness outside green areas. The existence of big green areas in “San Telmo” compensates somehow urban pressure. It has the highest level of breeding species and richness of exotics. Open places contribute to the presence of raptors. “Almagro”, due to the lack of green areas and the dominance of high edification, behaves as a centric neighbourhood. It is characterized by high density of exotic species and poor richness.

Decreases of bird richness and diversity and increases of exotic dominance trough urbanization could be mitigated creating green areas, especially woodlands and conserving and constructing new residential areas of low edification. These are suggestions to take into account for a future urban planning and management.

Landscape-ecological conditions for the development of Bratislava

T. Hrnčiarová

Institute of Landscape Ecology of Slovak Academy of Sciences, Štefánikova 3, P. O. Box 245, 814 99 Bratislava, Slovak Republic
e-mail: tatiana.hrnciarova@savba.sk

The basis of the landscape ecological evaluation of the area was the LANDEP methodology of landscape ecological planning. It was aimed at the evaluation of settlements as well as the latest methodological procedures. The presented work includes the methodological approach of evaluation of urban landscape on the basis of ecological and partially also on environmental principles. One of the main causes of disharmony in land use is the misunderstanding of the features of landscape elements and their interrelations. For this reason we elaborated the methodological procedure of optimum spatial arrangement and functional land use (landscape ecological plan) with respect to landscape ecological, cultural-historical and socio-economical conditions. The procedure of elaboration of the landscape ecological plan is based on the methodology LANDEP and has five basic steps. A high proportion of Bratislava is now built-up, therefore decision making as well as proposals will include areas now used for agricultural purposes and partially for forest management. The presented proposals can be divided into two outputs:

(i) **Proposal of optimum land use for seven required activities and land use** within the whole town area. Suitability of use follows from abiotic, ecological and hygienic limits. For each activity an independent map was elaborated: suitability of land use for the required activity according to abiotic limits; suitable of land use for the required activity according to abiotic and ecological limits; landscape ecological suitability of land use for the required activity involving landscape ecological potential.

(ii) **Landscape ecological plan of urban areas** is based on landscape ecological suitability and the establishment of territorial potential and it gives an alternative proposal on how to use the given area. It is a synthesis of three previous proposals. Proposals are completed with landscape ecological measures to mitigate the main negative impacts. The presented methodological procedure represents how landscape ecological limits ought to be taken into account in decision making about the development of the town in the future. Intensive further construction in the town does not allow decisions always to be made according to landscape ecological conditions of land use. In many cases the land use is unchanging, so it is possible only to define or complete the intensity of use and proposal of different measures.

This work was supported by the Ministry of Education of the Slovak Republic under the contract No. 2/7027/27 Evaluation of landscape diversity changes and by the Slovak Research and Development Agency under the contract No. APVV-51-035102 Creation of environmental limits for sustainable development (on example of model territories).

Socio-cultural influences on urban ecosystems: A case study of Tommy Thompson Park

Y. Westerveld Cardoso, K. Landman

University of Guelph - Guelph, Ontario, Canada.
e-mail: ycardoso@uoguelph.ca

This study highlights the socio-cultural influences on urban ecosystems with a particular focus on the achievements, setbacks and challenges in the regeneration and management of Tommy Thompson Park (TTP) in Toronto, Canada. TTP is a lakefill created of construction rubble and dredged material, and today is being managed by the Toronto and Region Conservation Authority (TRCA) as an urban wilderness. Its current configuration extends 5 kilometres into Lake Ontario, with total land base of 160 hectares and a water surface area of 100 hectares composed of embayments and disposal cells. The site context and history are complex. The park has been shaped by a web of influences such as political will, scientific rationale, natural forces, and the passion of citizens and park users. Ecological regeneration of culturally-modified urban ecosystems is a challenge and requires strategies for re-development. For TTP, these strategies are affected by the uncertainty of biophysical processes, socio-cultural influences and constant change, and are amplified by value-laden issues advocated by stakeholders. This study features an in-depth, longitudinal case study of this urban wild, situated on this metropolitan, post-industrial site. It presents the history, planning and management at varying spatial and temporal scales, which uncovers social and ecological patterns and processes and reveals process complexities from pre-planning to master plan implementation and management.

Feasibility of trail development along secondary urban watercourses in Tucson, AZ, USA

M. Livingston[1], J. E. Jones[2], J. L. Patton[3]

[1]University of Arizona, School of Landscape Architecture, Tucson, AZ, USA.
e-mail: mlivings@u.arizona.edu
[2] CFA, 1150 Corporate Blvd., Reno, NV, , USA.
[3] Norris Environmental, 100 N Stone Ave, Tucson, Tucson, AZ, USA.

Introduction

Vegetated buffers along urban watercourses are typically well-suited for recreational uses such as biking, walking trails and wildlife-viewing. However, development pressures in cities can lead to fragmented and redirected watercourses to accommodate other land uses. In some cases, unplanned access increases erosion, and loss of vegetation and potential wildlife habitat in these areas. It is critical that appropriate access to these semi-natural areas be addressed for future conservation efforts. Such efforts would also provide a basis for creating passive recreational opportunities where currently few exist in urban areas, except along larger waterways.

Methods and results

This research evaluated the feasibility of access and trail development along secondary watercourses within the urban core of Tucson, AZ. The following question was posed, "How feasible are existing smaller urban watercourses in Tucson for access and trail development?" Feasibility of individual corridors was evaluated and ranked based on watercourse composition and bank treatment, adjacent buffer and streambed vegetation, streambed surface, path corridor, barriers (road crossings, underpass properties and elevation changes), and linkages to larger watercourses. Results indicated that the majority of the watercourses studied have natural banks, accessible dry streambeds, and predominantly exotic vegetation. Two-lane road crossings were the predominant barrier, and linkages with larger watercourses were not prevalent. Results suggested that planned access is possible for particular watercourses within the study area, but linkages between secondary and primary watercourses is limited and needs to be addressed. Recommendations related to trail development including design applications addressing circulation and urban wildlife habitats along these urban watercourses will be discussed.

Development of a future scenario model of compact growth in the Charlotte, North Carolina region of the U.S.

D.H. Yankee[1], M.H. Mehaffy [2], E.R. Smith [2]

[1] Tennessee Valley Authority – 400 W. Summit Hill Drive, Knoxville, TN 37828, USA. email: dhyankee@tva.gov
[2] U.S. Environmental Protection Agency – 109 T.W. Alexander Drive
Research Triangle Park, NC 27711, USA

The negative impacts of urban sprawl on natural resources are a growing problem for many regions across the United States. A solution was investigated for the 15-county Greater Charlotte Bi-State Region in North Carolina and South Carolina. A partnership among the Environmental Protection Agency, local Council of Governments, and University of North Carolina at Charlotte was established to assess how alternative development patterns could protect environmental quality while also bolstering economic growth. Input was obtained from multiple types of stakeholders to formulate two future development scenarios. Spatial representations of current conditions and the two future growth scenarios were created from which water, terrestrial, and socioeconomic variables were derived. One scenario was a “growth as usual” scenario while the “Center’s” scenario explored the feasibility of directing the majority of projected growth toward existing municipalities and other regional centers and thereby preserving the outlying area from unchecked sprawl. This poster will address the methods and techniques used to model the “Center’s” scenario as well as compare the resulting environmental impacts from “growth as usual” and “Center’s” compact development scenario. The model suggests that high-density growth along these re-developed corridors would accommodate the high level of projected population growth. Growth directed in such a manner would reduce development pressure in the areas outside of the corridors and prevent the capacity of the infrastructure in these areas from being exceeded.

Effects of traffic noise on acoustic communication in birds

K.M. Parris

School of Botany, University of Melbourne VIC 3010, Australia.
e-mail: k.parris@unimelb.edu.au

Introduction

Birds use acoustic signals for a number of purposes: to attract and bond with mates, defend territories, beg for food, and warn of danger from predators. Background noise reduces the distance over which an acoustic signal (a song or call) can be detected, and birds can use a variety of strategies to maximise the audibility of their signals in naturally noisy habitats (Brumm and Slabbekoorn 2005). Anthropogenic noise such as traffic noise provides an additional challenge for acoustically-communicating animals. Field studies have shown reduced densities of some bird species in habitats close to roads (e.g. Reijnen *et al*. 1995; Rheindt 2003), and changes in the characteristics of bird song in noisy urban areas (e.g. Slabbekoorn and den Boer-Visser 2006; Wood and Yezerinac 2006).

Model & Data

I will present a mathematical model of the effect of traffic noise on the distance over which acoustic signals of varying frequency (pitch) can be detected by a conspecific bird, based on the frequency distribution of traffic noise, the structure of the avian auditory system (Langemann *et al*. 1995; Lohr *et al*. 2003), and the attenuation of sound in open forests. The model demonstrates that birds with lower-frequency signals will experience more acoustic interference from traffic noise than birds with higher-frequency signals, despite an increase in the bandwidth of auditory filters with frequency. I have used the model to predict the effect of traffic noise on detection of calls by eight species of birds from south-eastern Australia. I expect all species to demonstrate a frequency shift (Warren *et al*. 2006) by singing/calling at a higher pitch at noisy sites than at quiet sites, thereby reducing acoustic interference from traffic noise. However, I expect species with lower-frequency signals to demonstrate a larger frequency shift. To test these predictions, I have collected high-quality recordings of bird calls and songs at 60 survey sites south-east of Melbourne, Australia. All sites are in strips of remnant vegetation next to roads, but the roads vary in size from small dirt roads with little traffic to multi-lane freeways. I am currently analysing the recorded signals to assess the presence and size of a frequency-shift in populations of birds exposed to traffic noise.

References

Brumm, H. & Slabbekoorn, H. (2005) Acoustic communication in noise. *Advances in the Study of Behavior* **35:** 151-209.

Langemann, U., Klump, G.M. & Dooling, R.J. (1995) Critical bands and critical-ratio bandwidths in the European starling. *Hearing Research* **84:** 167-176.

Lohr, B. Wright, T.F. & Dooling, R.J. (2003) Detection and discrimination of natural calls in masking noise by birds: estimating the active space of a signal. *Animal Behaviour* **65:** 763-777.

Reijnen, R., Foppen, R., ter Braak, C. & Thissen, J. (1995) The effects of car traffic on breeding bird populations in Woodland. III. Reduction of density in relation to the proximity of main roads. *Journal of Applied Ecology* **32:** 187-202.

Rheindt, F.E. (2003) The impact of roads on birds: does song frequency play a role in determining susceptibility to noise pollution? *Journal für Ornithologie* **144:** 295-306.

Slabbekoorn, H. & den Boer-Visser, A. (2006) Cities change the songs of birds. *Current Biology* **16:** 2326-2331.

Warren, P.S., Katti, M., Ermann, M. & Brazel, A. (2006) Urban bioacoustics: it's not just noise. *Animal Behaviour* **71:** 491-502.

Wood, W.E. & Yezerinac, S.M. (2006) Song sparrow (*Melospiza melodia*) song varies with urban noise. *The Auk* **123:** 650-659.

Human-Nature Symbiosis -- Landscape Ecological Planning for the Renewal of Suburban Park

N. Yen, F. C. Yu

Graduate Institute of Building and Planning, National Taiwan University
No.1, Sec. 4, Roosevelt Rd., Da-an District, Taipei City 106, Taiwan (R.O.C.)
e-mail: r94544007@ntu.edu.tw

Introduction

Landscape ecological planning has been paid much attention by planners over urban and nature areas, but cases in suburbs have been rarely mentioned. The suburban landscape is a mosaic of human buildings and nature habitats, in suburbs of Taipei, Grant Lake Park serve as a stepping stone between urban parks and forested basin edge. The ecological function of the park is getting more concern because of the traversing MRT (Mass Rapid Transport System). Therefore, we propose the park renewal plan with principles of landscape ecology. In the local scale, the ecological network plan can be made through delicate observation: birds' flying routes, extent of noise, and green coverage, etc; instead of accurate estimation of landscape ecology indices. The results proved that for a local park in the human-nature symbiosis suburbs, planning principles and process are the same for human and fauna: to make a better place for living, feeding and transportation.

Landscape ecology concepts

In Grant Lake park renewal plan, have we used landscape ecology principles on planning the edge and boundary of water and woodland patches, greenway corridors, and a vegetation network.

In Grant Lake Park, we have used bird behaviour and movement as a model for the ecological network. The avian species observed are: Little Egret (*Egretta garzetta*), Cattle Egret (*Bubulcus ibis*), Black-crowned (*Nycticorax nycticorax*), Taiwan Blue Magpie (*Urocissa caerulea*). The movement network for birds were also studied and mapped.

Planning features

In order to create isolated habitats, we planned several floating islands in the middle of the Grand Lake; birds can then have more resting and nesting sites. The vegetation cover should be replaced by native plants which will create diverse habitats of islands, woods, hedges, wetlands and sandbanks, to increase vegetation diversity of the water bank, and to make abundant microhabitats. Most important, we suggest a green tunnel for the MRT line, which the vegetation covering will fill up the ecological gap. The renewed Grand Lake park will be no more just a neighbourhood park but a thriving human-nature symbiosis resort.

References

Dramstad. W. E.; Olson, J. D.& Forman, R. T. T. (1996) *Landscape Ecology Principles in landscape Architecture and Land-use Planning.* Island Press, Washington DC, US

Forman, R. T. T. (1995) *Landscape Mosaic.* Cambridge University Press, Cambridge, UK. P.273-274

Jongman, R. & Pungetti, G (2004) *Ecological Networks and Greenways.* Cambridge University Press, Cambridge, UK.

Searching for participatory planning in the urban-rural fringe in Spain

V. Hernández-Jiménez, B. Ocón, D. Pereira

Dpto. Proyectos y Planificación Rural. ETSI Agrónomos. Universidad Politécnica de Madrid.
Av/ Ciudad Universitaria s/n. 28040 Madrid, Spain.
e-mail: veronica.hernandez-jimenez@ncl.ac.uk

The institutional and landscape changes in Spain over the last three decades have shaped current decision-making processes in the land planning system. Natural protected areas, strategic farming areas (i.e. typical Mediterranean agro-ecosystem) and new or potential urbanized areas shape and share the territory. The intensive use of land in the urban-rural fringe and the wide range of stakeholders involved, have generated social and environmental conflicts. Different themes such as territorial planning and governance need to be explored taking into account the role of integrative research. The combination of quantitative methods and discursive approaches could harmonize the complexity of these emergent conflicts in regional planning and management.

This research group deals with these issues in the framework of the Integrative Systems and the Boundary Problem project (ISBP) funded by the EU FP6 (NEST-2005-Path-CUL). ISBP emerged from a former research (TiGrESS - MADRID) which was instrumental in helping stakeholder communities to adapt to emerging circumstances and changes in the regional planning process. This work suggested a set of future scenarios, under a common framework of sustainability. These scenarios were explored enhancing stakeholder participation. ISBP will continue this former study exploring how to negotiate new institutional boundaries to reduce tension between antagonized communities of stakeholders.

The Madrid Autonomous Community and Barcelona (one of the four regions of Catalonia) are the case studies chosen for this work due to their remarkable moment as the two greatest metropolitan areas in Spain.

Carried out by the research group on Sustainable Planning at the Polytechnic University of Madrid (Spain) in collaboration with Newcastle University (UK).

References

Healey, P. (1997a). Collaborative Planning: Shaping Places in Fragmented Societies. Planning, Environment and Cities. Palgrave McMillan. London

Pike, A., Rodriguez-Pose A. and J. Tomaney (2006). Local and Regional Development. Routledge. New York

Winder, N. (Ed) (2006). TiGrESS Final Report. Retrieved: June 2006 from http://www.tigress.ac

Winder, N. (Coord.) (2006). ISBP. Retrieved: February 2007 from http://www.tigress.ac/isbp/

Green space strategy (Dublin)

D. Sgouros

Landscape Architect, Zygomalli 7, 45332 Ioannina, Greece.
e-mail: disgouros@yahoo.gr

The study area is in the triangle between Richmond Road, Clonliffe Road and Drumcondra Road. Most of the land is covered by the premises of Holly Cross College, where there is the Archbishop's House, the main buildings of the historical college, and other buildings that are recorded as National Monuments. The open area of the site is approximately 20 acres. There is no use or specific activity in the site. **Tolka river** runs in the site towards southeast.

The river is the boundary of the college land. On the north bank there are houses but the land is dominated by old buildings that are currently being used as garages, warehouses and light industries. At the southeast part of the study area there are houses. The character of this part of the city is very degraded.

Especially on the north bank the land is almost derelict and the people who live in the adjoined houses are subjected to views of very low aesthetics.

The aim of the project is to change radically the character of the study area by creating **new housing and a new park**. It will be part of a "chain" of green areas which will include the existing surrounding parks. This principle could subsequently be followed in the broad area of Glasnevin, Whitehall and Marino where there is abundance of open institutional land.

The river Tolka is a natural feature of significant proportion. It can be the focal point of this part of the urban environment.

The geomorphology of the site presents a uniformity that offers a broad potential of

The existing mature vegetation offers the opportunity of a plan that can be Implemented in short term, and be integrated with a long term planting plan.

The access to the river corridor is presently almost non existent. The current use of land does not step with the creation of a new amenity and recreation space of vast size. At the north bank there are residencies in low density, warehouses and small industries. The south bank is covered mostly by the land of Holly Cross College. Holly Cross College is an institution of great historical importance for Dublin and Ireland that dates in the middle 19th century. The site includes the Archbishop's House and other buildings (i.e. The Red House) which are recorded as National Monuments. Any intervention into the very premises of the institution should not be undertaken without serious consideration.

The adjacent land of Holly Cross College can become a new area of amenity. It can be part of an integrated **green space strategy** for the broad area (Drumcondra, Glasnevin, Whitehall and Marino) that will:

1. Create more publicly accessible open spaces
2. Provide recreational routes for walkers, joggers and cyclists
3. Increase the accessibility of both existing and new public parks
4. Create links between pedestrian origins and destinations for journeys to work, to schools, to public transport.

There is a challenge to **increase residential density** and **redevelop derelict lands.** Such a task will improve the living conditions and quality of life of the inhabitants, by providing new housing and creating an adjacent amenity area (neighbourhood park) of significance along the river. The project includes the design of **anti-flooding measures** to tackle with the problem of flooding that can occur in the area after heavy raining, as it happened during 2002.

Landscape fragmentation of urban green spaces in Hong Kong

Y. H., Tian, C. Y., Jim

School of Geography, University of Hong Kong, HKSAR, China.
e-mail: tianyuhong@hkusua.hku.hk

A large amount of literatures has assessed the complicated process of landscape fragmentation. However, few studies tackle the urban green spaces (UGS) system in the most compact city in the world such as Hong Kong. Inspired by related studies and assisted by the statistical, GIS and RS techniques and FRAGSTAT 3.3 software. The study area include 13 districts of Hong Kong: 4 old districts of Hong Kong Island, 5 old districts of Kowloon and 3 new towns of the New Territories which represent first generation, second generation and the latest generation. The Fragmentation Index of green patches in the study area is modeled with the hexagon of 160 ha as appropriate sample unit. The model of fragmentation includes almost all the characteristics of landscape pattern: AREA_MN, PD, SHAPE_MN, ENN_MN, CONNECT, DIVISION, MESH and SPLIT. Results indicate that the fragmentation level of UGS are increasing from the countryside to the center of the districts, and built-up areas especially those in the center of Kowloon districts have the highest fragmentation of UGS. New towns always have lower fragmentation and higher ecological functions of UGS than old towns because of the increasing concerns on the construction of green spaces on spacious lands. This model is validated to be applicable in the study. The uneven distribution of fragmentation of green spaces indicates the unbalanced distribution of spatial pattern of green patches in the study area and in the built-up areas of different districts. More measures could be introduced to increase the continuity of green patches and the green cover. These measures may include constructing greenways or green corridors, setting up green stepping stones, enlarging the existing green patches and strengthening the management.

Theme 3. Ecological Networks, fragmentation and connectivity

3.1 Symposium 5: Ecological infrastructure: theory and application

Green Infrastrucure for Cities: The Spatial Dimension

J.Ahern, S. Kato

University of Massachusetts, Department of Landcape Architecture and Regional Planning, Amherst, MA, USA.
e-mail: jfa@larp.umass.edu

Planning for sustainable cities is a complex process addressing the fundamental areas of economic, environmental and socially-equitable sustainability. This paper focuses on the environmental area, with theories, models, and applications illustrating possible spatial configurations of a green infrastructure to support ecological and physical processes in the built environment including: hydrology, biodiversity, and cultural/human activities. Green infrastructure is an emerging planning and design concept that is principally structured by a hybrid hydrological/drainage network, complementing and linking relict green areas with built infrastructure that provides ecological functions. Green infrastructure plans apply key principles of landscape ecology to urban environments, specifically: a multi-scale approach with explicit attention to pattern:process relationships, and an emphasis on connectivity. The paper provides theoretical models and guidelines for understanding and comparing green infrastructure approaches. International examples at multiple scales are discussed to illustrate the concepts and principles introduced.

Key Ecological Processes and Functions

Ecological processes are the mechanisms by which landscapes function – over time, and across space - and are therefore appropriate to use as the goals for - and the indicators of - sustainability. Landscape ecology provides a theoretical perspective and the analytical tools to understand how complex and diverse landscapes, including urban environments function with respect to specific ecological processes (Pickett et al. 2004).

The Ecological Society of America defines ecological functions as those that provide "services" that moderate climatic extremes, cycle nutrients, detoxify wastes, control pests, maintain biodiversity and purify air and water (among other services) (ESA 2006).

Landscape Ecology Principles for Green urban Infrastrucutre

Key ideas from landscape ecology that are relevant to green urban infrastructure for sustainable cities include: 1) A multi-scaled approach is based on hierarchy theory that addresses the structure and behavior of systems that function simultaneously at multiple scales. 2) The pattern:process dynamic is arguably the fundamental axiom of landscape ecology because the spatial composition and configuration of landscape elements directly determines how landscapes function, particularly in terms of species movement, nutrient and water flows (Turner 1989). 3) Connectivity is a property of landscapes that illustrates the relationship between landscape structure and function. In general, connectivity refers to the degree to which a landscape facilitates or impedes the flow of energy, materials, nutrients, species, and people across a landscape.

Guidelines for Planning and Designing a Green Urban Infrastrucutre

<u>Articulate a Spatial Concept</u>
Spatial concepts guide, inspire and communicate the essence of a plan or planning strategy to provide for specific ABC functions. Spatial concepts are often articulated as

metaphors that are highly imaginable and understandable by the public, but which also can support and inspire the planning process (Zonneveld 1991). Spatial concepts are well understood in planning, but less so in science. They represent an important interface of empirical and intuitive knowledge through which rational knowledge is complemented with creative insights..

Strategic Thinking

When the existing landscape supports sustainable processes and patterns, a protective strategy may be employed. Essentially, this strategy defines an eventual, or optimal landscape pattern that is proactively protected from change while the landscape around it may be allowed to change. When the existing landscape is already fragmented, and core areas already limited in area and isolated, a defensive strategy can be applied. This strategy seeks to arrest /control the negative processes of fragmentation or urbanization. An offensive strategy is based on a vision, or a possible landscape configuration that is articulated, understood and accepted as a goal. The offensive strategy differs from protective and defensive strategies in that it employs restoration, or reconstruction, to re-build landscape elements in previously disturbed or fragmented landscapes. The opportunistic strategy is conceptually aligned with the concept of green infrastructure by seeking new or innovative "opportunities" to provide ABC functions in association with urban infrastructure.

The Greening of Infrastructure

To achieve sustainability in urban landscapes, infrastructure must be conceived of, and understood as a genuinely possible means to improve, and contribute to sustainability. If one only thinks about avoiding or minimizing impact related to infrastructure development, the possibility to innovate is greatly diminished.

Learn by Doing

The adaptive approach is promising for green infrastructure because the knowledge to plan and implement these systems is evolving. If experimental applications can be practiced routinely, the potential to build empirical knowledge, while exploring sustainability is quite profound.

References

Ecological Society of America, 2006. Retrieved on June 30, 2006 http://www.actionbioscience.org/environment/ esa.html

Pickett S T A, Cadenassso M L and Grove J M , 2004. Resilent cities: meaning, models, and metaphor for integrating the ecological, socio-economic, and planning realms. Landscape and Urban Planning: 69:4, 369-384.

Turner M G , 1989. Landscape Ecology: the Effect of pattern on process. Annual Review of Ecological Systematics. 20:171-197.

Zonneveld W , 1991. Conceptvorming in de Ruimtelijke Planning. Universetiet van Amsterdam.

Why patches of fragmented woods in the city? - Contemporary uses of satoyamas in Japanese urban areas as a source of renewable resources

M. Yokohari[1], T. Terada[2]

[1] Graduate School of Frontier Sciences, The University of Tokyo, Kashiwa, Chiba, Japan;
e-mail: myoko@k.u-tokyo.ac.jp
[2] Graduate School of Systems and Information Engineering, Univeristy of Tsukuba, Tsukuba, Ibaraki, Japan

Satoyama and the Kyoto Protocol

The majority of forests in Japan, which cover nearly 70% of the land area, are on mountains, however a number of forests patches surrounded by farmlands and urban areas can still be found on hills, plateaus and lowlands. These fragmented woods remaining in the areas close to human settlements are known as satoyamas, a landscape type that represents up to 20% of Japan's land area. Most *satoyamas* have a common historical background having been maintained for agricultural uses; harvesting firewood and charcoal, and collecting litter for making organic fertilizer. However, the introduction of fossil fuels and chemical fertilizers deprived *satoyamas* of their economic viability, leading to their neglect.

The importance of maintaining *satoyamas* for safeguarding ecological values has recently been discussed. However, because the current management schemes are mostly conducted by volunteers, those *satoyamas* that enjoy continuous maintenance are extremely limited. A sharp increase of maintained *satoyamas* may never be expected unless new incentives for maintenance are introduced.

Restoration of *satoyamas* can be expected by utilizing renewable resources, especially wood and litter harvested from satoyamas. The Kyoto Protocol to the UN Framework Convention on Climate Change has set the goal for Japan to reduce collective emissions of greenhouse gases by 6% compared to the 1990 emission rate, which should be achieved by 2010, and the reduction of the CO_2 emission is regarded as the key issue to achieve the goal. Substituting biomass as an alternative energy source for fossil fuels is expected to be an indispensable issue for the reduction of CO_2 emission. If we can utilize woods and litter from satoyamas as biomass resources it may add a substantial incentive for satoyamas to be maintained.

Data collection and the estimation of potential biomass production

To estimate the potential amount of biomass that may be harvested, we have taken Tsukuba City, Japan as a case study. Although Tsukuba is located on the fringe of Tokyo, land use of the city is still fairly rural where approximately 12% of the land area is covered by satoyamas. The actual stock of biomass in *satoyamas* in Tsukuba was estimated by measuring the number and sizes of trees and ground cover in the selected satoyama patches, and applying the data sets to the models derived from precedent studies.

The amount of biomass which can be harvested from satoyamas is determined not only by the actual stock of biomass but also by the way the satoyamas are maintained. In this study maintenance schemes to realize four goals named as "scenic beauty", "quiet recreational use", "active recreational use", and "bio-diversity" were set, and the amount of biomass which may be harvested according to the four schemes were estimated by developing estimation models. As the result, "Bio-diversity" scheme with clear cutting of trees is expected to provide the highest amount of biomass at 4,000 tons annually, while "scenic beauty" scheme only with the forest bed management is estimated to result in the lowest amount as 1,600 tons.

Generating electric power by biomass to reduce CO_2 emission

Among various schemes for CO_2 reduction, generating electric power by biomass as an alternative and renewable energy source is one practical means to substitute for fossil fuels. We therefore estimated the amount of electric power that can be generated by biomass harvested from satoyamas in Tsukuba to identify how the biomass will be contributing to the reduction of CO_2 emission.

The amount of electric power generated by biomass has been estimated as 6 to 28 million kilowatts annually, sufficient for 1,300 to 5,200 households, 2 to 7%, in Tsukuba. The Ministry of Environment Japan is currently entering discussions to reduce the collective greenhouse gas emissions from each local municipality. Accordingly, in 2002 Tsukuba set a goal to reduce the CO_2 emission by 2,132 tons per year. From precedent studies it is estimated that 1 ton of biomass will reduce 0.42 tons of CO_2 emission when the biomass is used for generating electric power. According to this estimation the biomass harvested according to the “scenic beauty” management scheme will achieve 90% of the goal set by Tsukuba when the biomass is used for generating electric power, while the “bio-diversity” scheme will clear nearly 400% of the goal. Thus Tsukuba may easily exceed the goal only by utilizing biomass provided from satoyamas.

Satoyamas remaining in and around urban areas are no longer useless fragmented woods waiting for future urban developments, but may become indispensable uses of land for the sustainable future of the city.

Green infrastructure: a strategic approach for landscape ecology in urban areas

P. Pellegrino

University of São Paulo, Faculty of Architecture and Urbanism, Design Department, Rua do Lago 876. 05508-900. São Paulo SP Brazil
e-mail: prmpelle@gmail.com

Introduction

The application of landscape ecology principles in landscape architecture and planning as part of an overall green infrastructure are yet to be fully tested. The use of the concept of green infrastructure is presented as being strategically effective to support ecosystem services in the urban fabric. The opportunities and restraints for the implementation of this green tapestry of different kind of open spaces is reviewed through two case studies in São Paulo City. They encompass different scales: an urban watershed plan in the border of a forest reserve and a design proposal for an inner city neighborhood watershed; and, in this way, providing the opportunity to look for the real viability of maximizing the overall performance and sustainability of the urban open spaces.

Development of an urban landscape approach

Why Green Infrastructure?

The interconnected network of natural areas and other open spaces that conserves natural ecosystems values and functions inside and around the urban areas can be seen as the backbone of their green infrastructure (Benedict and McMahon, 2006). The abundance and distribution of natural features in the urban landscape like forests, wetlands, and streams should be seen as an infrastructural capacity just as built infrastructure like roads and utilities are, since they provide the ecosystem services that are equally necessary for the sustainability of the built areas as also of the remnant natural elements (Weber *et al*, 2005).

Green infrastructure strategy

Green infrastructure planning

Landscape Ecology principles can be more easily understood and applied in the scale of a plan for an urban watershed, like the example chosen, that is located in the fringe of the urban region with part still covered with forest, confronting the other half characterized by the growing overall impervious coverage of the city, in the process of encroaching the watershed with the continuous canalization of disconnected urban creeks and rivers, and the implementation of urban detention basins. The implementation of a green infrastructure was, then, viewed as an opportunity to counteract these trends, buffering the natural ecosystems and creating a distinctive local landscape identity and a more sustainable urban environment.

Figure 1. View of the proposed Green Infrastructure for the Urban Watershed Plan.

Green Infrastructure design

Can landscape design be viewed as much more than mere beautification of the urban environment? An emergent palette of landscape design typologies – like rain gardens, bioswales, wetponds and green grids - plus the concept of the urban forest, are part of this effort, that goes in the direction to integrate pieces of a high-performance infrastructure that protects and even improves urban hydrology, climate, and ecology. Adopting these principles in the adaptation of the cycles and processes found in nature in the scale of an inner city neighborhood watershed, that has been totally urbanized and deprived of its former natural features, was the goal of the example shown here at the design scale.
.

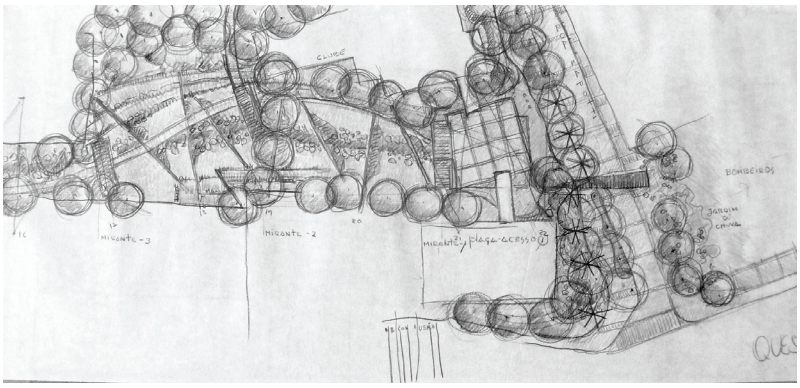


Figure 2. Bioswales and rain gardens are connected as a green grid with the urban forest.

References

Benedict, M. & McMahon, E. (2006) *Green Infrastructure: linking landscapes and communities.* Island Press, Washington, DC.

Frischenbruder, M. & Pellegrino, P. (2006) Using greenways to reclaim nature in Brazilian cities. *Landscape and Urban Planning* 76**:** 67-78.

Weber, T; Sloan, A. & Wolf, J. (2006) Maryland's Green Infrastructure Assesment: development of a comprehensive approach to land conservation. *Landscape and Urban Planning, 77:1-2:94-110.*

Patch Dynamics and Urban Design

S.T.A. Pickett[1], B.P. McGrath[2], M.L. Cadenasso[3], J.M. Grove[4]

[1]Institute of Ecosystem Studies, Millbrook, NY, USA,
[2] Columbia University Graduate School of Architecture, Planning and Preservation, New York, NY, USA and Urban-Interface, LLC, Newark NJ, USA,
[3]University of California, Davis, USA, and
[4]US Department of Agriculture Forest Service, Burlington, VT, USA.

Patch dynamics is both an evocative term for interacting with urban design professions, and the shorthand for a well developed theoretical approach to landscape ecology. This theory addresses the structure and function of spatial heterogeneity in ecological systems at any scale. Patch dynamics theory highlights the mosaic or graded structure of spatial heterogeneity, the flows among patches, the role of patch boundaries, and the temporal changes in individual patches as well as the entire mosaic. This ecological theory applies quite well to human ecosystems, such as the varied areas of urban regions, and can accommodate biophysical, social, buildings, and infrastructural mosaics. These different mosaics are in fact linked and interacting, and the dynamics of each on is important to the others. We present examples of these mosaics, using metropolitan Baltimore, Maryland, USA, as a case study. Furthermore, we present how patch dynamics can be translated to the fields of urban design, where it encourages a connected, systems approach to design, and stimulates designs that recognize the dynamic nature of the urban mosaic. Effectiveness and relevance are demonstrated with two cases. One, an attempt to use landscape as energy machine/infrastructure, in the Northern Netherlands, and two, restructuring Rotterdam as 'Water City' to enhance its attractiveness, identity and sustainability by revealing its ecological and land/historical heritage that has been severely disturbed by a modernist approach to Post-war urban construction.

Ecological Infrastructure and Landscape Urbanism

J. Koh

Wageningen University, Netherlands

There is growing awareness among planners and designers that large-scale design must be more adaptive and open-ended than determined, that design at the urban scale involves more repair and restructuring than new construction, and that city and landscape must form an integrated and complementary whole.

Ecological infrastructure (1) provides a useful tool that gives robust structure and continuity to the open-ended approach to large-scale and long-term design, and (2) demonstrates how a landscape approach to urban and regional design, landscape urbanism, is relevant, effective, and contemporary.

Effectiveness and relevance are demonstrated with two cases. One, an attempt to use landscape as energy machine/infrastructure, in the Northern Netherlands, and two, restructuring Rotterdam as ‘Water City’ to enhance its attractiveness, identity and sustainability by revealing its ecological and land/historical heritage that has been severely disturbed by a modernist approach to Post-war urban construction.

Design Ahead of Time: Urban Growth Pattern Based on Ecological Infrastructure

K. Yu, D. Li

[1]The Graduate School of Landscape Architecture, Peking University, Beijing China;
e-mail: kjyu@urban.pku.edu.cn

The Negative Approach — Landscape as Infrastructures for Urban Development

How landscapes change is related to the issue of time. Recognizing that urbanization and globalization processes are fast and overwhelming, a “negative approach” should be in contrast with the conventional development planning approach. By “negative”, We mean landscape architects and planners should plan and guide urban development by identifying and designing an ecological infrastructure (EI) before the development plan evolves. The EI is defined as a structural landscape network composed of the critical landscape elements and spatial patterns that are of strategic significance in safeguarding the integrity and identity of the natural and cultural landscapes and securing sustainable ecosystem services, protecting cultural heritages and recreational experiences.

In a conventional model of urbanization, time can be visualized as concentric annual-ring sprawl. Earlier, greenbelts and green wedges were seen as landscape structures to stop and prevent sprawl, and they were included in the comprehensive master plan. Current evidence shows that these greenbelt and wedge dreams have often failed (Ahern, 2002; 2003; Kühn, 1995; Yokohari, 2002).

Landscape ecology, provides a new ecological planning model which focuses on landscape patterns, horizontal processes and change, provides fundamentals for developing green infrastructure that can be used to integrate the horizontal processes of urban development with ecological protection.

At the regional scale, ecological infrastructure is represented as permanent regional landscape of flood prevention, ecological networks, heritage corridors and recreational corridors, which are planned for protection and used to define the urban growth pattern and city form. At the intermediate scale, the regional ecological infrastructure is to be integrated into the interior urban structure, and become the urban green space system that integrates various functions such as commuting, cycling, heritage protection and recreational activities. At the fine scale, the ecological infrastructure is to be used as the defining structure for urban land development, and to be used to guide the site-specific design.

EI becomes an integrated medium of various processes, bringing nature, man and spirits together. It is the efficient landscape security pattern to safeguard ecological and environment integrity, cultural identity and to provide for people’s spiritual needs.

The Case study: Urban Growth Based on Ecological Infrastructure

Taizhou is located at the south east coast of China, with a total area of 9411 square kilometers and a population of 5.5 million. Of these 0.7 million live in urban areas; the urban population will increase to 0.9 million in 2010, and 1.3 million in 2020, and 1.5 million in 2030. Although quite rural and agricultural in character, it is now one of the fastest growing areas in China due to the booming of small private industries. Under the influence of the monsoon climate and being adjacent to the east sea, flooding has been a major hazard. In response to stormwater and flood problems, the landscape has been shaped into a unique form with a network of water courses that integrate natural water systems, wetlands and man made ditches, as well as cultural heritage features. This water network landscape, which has been effective in safeguarding the agricultural processes for thousands of years, is now facing the challenge of being destroyed by the rapid urbanization process beginning in the 1990s. The wetlands have been filled, rivers have been straightened and channelized, cultural heritages that are not listed as protected historical relics have been destroyed, visual and recreational experiences have been totally ignored. In addressing the above situations, ecological infrastructures at various security levels were then identified and planned to safeguard the sustainability of the living landscape and guide the urban sprawl according to alternative development scenarios.

Defining ecological infrastructure at the large scale: The regional EI was planned through the identification of critical landscape patterns (security patterns) for the targeted processes (Yu, 1996). The security patterns are composed of elements and spatial positions that are strategically important in safeguarding the different processes of the landscape. Models including suitability analysis, minimum cost distance and surface models were applied to identify security patterns for specific processes. Three security levels - low, medium and high - are used to define the quality of the security patterns in safeguarding each of the targeted processes.

Using the three EI alternatives as framing structure, scenarios of regional urban growth patterns were simulated using GIS: the Adjusted Sprawl Scenario, the Aggregated Scenario, and the Scattered Scenario. Comparative impact evaluations were made for these scenarios by a planning committee composed of decision makers of the city, planning experts from all over the country, stakeholders include officials from various functional departments of the Taizhou city government, representatives of individual villages who originally owned the land, representatives of real estate developers and representative of investors who are eagerly waiting for the development rights for the land. One of the three urban pattern scenarios was finally selected as the most feasible by the decision makers, after a long time and multiple brainstorms among the planning committee. As expected, the Aggregated Scenario, which is based on the medium quality EI, was considered the more balanced and less difficult to be realized.

Defining ecological infrastructure at the medium scale: Based on the aggregated Scenario and the green lines of the regional EI, overall design and management guidelines were developed for the medium quality EI, and especially for the green corridors that function as critical EI elements in water management and biodiversity conservation, heritage protection and recreation. During this process of making design guidelines, interactions were made between the planners and local people.

(6) New models of urban land development: testing EI at the small scale: At a selected site (10 square kilometers in size), following the EI guidelines developed above, alternative urban development models were designed to test the possibility of building an EI-based city. In these, ecosystem services safeguarded by EI are built into the urban fabric so that typical urban sprawl can be avoided. These new urban land development models were presented to the developers and investors, as well as the city decision makers, to let them know that the business-as-usual models of land development can be avoided. The new way of development by building the EI into their land use scheme will not only help the whole city, but will also benefit future development ecologically and economically.

References

Ahern, J., 2002. Greenways as Strategic Landscape Planning: Theory and Application. Wageningen University, The Netherlands.

Manfred Kühn, 2003, Greenbelt and Green Heart: separating and integrating landscapes in European city regions, Landscape and Urban Planning, 64:19–27.

Yokohari, Makoto, Takeuchi, Takeuchi, Watanable, Takashi, and Yokota, Shigehiro 2000, Beyond greenbelts and zoning: A new planning concept for the environment of Asian mega-cities. Landscape and Urban Planning, 47:159-171.

Yu, K.-J., 1996. Security patterns and surface model in landscape planning. Landscape and Urban Planning, 36(5):1-17.

3.2 Symposium 7: Landscape genetics: testing landscape effects on gene flow

Does the matrix matter? Landscape structure and population genetic architecture of amphibians

A.G. Nicieza[1], M. Choda[1], S. García[1], and D. Álvarez[1,2]

[1]Ecology Unit, Department of Biology of Organisms and Systems, University of Oviedo, Oviedo, Asturias, Spain
e-mail: agnic@uniovi.es
[2]Genetics and Natural Resources Group, Department of Functional Biology, University of Oviedo, Oviedo, Asturias, Spain

Introduction

The increasing anthropogenic impact on natural ecosystems urges for the design and application of programmes for monitoring genetic diversity at the appropriate spatial and temporal scales (Schwarzt *et al*., 2007). Ideally, these programmes should be based on the knowledge of fine-scale genetic structures of target species in specific landscapes, which allow for the identification of evolutionary significant units (ESUs) and delineation of management units (MUs) (Palsbøll *et al*., 2007). Given the interdependence between fine-scale genetic structure and gene flow, and the potential influence of gene flow on population genetic diversity and long-term population viability (Whitlock and McCauley 1999), assessing the spatial and geographic scales over which substantial gene flow occurs is a critical step for the conservation and management of threatened species.

Over the last decades, a significant number of amphibian species have undergone severe declines or extinction (Stuart *et al*., 2004). Surprisingly, despite many amphibian species are particularly deme-structures organisms, very few studies have been conducted to produce data on gene flow across a fine geographic scale. The paucity of information may be even worse because one can expect different genetic structures for a species inhabiting different landscapes. Similarly, differences in reproductive modes or dispersal abilities among species or populations occupying equivalent landscapes can generate substantial differences in the spatial organization of genetic diversity. Here we present a study aimed to explore how the 'interaction' of spatial landscape patterns and the species' attributes can mould the structure of subdivided populations.

Study system

We examine how landscape patterns can affect genetic diversity and its spatial structure by using a model system consisting of three contrasting landscapes and amphibian species differing in dispersal and reproductive modes, and dependence on the aquatic habitat. In a first step we used two species, *Rana temporaria* and *Salamandra salamandra*, as model organisms. In *R. temporaria*, the sites for breeding and larval development can be viewed as small islands or archipelagos of aquatic habitat within a surrounding non-habitat matrix of land. In contrast, in the study area *S. salamandra* can breed either in small creeks and rivers (ovoviviparous reproductive mode) or in the absence of aquatic habitat (viviparous reproductive mode). In the Cantabrian Range, the two species can be found along a 2200 m altitude gradient. To identify the mechanisms involved in generating different population structures ("continuous" population, metapopulation, small isolated populations) we sampled over 30 breeding areas allocated among three different types of landscape: i) a coastal area with smooth topography, ii) a mountain area with substantial barriers and a soft matrix (expected low resistance), and iii) a karstic, mountain area with large barriers and a hard matrix (expected high resistance). We used a hierarchical sampling design which included four rings with decreasing sampling intensities. Landscapes i) and iii), and the transition zone between them, form the first ring, a 2000-km^2 area, characterised by a relatively complex topography. Landscape ii) is in the third ring, but the scale of sampling was equivalent to that of the coastal and karstic areas. Within these landscape structures, distances between breeding sites ranged from 0,5-20 km.

For *R. temporaria* we are examining variability for 12 microsatellite loci to determine whether a model of isolation by distance or a model incorporating the effects of physical barriers can explain the observed variation in genetic diversity and the pattern of population differentiation. In the coastal area, breeding sites have a fine-grained distribution, with a relatively large number of relatively neighbouring, small units. In contrast, in mountain areas the species tends to a coarse-grained distribution, with large but more isolated populations. We hypothesize that, in different landscapes, differences in the degree of isolation between population units and overall connectivity will generate contrasting types of population structure and large variation on overall and local genetic diversity. A parallel approach is being conducted for *S. salamandra*: we expect the same landscape can generate diverse population structures in species differing in dispersal and reproductive modes. Our ultimate objective is to produce a general framework to predict the spatial scales, or the topographic structures, for evolutionary significant units from data on species life-history and geographic information.

References

Palsbøll, P.J., Bérubé, M. & Allendorf, F. (2007) Identification of management units using population genetic data. *Trends in Ecology and Evolution* **22**: 11-16.

Schwartz, M.K., Luikart, G. & Waples, R.S. (2007) Genetic monitoring as a promising tool for conservation and management. *Trends in Ecology and Evolution* **22**: 25-33.

Stuart, S.N., Chanson, J.S., Cox, N.A., Young, B.E., Rodrigues, A.S.L., Fischman, D.L. & Waller, R.W. (2004) Status and trends of amphibian declines and extinctions worldwide. *Science* **306**: 1783-1786.

Whitlock, M.C. & McCauley, D.E. (1999) Indirect measures of gene flow and migration: $F_{ST} \neq 1/(4Nm+1)$. *Heredity* **82**: 117-125.

What can landscape genetics contribute to landscape ecology?

V. H. Dale[1], G. M. Crutsinger[2], A. Classen[3]

[1]Environmental Sciences Division, Oak Ridge National Laboratory,
P.O. Box 2008, Oak Ridge, TN 37831-6036, USA.
e-mail: dalevh@ornl.gov
[2]Department of Ecology and Evolutionary Biology, University of Tennessee,
Knoxville, Tn 37996, USA. [3]Environmental Sciences Division, Oak Ridge National
Laboratory,P.O. Box 2008, Oak Ridge, TN 37831-6422, USA.

Landscape genetics deals with how genetic variation can affect the expression of phenotypic variation over space, the extended consequences of phenotypic variation on communities and ecosystem processes, and in turn, how spatial variations can influence genetic conditions (Holderegger and Wagner, 2006). Therefore, the new field and techniques of landscape genetics enrich the types of questions and relationships that can be explored by landscape ecologists. In particular, they allow a focus on processes (causes and implications of observed patterns) as well as the patterns themselves. The types of questions that can now be addressed include constraints and implications of hierarchical changes in diversity (ranging from genetic to landscape diversity), interactions between diversity within or among trophic levels, and how landscape structure can affect genetic variability via dispersal and gene flow. Some of these issues can be explored by using models, and the tools of landscape genetics provide the ability to consider these issues in quantitative controlled experiments.

Landscape ecology relates patterns of land cover and land use to environmental conditions over a variety of geographic scales and provides important theoretical principles that can be applied to the genetics conditions (Holderegger and Wagner, 2006). For example, landscape changes (e.g. habitat fragmentation, edge effects between dissimilar land uses, land cover corridors, and changes in hydrology) can concentrate or distribute a population, species, or community, thereby affecting ecological processes such as dispersal, migration, predation, etc. Changes in weather over time or longer-term changes in climate (including ecological disturbances such as fires and hurricanes) can also impact habitat, hydrology, and landscape dynamics in ways that affect the genetic variation within a landscape.

On the other hand, genetics conditions are increasingly being recognized as affecting landscape patterns and processes. Whitham et al. (2006) show that heritable genetic variation within individual species has community and ecosystem influences (such as leaf litter decomposition and N mineralization) in examples from microbes to vertebrates. Furthermore, the interactions among genotypes within a local population (i.e. genotypic diversity) can determine the diversity or associated species and drive ecosystem level processes. For example, Crutsinger et al. (2006) experimentally showed that increasing population genotypic diversity in a dominant old-field plant species, *Solidago altissima*, determined arthropod diversity across trophic levels and increased net primary production (Figure 1). Surprisingly, the magnitude of the effects of plant genotypes on communities and ecosystem processes were directly comparable to the effects at the plant species level. Recent evidence also shows how genetic interactions link terrestrial and aquatic communities and may have significant evolutionary and conservation implications (Leroy et al. 2006).

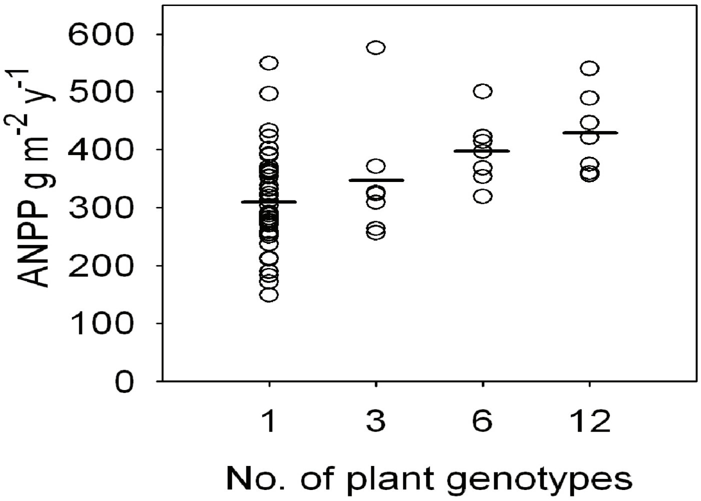


Fig. 1. The positive relationship between genotypic diversity of *S. altissima* and ANPP. Each circle represents plot-level biomass at peak-growing season.

But, to date, no one has developed a conceptual model for how genetic influence may play out at the landscape level or used an organized approach to define and prioritize the key research questions in the field and how they can be addressed. Holderegger and Wagner (2006) compiled a guide on the disparate disciplines may best interact. Manel et al. (2003) reviewed available tools for such studies (although the tools and technologies for such analyses are rapidly expanding).

Therefore, we have designed a new conceptual model for understanding how genetic factors contribute to landscape patterns and how landscape conditions affect genetics. A key focus is on the interactions between these two perspectives and fields of study. We also demonstrate the benefits of an interdisciplinary approach in addressing the mechanisms underlying landscape genetics and develop the key research questions and conceptual model of how landscape ecology interacts with genetics. Our perspective is that landscape ecology and genetics interact in a complex manner to explain hierarchical patterns and processes at the genetic-, species-, and ecosystem-level. Linking these disparate fields of study allows innovations within each field as well as a commitment to a new holistic perspective on analytic tools that may enable scientists to better answer complex global questions.

References

Crutsinger, G.M.; Collins, M.D.; Fordyce, J.A.; Gompert, Z.; Nice, C.C. & Sanders, N.J. (2006) Plant genotypic diversity predicts community structure and governs an ecosystem process. *Science* **313**: 966-968.

Holderegger, R. & Wagner, H.H. (2006) A brief guide to landscape genetics. *Landscape Ecology* **21**: 793-796.

LeRoy, C.J.; Whitham, T.G.; Keim, P. & Marks, J.C. (2006) Plant genes link forests and streams. *Ecology* **87**: 255-261.

Manel, S.; **Schwartz, M.K**.; **Luikart, G**. & **Taberlet, P**. **(2003)** Landscape genetics: combining landscape ecology and population genetics. *Trends in Ecology & Evolution* **18**: 189-197.

Whitham, T.G.; Young, W.P.; Martinsen, G.D.; Gehring, C.A.; Schweitzer, J.A.; Shuster, S.M.; Wimp, G.M.; Fischer, D.G.; Bailey, J.K.; Lindroth, R.L.; Woolbright, S. & Kuske, C.R. (2006) Community and ecosystem genetics: A consequence of the extended phenotype. *Ecology* **84**: 559-573.

Molecular genetic testing of landscape ecological hypotheses: the dynamics of amphibian species distributions

J. W. Arntzen

National Museum of Natural History | Naturalis - P. O. Box 9517,2300 RA Leiden, The Netherlands,
e-mail: arntzen@nnm.nl

Introduction

Most amphibian species in the Holarctic realm (frogs, toads and salamanders) reproduce in standing water. Water bodies such as ponds are mostly man-made and spaced out (water supply to cattle, reservoirs for fire-fighting etc.) and not randomly distributed over the landscape. In spring adult amphibians migrate to the ponds for breeding after which they return to the terrestrial habitat where they will spend most of the year for shelter and foraging. Given that adult amphibians show breeding site fidelity with low dispersal, ponds represent localized breeding populations (or demes) and the matrix of occupied ponds in the landscape represents a metapopulation. Therewith, amphibians provide us with a well-defined and tangible system for spatial ecological research (Jehle et al., 2005a).

Dispersal comes into effect with the successful reproduction of an individual in a pond other than the one it was born. Under this definition dispersal amounts to gene-flow. In amphibians the spread from the natal pond takes mostly place during the juvenile phase, in between metamorphosis and maturation. At the population level, amphibian survival depends on the metapopulation structure, in particular on the dispersal among local populations (Halley et al., 1996) and dispersal is thought to be a function of the distance between ponds and the characteristics of the intervening habitat. This provides an excellent setting to study the effect of landscape features on amphibian population persistence, for the purpose of nature conservation and management. Since juvenile amphibians are small and not amenable to tagging the inferences on dispersal (gene-flow) will be indirect, using molecular genetic markers (Jehle and Arntzen, 2002).

Materials and methods

Surveys were conducted on the pond presence/absence of toads (*Bufo bufo*) and salamanders (*Triturus cristatus, Triturus marmoratus*) in agricultural landscapes of Britain (259 ponds, Leicestershire) and France (300+ ponds, Mayenne). Landscape features such as agricultural field use, forestation, waterways, presence of competing species etc. etc. were gathered from topographical maps and satellite remote imagery. Logistic regression was used to identify landscape features associated with amphibian occurrence. Genetic variation at 3, 8, and 5 mini- and microsatellite loci (amounting to 9500 genotypes) was used to estimate pairwise genetic distance between occupied demes. I worked under the assumption that good habitat to live in is good habitat to disperse through (and the converse) and I tested with partial-Mantel tests the hypothesis that dispersal between demes is not only affected by distance (i.e., isolation by Euclidean distance) but also influenced by the quality of the intervening habitat (i.e., 'ecological distance').

Results

Firstly, positive and statistically significant effects were found in salamanders between the connectedness of populations and local population size. Secondly, genetic distance and Euclidean distance between populations were significantly associated in each species investigated. The relationship between connectedness and population size was frequently asymmetric, with gene-flow directed from large to small populations. Additional associations with habitat features were insignificant, except when ecological distance included the presence of rivers as barriers to dispersal in *Triturus cristatus* in Britain and the presence of a competing *Triturus* species (*T. cristatus* vs. *T. marmoratus*) as a barrier to dispersal in France.

Discussion

Effects of isolation by distance (Euclidean, ecological) were demonstrated. The ecological effects operated for relatively large scale phenomena (rivers, interspecific competition) and not for small landscape elements (hedgerows, spinneys, ditches) or land use, that are often hypothesized to affect metapopulation connectivity and thought to be crucial to amphibian survival. Asymmetric gene-flow is probably related to reproductive output and the numbers of juveniles available for dispersal (Jehle et al., 2005b). However, reproductive success fluctuates dramatically from pond to pond and from year to year, rendering the system fairly intractable at small spatial and temporal scale.

As a by-product of the amphibian survey in France, I discovered pockets of *T. marmoratus* completely surrounded by *T. cristatus* (cf. Arntzen & Wallis, 1991). Because amphibians have limited terrestrial dispersal capability and because the *cristatus* - *marmoratus* species distribution is largely parapatric, I argue that the enclaves are the signature of a *T. cristatus* range expansion at the expense of *T. marmoratus*. Elsewhere I found enclaves for fire bellied toads in central Europe (*Bombina bombina, B. variegata*), for marbled news in central Portugal (*Triturus marmoratus, T. pygmaeus*) and for crested newts in Serbia (*Triturus cristatus* superspecies). The enclaves vary in size from several to hundreds of km and vary in age from decades to thousands of years. I argue that in amphibians and other species with low dispersal capability enclaves help to reconstruct past distributions and that pattern (distribution) implies process (dispersal). GIS-based analysis of landscape ecological parameters help to fine-tune the inferred biogeographical scenarios. The generated hypotheses can be tested with the help of molecular genetic data. In my congress presentation I will illustrate this approach, with examples from toads and salamanders.

References

Arntzen, J.W. & Wallis, G. (1991) Restricted gene flow in a moving hybrid zone of newts (*Triturus cristatus* and *T. marmoratus*) in western France. *Evolution* **45**: 805-826.

Halley, J; Arntzen, J.W. & Oldham, R. (1996) Predicting the persistence of amphibian populations with the help of a spatial model. *Journal Applied Ecology* **33**: 455-470.

Jehle, R. & Arntzen, J.W. (2002) Microsatellite markers in amphibian conservation genetics. *Herpetological Journal* **12**: 1-9.

Jehle, R.; Burke T. & Arntzen, J.W. (2005a) Delineating fine-scale genetic units in amphibians: probing the primacy of ponds. *Conservation Genetics* **6**: 227-234.

Jehle, R.; Wilson, G.A.; Arntzen, J.W. & Burke, T. (2005b) Contemporary gene flow and the spatio-temporal genetic structure of subdivided newt populations (*Triturus cristatus*, *T. marmoratus*). *Journal Evolutionary Biology* **18**: 619-628.

Inferring the influence of landscape on roe deer gene flow using connectivity estimates based on a weighted combination of several landscape features

A. Coulon[1], J.F. Cosson[2], N. Ray[3], A.J.M. Hewison[1]

[1] Comportement et Ecologie de la Faune Sauvage, Institut National de la Recherche Agronomique, BP 27, Castanet-Tolosan Cedex, F 31326, France ; present : Cornell Laboratory Of Ornithology,159 Sapsucker Woods Road, Ithaca, New York 14850, USA.
e-mail: ac462@cornell.edu
[2] Centre de Biologie et de Gestion des Populations, Institut National de la Recherche Agronomique, Campus International de Baillarguet, CS 30016, Montferrier-sur-Lez, F 34988, France
[3] Computational and Molecular Population Genetics, Zoological Institute, University of Bern, 6, Baltzerstrasse, CH-3012 Bern, Switzerland

Introduction

Landscape genetics has been touted as a powerful approach to infer the influence of landscape on animal dispersal movements. One method consists of comparing how different types of geographic distances between populations or individuals explain genetic distances between them. This approach usually compares straight-lines and least-cost paths, the latter being the shortest pathways which follow or avoid a given landscape element hypothesised to influence dispersal movements (e.g. Michels *et al.* 2001, Berthier *et al.* 2005). A better correlation between genetic distances and geographic distances along least-cost paths indicates that they are closer to the real dispersal paths than the straight-lines, and that the landscape feature they are based on influences gene flow and dispersal movements. Until now, most least-cost distances have been calculated in relation to the distribution of a single type of landscape feature. However, dispersal movements of a given species are likely to be influenced to varying degrees by several landscape features. It would hence be valuable to compute least-cost paths reflecting this combined influence of several landscape elements. A few studies combined several landscape features but without taking into account the fact that they probably influence dispersal movements to different degrees (Spear *et al.* 2005, Vignieri 2005). Indeed, the difficulty is to set the relative weight of each element. Here, we used direct data of roe deer (*Capreolus capreolus*) movements sampled by GPS collars to model multi-feature connectivity and test its influence on roe deer gene flow in a fragmented landscape.

Estimation of multi-feature connectivity

Roe deer movement analysis

We fitted 20 roe deer with GPS collars recording each animal's location at regular time intervals (one fix every 2 to 6 hours). We used these locations and a GIS of the study area to model with a Step Selection Function (SSF, Fortin *et al.* 2005) roe deer preferences for landscape features during movements. An SSF describes the probability that a given segment of the landscape is used by an individual during a movement step, as a function of several variables. Here, we included the extent of woodland around the step, the distance of the step to the nearest road, and the topographic position of the step (i.e. valley bottom or ridge). The selected model indicates that in the study area, moving roe deer tend to avoid roads, but only in relatively open landscapes; it also suggests that they avoid most forested sectors and valley bottoms.

Connectivity modelling

The model estimated from the GPS data enables to estimate the probability of use of a landscape segment as a function of the simultaneous and weighted presence of several landscape elements. We extrapolated multi-feature connectivity values from this model by applying it to the full extent of the study area. In this setting, the probability of use of a landscape unit (pixel) is directly related to its connectivity.

Influence of connectivity on roe deer gene flow

We sampled 800+ roe deer from two genetically differentiated populations covering an area of 40 × 55 km (containing the smaller area where the GPS study was performed). We genotyped them at 11 microsatellite loci. We used the multi-feature connectivity map to elaborate least-cost paths between genotyped roe deer within each population. To test the influence of this connectivity on dispersal movements, we then carried out Mantel tests between inter-individual genetic distances and several variables reflecting length and landscape composition of alternative paths.

Preliminary results indicate that genetic distances between roe deer are not always better explained by least-cost distances compared to Euclidean distances (Table 1). However, tests involving potentially more informative characteristics of alternative paths (i.e. incorporating information on the type of landscape crossed by least-cost paths) are currently being performed. We will also estimate the gain of combining several landscape features to estimate connectivity, compared to a single-variable approach.

Table 1. Correlation coefficients and P-values (in brackets) of the Mantel tests between pairwise genetic and geographic distances, for two types of geographic distances.

Population	Sex	Euclidean distance	Least-cost distance
North-western (N=667)	Males	0.0162 (0.081)	0.017 (0.078)
	Females	0.0325 (0.003)	0.0344 (0.001)
South-western (N=173)	Males	0.041 (0.03)	0.0398 (0.038)
	Females	0.0342 (0.073)	0.0333 (0.083)

References

Berthier, K.; Galan M.; Foltête J. C.; Charbonnel N. & Cosson J.-F. (2005) Genetic structure of the cyclic fossorial water vole (*Arvicola terrestris*): landscape and demographic influences. *Molecular Ecology* **14:** 2861-2871.

Fortin, D.; Beyer H. L.; Boyce M. S.; Smith D. W.; Duchesne T. & Mao J. S. (2005) Wolves influence elk movements: behavior shapes a trophic cascade in Yellowstone national park. *Ecology 86:* 1320-1330.

Michels, E.; Cottenie K.; Neys L.; De Gelas K.; Coppin P. & De Meester L. (2001) Geographical and genetic distances among zooplancton populations in a set of interconnected ponds: a plea for using GIS modelling of the effective geographical distance. *Molecular Ecology* **10:** 1929-1938.

Spear, S. F.; Peterson C. R.; Matocq M. D. & Storfer A. (2005) Landscape genetics of the blotched tiger salamander (*Ambystoma tigrinum melanostictum*). *Molecular Ecology* **14:** 2553-2564.

Vignieri, S. N. (2005) Streams over mountains: influence of riparian connectivity on gene flow in the Pacific jumping mouse (*Zapus trinotatus*). *Molecular Ecology* **14:** 1925-1937.

Influences of landscape features on gene flow of Martes Americana in northern Idaho, USA

T. N. Wasserman[1], S.A. Cushman[2], M.K. Schwartz[2]

[1]Huxley College of the Environment, Western Washington University, Bellingham, WA., USA
e-mail: moonhowlin@yahoo.com. 360-650-7353
[2]USDA Forest Service, Rocky Mountain Research Station, 800 E Beckwith, Missoula, MT.

Introduction

Forest fragmentation can have a dramatic effect on landscape connectivity and dispersal of animals, potentially reducing gene flow within and among populations. American marten populations (*Martes americana*) are sensitive to forest fragmentation and the spatial configuration of patches of remnant mature forest has an important impact on habitat quality. Habitat fragmentation leads to a decrease in landscape connectivity, thus hindering movement among resource patches. This alteration can result in a reduction in gene flow between populations, leading to a loss of genetic diversity within fragments.

Methods

In this study, three landscapes were surveyed covering the Selkirk, Purcell, and Cabinet Mountain ranges in Northern Idaho over four winters where genetic information from *Martes americana* were collected via non-invasive methods. Hair snares were set along transects across the Idaho Panhandle Nat'l Forest during the winter months of January, February, and March of 2004, 2005, 2006 and 2007. Each trap was baited with deer meat, beaver castor, and gusto, a commercial call lure. Each trap was lined with 5 gunbrushes to non-invasively obtain hair samples from animals visiting the snare, from which genetic data was obtained. Bait stations were set for 2 weeks after which each station was revisited to collect hair samples and re-baited for another 2-week cycle. During the check, hair was collected from the gunbrushes. Each gunbrush is considered a single sample. Hair samples were sent to the RMRS Wildlife Genetics Lab in Missoula, MT. Genetic relationships were determined using diagnostic restriction enzyme patterns followed by amplification of a region of cytochrome b on mitochondrial DNA.

The study area lies within the Idaho Panhandle Nat'l Forest and is a 4,000 square kilometer area encompassing the Selkirk, Purcell, and Cabinet mountains. The topography is mountainous, with steep ridges, narrow valleys and many cliffs and cirques at the highest elevations. Elevation ranged from approximately 700m to 2000m above sea level. The Kootenai River trench runs down the middle of the study area, separating the Selkirk Mountains on the west from the Purcell Mountains on the east, with a five to seven mile wide unforested, agricultural valley and a broad, deep river between. The climate is characterized by cold, wet winters and mild summers. The area is heavily forested, with *Abies lasiocarpa* and *Picea engelmannii* codominant above 1300 meters, and a diverse mixed forest of *Pseudotsuga menziesii*, *Pinus contorta*, *Pinus ponderosa*, *Pinus monticola, Abies grandis*, *Tsuga heterophylla, Thuja plicata, Larix occidentalis, Betula papyrifera, Populus tremuloides, Populus trichocarpa* dominating below 1300 meters.

Results

Over 100 individual marten were detected across the 4,000 square kilometer study area. The genetic similarities were based on the pair-wise percentage dissimilarity among all individuals based on 9 microsatellite loci. We compared their genetic similarities with several dozen landscape resistance hypotheses. The landscape resistance hypotheses describe a range of potential relationships between movement cost and landcover, slope, elevation, roads, Euclidean distance and a putative movement barrier. These hypotheses were divided into several organizational models.

The degree of support for each model was tested with causal modeling on resemblance matrices using partial Mantel tests. Quantifying the relationship between landscape structure and gene flow can give biologists insight into connectivity of populations and metapopulations through space and time. Correlating genetic similarity of individuals across large landscapes with hypothetical movement cost models can give reliable inferences about population connectivity. By linking cost modeling to the actual patterns of genetic similarity among individuals it is possible to obtain rigorous, empirical models describing the relationship between landscape structure and gene flow, and to produce species-specific maps of landscape connectivity.

Corridor network connectedness does not necesseraly enhance biological connectivity: the case of the landscape genetics and pollen flows of *Primula vulgaris* in a hedgerow network landscape

P. Campagne, A. Baumel, L. Affre, P. Roche, T. Tatoni

IMEP, CNRS UMR 6116 (Institut Méditerranéen d'Écologie et de Paléoécologie), Université Paul Cézanne (Aix-Marseille III), Europole méditerranéen de l'Arbois, Bâtiment Villemin, BP 80. F - 13545 Aix-en-Provence cedex 04 FRANCE.
e-mail: pascal.campagne@univ-cezanne.fr

Introduction

Landscape connectivity is generally considered to facilitate gene flow between populations. Hence, highly connected hedgerow networks are often thought to support higher gene flow than disconnected hedgerow networks or open landscapes.
In order to test this hypothesis, we studied gene flow between *Primula vulgaris* populations at the landscape level. This species is restricted to wooded elements (patches and hedgerows) and we considered two contrasted study sites (dense and connected hedgerow networks vs. disconnected, open hedgerow networks).

Material and Methods

We used AFLP markers to study the spatial population genetics and a fluorescent powder as a pollen analogue to study spatial pollen flow. We also examined ant dispersed seed flow.

Results and Discussion

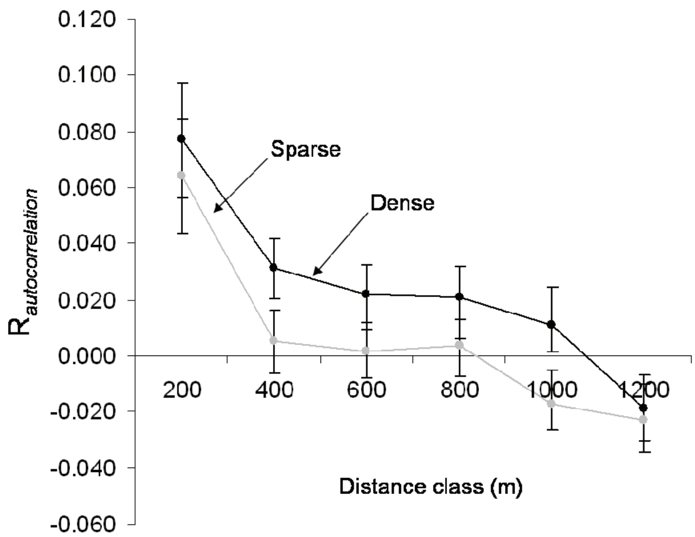


Figure 1. Moran's I_{std} correlograms for AFLP markers in dense and sparse hedgerow networks. Error bars indicate 95% confidence intervals. To simplify, upper distance classes (more than 1200 ml) were excluded from analysis.

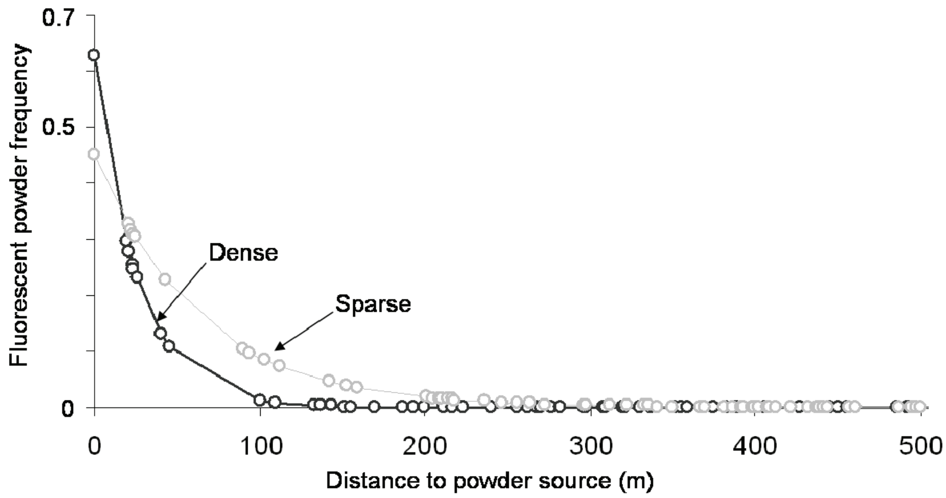


Figure 2. Predicted values for a GLM model (link: logarithm; Quasi-poisson distribution) of fluorescent powder frequency as a function of distance to powder source.

Our results indicated a strong spatial genetic autocorrelation that is significantly more pronounced in the dense and connected hedgerow networks than in the open and disconnected ones up to 400 m (Figure 1). This means that for a given distance, two individuals are more similar in the open landscape than in the dense connected landscape. Seed dispersal by ants is very short scale (about few metres), while pollen flow estimated by pollen dye analogues appeared to occur up to 400 m. When considering the decay of fluorescent dye frequency with distance from sources, it appears that pollen analogues are dispersed to significantly longer distances in the open and disconnected landscape (Figure 2; Table 1).

Table 1. Parameter estimation by the GLM model (link: logarithm; Quasi-poisson distribution) of fluorescent powder frequency as a function of distance to powder source.

	Estimate	Std Error	t value	p value
Intercept	2.75	0.078	35.03	< 0.001
Distance	-0.04	0.005	-8.03	< 0.001
Type of network (Sparse)	-0.33	0.113	-2.87	< 0.01
Interaction	0.02	0.005	4.48	< 0.001

These results lead us to conclude that while landscapes with dense and connected hedgerow networks offer a continuous distribution of suitable habitat for *Primula vulgaris*, in the mean time it leads restricted gene flow, mainly through reduced pollen dispersal.

A comparison of current methods for linking genetic variation to landscape heterogeneity using simulated data.

N. Balkenhol, L. P. Waits

University of Idaho, Department of Fish & Wildlife Resources, Moscow, ID, , USA.
e-mail: nbalkenhol@uidaho.edu

Introduction

The goal of landscape genetics is to describe and explain how landscape attributes affect genetic variation of plant and animal populations. Various statistical methods for linking genetic information to landscape data exist, and many of them are described in Manel *et al.* (2003) and Storfer *et al.* (2006). There are, however, very few published studies that test the utility of different approaches, or compare them under realistic scenarios. Due to the rapid rate of analytical development, no consensus exists on the best approach for relating genetic variation to landscape attributes. Although it is unclear whether current statistical methods produce comparable and repeatable results, a large number of researchers have applied these methods to a variety of research questions in molecular ecology and conservation biology (Holderegger and Wagner, 2006; Storfer *et al.*, 2006).

To evaluate the performance of different methods, we analyzed simulated data with known landscape genetic relationships using eight of the most commonly used statistical approaches in landscape genetics. This simulation study represents the first rigorous comparison of the multitude of current approaches in landscape genetics.

Methods

Landscape genetic simulations

We identified and simulated six landscape genetic scenarios commonly encountered in empirical datasets. These scenarios include:

1. *Isolation-By-Distance (IBD).* In this scenario, spatial (i.e., Euclidean) separation distance influences genetic differentiation among populations.
2. *Landscape resistance (LR).* In this scenario, the landscape matrix shows varying degrees of movement resistance, thereby influencing gene flow and genetic differentiation among populations.
3. *IBD and LR*. A combination of spatial separation distance and matrix resistance influences population genetic differentiation.
4. *Habitat relationships*. Genetic differentiation is influenced by habitat dependent dispersal, leading to greater gene flow within than between habitat types.
5. *Barrier.* Genetic differentiation among populations is influenced by one or more (linear) barriers to movement.
6. *Panmixia.* Genetic differentiation is not influenced by space or landscape attributes.

The different scenarios were simulated using a combination of Easypop (Balloux, 2002) and ArcGIS (ESRI, 2005). We first simulated the spatial distribution of populations and the landscape factors influencing genetic differentiation in the GIS. We then used this spatially explicit data for the genetic simulations in Easypop. A set of control criteria was calculated for each simulation, to verify that the desired landscape-genetic relationships were successfully simulated. All landscape scenarios and the population genetic data were simulated multiple times with varying configurations, so that valid conclusions could be drawn from the analyses.

Compared statistical approaches

The simulated data were analyzed with different statistical approaches that can be used to link genetic information to landscape attributes. These approaches include Mantel tests (Mantel, 1967), RELATE (Clarke and Warwick, 2001), partial Mantel tests (Smouse *et al.*, 1986), multiple matrix regression (Legendre *et al.*, 1994), BIOENV (Clarke and Ainsworth, 1993), a hierarchical Bayesian approach (Foll and Gaggiotti, 2006), distance-based redundancy analysis (dbRDA; Legendre and Anderson, 1999), and canonical correlation analysis (CCA; ter Braak, 1986).

We used these statistical approaches to test different landscape genetic hypotheses that correspond to the simulated scenarios. We then compared results obtained with the different methods, and the conclusions that researchers would draw from them, using a causal modeling framework.

Results & Discussion

Our results suggest that the different approaches do not always identify the same landscape factors as having an effect on genetic differentiation, even under relatively simple scenarios. This could potentially lead to erroneous conclusions about landscape genetic relationships, if only a single method is used for the analysis. We therefore recommend that several methods should be applied to a given empirical data set, and that the statistical approaches should carefully be matched to the ecological hypotheses tested. The results will help scientists choose appropriate methods for particular research questions and data. Our analyses are also useful for teaching landscape genetics, and can help to identify further research needs in this young field.

References

Balloux, F. (2002) *EasyPop version 1.8: A software for population genetics simulations.* I.C.A.P.B. (Institute of Cell, Animal and Population Biology), University of Edinburgh, Edinburgh, Scotland UK.

Clarke, K. & Ainsworth, M. (1993) A method of linking multivariate community structure to environmental variables. *Marine Ecology Progress Series* **92:** 205-219.

Clarke, K. & Warwick, R. (2001) *Change in marine communities: an approach to statistical analysis and interpretation, 2nd edition*. PRIMER-E, Plymouth.

ESRI (2005) *ArcGIS - ArcInfo*. Environmental Systems Research Institute, Inc.

Foll, M. & Gaggiotti, O.E. (2006) Identifying the environmental factors that determine the genetic structure of populations. *Genetics* **174:** 875-891.

Holderegger, R. & Wagner, H.H. (2006) A brief guide to Landscape Genetics. *Landscape Ecology* **21:** 793-796.

Legendre, P. & Anderson, M.J. (1999) Distance-based redundancy analysis: Testing multispecies responses in multifactorial ecological experiments. *Ecological Monographs* **69:** 1-24.

Legendre, P; Lapointe, F.-J. & Casgrain, P. (1994) Modeling brain evolution from behavior: A permutational regression approach. *Evolution* **48:** 1487-1499.

Mantel, N. (1967) The detection of disease clustering and a generalized regression approach. *Cancer Research* **27:** 209-220.

Smouse, P.E; Long, J.C. & Sokal, R.R. (1986) Multiple regression and correlation extensions of the Mantel test of matrix correspondence. *Systematic Zoology* **35:** 627-632.

Storfer, A; Murphy, M. A; Evans, J. S; Goldberg, C. S; Robinson, S. J; Spear, S. F; Dezzani, R; Delmelle, E; Vierling, L. & Waits, L. (2006) Putting the “Landscape” in Landscape Genetics. *Heredity* advance online publication 1 November.

ter Braak, C. (1986) Canonical Correspondence Analysis: A new eigenvector Technique for multivariate direct gradient analysis. *Ecology* **67:** 1167-1179.

3.3 Symposium 16: Animals on thermal landscapes

Global climate model data for the Predictive Modeling in Seascapes: Pelagic Seabird-Habitat associations revisited

F. Huettmann[1]

[1] EWHALE lab, Institute of Arctic Biology, Biology and Wildlife Department, University of Fairbanks-Alaska, Fairbanks Alaska 99775 USA.
e-mail: fffh@uaf.edu

Introduction

Seabirds occur on all oceans; they are among the most abundant bird species in the world. Besides many well-known breeding populations on colonies, the majority of birds is actually found at sea where they spend by far most of their lives (Schreiber & Burger 2002; Gaston 2004). Most habitat associations of pelagic seabirds are poorly known, and often vaguely described quantitatively and without confidence as being 'associated' with prey patches, shelf-edges, and proximity to colonies. Much confusion on seabird-habitat characteristics stems from soft or inappropriate concepts to describe seabird-habitat associations (Jones 2001; Gottschalk *et al*. 2005 for review), and from ignoring scale (Huettman and Diamond 2006 for review and application). Often, such studies are done directly on variables measured in the field ('*in situ*') using an opportunistic small scale study design, rather than using generalized and well-assessed data, or ones collected that address specific questions with the goal that findings should be generally applicable (Aebischer & Robertson 1993; Braun 2005). Many of such investigations deal with prey and space, but ignored the importance of temperature layers.

Based on six intensive seabird-habitat models, here I investigate whether the online publication of climate data like the World Ocean Atlas (WOA Levitus 1994: namely air, sea surface SST and water body temperature) provided for a major change in our knowledge of seabird habitat.

Methods

The models assessed here used besides WOA additional ocean climate datasets such as COADS (e.g. air pressure) or the NSCAT instrument (e.g. wind speed and wave height). The analysis of the climate layers was done by the author and colleagues in concert with traditional habitat descriptors using progressive modelling software tools (GLM, Mixed Models, CART, MARS, TreeNet and Ecological Niche Modeling) applied in the North Atlantic and Gulf of Maine (>15 seabird species), Falkland Islands (Black-footed Albatross), coastal British Columbia (Marbled Murrelet) and Bering Sea (Short-tailed Albatross) (Huettmann & Diamond 2001, Yen *et al.* 2004, Pittmann & Huettmann 2006, Huettmann et al. unpublished for Albatross)). These studies were then analysed for providing progress in our understanding of seabird-habitat relationships by ranking climate layers vs. traditional habitat predictors.

Results

Results suggest that 'Seascape Ecology' offers large opportunities for study (see also Huettmann & Diamond 2006), especially when climate layers are incorporated. In many instances, climate layers are driving the large-scale seabird distribution by forming entire ecosystems with a specific species set-up. However, other than plain correlations, it is currently not well addressed how SST exactly links with air and waterbody temperatures. Virtually all concepts from Landscape Ecology and terrestrial wildlife can be applied to seabirds and how they use seascapes. The advent of climate layers has also added a new dimension to seabird-habitat studies and relationships. The fact that these climate layers are provided online and for free has created a global role model for data delivery in general (e.g. www.worldclim.org).

Discussion

Results indicate that seabird habitat preferences are robust in space when implementing general at-sea weather patterns. Climate drives much of the species set-up in an ecosystem. Specific climate-related topics such as the 'tail wind' hypothesis or the value of using Di-Methyl Sulfid (DMS; a plankton-based climate-change aerosol affiliated with clouds) are not used to their full potential, yet. It is obvious that SST affects predatory performance through 'energy' questions, e.g. burst speed of the prey, and thus affects the large-scale distribution of seabirds (Cairns *et al.* in review, Newton 2003). Therefore, the current global warming trend will change seabird communities drastically, specifically in high latitudes (Schreiber & Burger 2002). This will add further to a stressed ocean environment (Myers & Worms 2003) and requires careful consideration for the sustainable management of seabirds and their seascape habitats (Nettleship 1991).

References

Aebischer, N. and Robertson P.A. (1993) Testing for Resource Use and Selection by Marine Birds: A Comment. *Journal of Field Ornithology* 65: 210-213.

Braun, C. E. (2005) Techniques for Wildlife Investigations and Management. The Wildlife Society (TWS), Bethesda, Maryland USA.

Cairns, A. J., Gaston, T. & Huettmann, F. (in review) Endothermy, Ectothermy, and the Global Structure of Marine Vertebrate Communities. *Marine Ecology Progress Series*

Gaston, A.J. (2004) Seabirds: A Natural History. Yale University Press, London.

Gottschalk, T., Huettmann, F. & Ehlers, M. (2005) Thirty years of analysing and modelling avian habitat relationships using satellite imagery data: a review. *International Journal of Remote Sensing* 26: 2631-2656.

Huettmann, F. & Diamond, A.W. (2006) Large-scale effects on the spatial distribution of seabirds in the Northwest Atlantic. *Landscape Ecology* 21: 1089-1108.

Huettmann, F. & Diamond, A.W. (2001) Seabird colony locations and Environmental determination of seabird distribution: A spatially explicit seabird breeding model in the Northwest Atlantic. *Ecological Modelling* 141: 261-298.

Jones, J. (2001) Habitat Selection Studies in Avian Ecology: A Critical Review. *Auk* 118:557-562

Levitus S.(1994) World Ocean Atlas 1994, 4 volumes, Washington, D.C., National Oceanic and Atmospheric Administration, National Oceanographical Data Center.

Myers, R.A. & Worm. B. (2003) Rapid worldwide depletion of predatory fish communities**.** *Nature* 423: 280-283.

Newton, I. (2003) The Speciation & Biogeography of Birds. Academic Press, London

Nettleship, D.N. (1991) Seabird management and future research. *Colonial Waterbirds* 14:77-84.

Pittmann, S. & Huettmann, F. (2006). Chapter 4 - Seabird Distribution and Diversity. *In: An Ecological Characterization of the Stellwagen Bank National Marine Sanctuary Region*: Oceanographic, Biogeographic, and Contaminants Assessment. Battista, T., R. Clark, S. Pittmann (eds). NOAA Technical Memorandum NCCOS 45. Silver Springs, MD.

Schreiber, E.A. & Burger, J. (eds). (2002) Biology of Marine Birds. CRC Marine Biology Series (P.L.Lutz, ed.) CRC Press, Washington D.C.

Yen, P., Huettmann, F. & Cooke, F. (2004). Modelling abundance and distribution of Marbled Murrelets (*Brachyramphus marmoratus*) using GIS, marine data and advanced multivariate statistics. *Ecological Modelling* 171: 395-413.

Amphibian physiology and landscape permeability: Modeling thermal landscapes to predict amphibian movements

P.E. Bartelt[1], R.W. Klaver[2], W.P. Porter[3], D.S. Pilliod[4], C.R. Peterson[5], A.L. Gallant[2]

[1]Department of Biology, Waldorf College, Forest City, IA 50436 USA.
e-mail: barteltp@waldorf.edu
[2]U.S. Geological Survey, Center for Earth Resources Observation and Science (EROS), Sioux Falls, SD 57198 USA
[3]Department of Zoology, University of Wisconsin, Madison, WI 53706 USA.
[4]U.S. Geological Survey, Snake River Field Station, Boise, ID USA.
[5]Herpetology Laboratory, Department of Biological Sciences, Idaho State University, Pocatello,ID 83209 USA.

Introduction

Calculating estimates of landscape permeability can be an effective way of understanding patterns of distribution and movements of animals across landscapes (Ray *et al*., 2002; Chardon *et al*. 2003). Amphibians require resources that often are dispersed across a landscape. For example, breeding ponds, foraging areas, and hibernacula may be separated by distances of kilometers. Costs associated with overland movements can affect the persistence of amphibian populations and help explain metapopulation dynamics (Funk *et al*., 2005). We used thermal and moisture landscapes and cost-surface analysis to model amphibian movement corridors through terrestrial habitats. Because amphibians are closely coupled with their physical environment, the costs of amphibians' overland movements reflect their ability to conserve body water while moving through suitable thermal gradients. Land use patterns that alter habitat structure can increase the costs of overland movements for amphibians, which can contribute to population declines.

Methods

Terrestrial habitats were modeled with first principles models of microclimate, heat and mass transfer, and amphibian physiology (Porter and Mitchell 2003). Spatial input for these models included topographic data, spatially interpolated meteorological data, and maps of vegetation cover types and density. We parameterized the models with measures of animal morphology and physiology, such as preferred core body temperatures and tolerance of dehydration. Model outputs included animal core body temperature, rates of evaporation, and discretionary energy. Using a cost-path function, we produced maps of least-cost paths and corridors of accumulated costs between source and destination habitat patches. These paths and corridors are measures of landscape permeability. We also produced sets of random paths and straight line paths to test the hypothesis that actual paths used by amphibians were less costly than random and straight line paths between the same source and destination habitats.

Results & Discussion

We applied this analysis to populations of Western toads (*Bufo boreas*) and Columbia spotted frogs (*Rana luteiventris*), both of which inhabit forested landscapes in Idaho, USA. We used our results to map movement corridors that reflected actual paths of telemetered individuals. Initial analyses showed that actual paths fell within some of the least costly movement corridors and avoided high-cost areas. However, total average accumulated costs for six female toads showed that actual paths were about 50% more costly than least-cost paths and were not significantly different from the cost of straight-line paths. In a previous study, these toads were highly terrestrial, active during the day (e.g., foraging), and they selected habitats that increased their ability to maintain warm body temperatures. For example, shrub habitats with little canopy cover had the warmest and most humid conditions among habitats used by toads (Bartelt, 2000) and had the highest selection measures (Bartelt *et al.*, 2004). However, the toads traveled primarily at night (when humidity was high) and this may help explain why costs of actual paths were not closer to that of least-cost paths. Oriented random paths were about twice as costly as actual paths, although some of these differences may be a function of the parameters set for random paths. Therefore, the applicability of this modeling approach may not fully explain amphibian movement corridors, but the approach still has value for modeling habitats suitable for retreat and daily activities. Analysis of similar data for spotted frogs continues at the time of this writing.

Several studies provide evidence that certain land cover changes – e.g., forest harvests (deMaynadier and Hunter, 1998) and habitat fragmentation (Funk *et al*., 2005) – can affect the distribution and movements of amphibians. Because global climate change also would alter microclimates among habitats, it, too, may affect amphibian populations. Refining this approach to modeling amphibian terrestrial habitats may help us better understand these relationships and minimize disruption to movement corridors, thereby improving amphibian conservation.

References

Bartelt, P.E. 2000. A biophysical analysis of habitat selection in Western toads (*Bufo boreas*) in southeastern Idaho. Ph.D. Dissertation. Idaho State University. Pocatello, Idaho.

Bartelt, P.E., C.R. Peterson, and R.W. Klaver. 2004. Sexual differences in the post-breeding movements and habitats selected by Western toads (*Bufo boreas*) in southeastern Idaho. *Herpetologica* **60**: 455-467.

Chardon, J.P., F. Adriaensen, E. Matthysen. 2003. Incorporating landscape elements into a connectivity measure: a case study for the Speckled wood butterfly (*Pararge aegeria* L.). *Landscape Ecology* **18**: 561-573.

deMaynadier, P.G. and M.L. Hunter, Jr. 1998. Effects of silvicultural edges on the distribution and abundance of amphibians in Maine. *Conservation Biology* **12**: 340-352.

Funk, W.C., A.E. Greene, P.S. Corn, F.W. Allendorf. 2005. High dispersal in a frog species suggests that it is vulnerable to habitat fragmentation. *Biological Letters* **1**: 13-16.

Funk, W.C., M.S. Blouin, P.S. Corn, B.A. Maxell, D.S. Pilliod, S. Amish, F.W. Allendorf. 2005. Population structure of Columbia spotted frogs (*Rana luteiventris*) is strongly affected by the landscape. *Molecular Ecology* **14**: 483-496.

Porter, W.P. and J.W. Mitchell. 2003. Method and system for calculating the spatial-temporal effects of climate and other environmental conditions on animals. US 2003/0040895 A1 U.S. Patent Office. Washington, D.C.

Ray, N., A. Lehmann, and P. Joly. 2002. Modeling spatial distribution of amphibian populations: a GIS approach based on habitat matrix permeability. *Biodiversity and Conservation* **11**: 2143-2165.

Thermal heterogeneity and river fish distribution in a groundwater-influenced high desert landscape

C.E. Torgersen [1], D.S. Bateman [2], D.P. Hockman-Wert [3], M.D. McSwain [4], R.E. Gresswell [5]

[1] USGS FRESC, University of Washington, College of Forest Resources
Box 352100, Seattle, WA 98195 USA.
e-mail: ctorgersen@usgs.gov
[2] Oregon State University, Department of Forest Science, Corvallis, OR 97331 USA.
[3] USGS FRESC, 3200 SW Jefferson Way, Corvallis, OR 97331 USA.
[4] BLM, Prineville District Office, 3050 NE Third, OR 97754 USA.
[5] USGS NRMSC, Montana State University, Bozeman, Montana 59717 USA.

Introduction

The Lower Crooked River is a remarkable groundwater-fed stream flowing through vertical basalt canyons in the Deschutes River Valley in central Oregon. The 15-km section of the river between the Crooked River National Grasslands boundary near Ogden Wayside and river km (RKM) 13 is protected under the National Wild and Scenic Rivers Act (16 U.S.C. 1271-1287) for its outstandingly remarkable scenic, recreational, geologic, hydrologic, wildlife, and botanical values (ORVs), and significant fishery and cultural values. Groundwater springs flow directly out of the canyon walls into the Lower Crooked River and create a unique hydrologic setting for native coldwater fish, such as inland Columbia Basin redband trout (*Oncorhynchus mykiss gairdneri*). To protect and enhance the ORVs that are the basis for the wild and scenic designation, the Bureau of Land Management (BLM) has identified the need to evaluate, among other conditions, fish presence and habitat use of the Lower Crooked River. The results of this and other studies will provide a scientific basis for communication and cooperation between the BLM, Oregon Water Resources Department, Oregon Department of Fish and Wildlife, and all water users within the basin. These biological studies initiated by the BLM in the region reflect a growing national awareness of the impacts of agricultural and municipal water use on the integrity of freshwater ecosystems.

The goal of this project was to examine spatial patterns in fish assemblages, aquatic habitat, and water temperature in the Lower Crooked River during summer conditions. Specific objectives were to (1) characterize the spatial distribution of native and non-native fishes, (2) describe variation in channel morphology, substrate composition, and water temperature, and (3) evaluate the associations between fishes, aquatic habitat, and water temperature.

Methods

The survey of fishes and aquatic habitat in 19 km of the Lower Crooked River was completed on July 29 - August 3, 2004. Fish and aquatic habitat sampling was conducted from RKM 13 to 32. Visual assessments of fishes were conducted with mask and snorkel by a two-person crew. The snorkelers conducted the survey in a downstream direction but surveyed fishes in individual channel units (pools, glides, riffles, and rapids) in an upstream direction. Fish were identified and counted in either the entire channel unit, or in a portion of the channel unit, depending on the length of the unit. Units longer than 100 m were sampled for fish only in the upper portion of the unit. Variation in stream temperature was assessed at six spatially dispersed locations in the Lower Crooked River. Spatially continuous longitudinal patterns of stream temperature were evaluated using forward-looking infrared (FLIR) remote sensing (Torgersen *et al*. 2001).

Results and discussion

Stream temperature and water quality parameters changed dramatically in a downstream direction in the Lower Crooked River. Longitudinal patterns in stream temperature indicated substantial cooling from groundwater inputs in a downstream direction. The distribution of fishes was marked by an upstream–downstream gradient dominated by salmonids in downstream reaches and cyprinids in upstream reaches. Spatial patterns in the distribution of pools, glides, riffles, and rapids were highly variable among the electrofishing/angling sites, as revealed by the spatially continuous survey of aquatic habitat conducted by snorkelers. Changes in water temperature and turbidity corresponded with distinct spatial structuring of fish assemblages in the Lower Crooked River. In only 18 km, the river transformed from a warm, turbid cyprinid stream to a clear, cold trout river. Longitudinal patterns in fish distribution, aquatic habitat, and water temperature suggested that temperature and, potentially, turbidity were the primary physical drivers of fish assemblage structure in the Lower Crooked River.

The unique groundwater-influenced thermal landscape of the Lower Crooked River created an environment in which coldwater fish (salmonids and cottids) were distributed among species that typically characterize a coolwater fish assemblage (cyprinids and catostomids). Fishes in the Lower Crooked River exhibited thermal preferences that were generally similar to those described in the literature for Pacific Northwest fish assemblages (Zaroban *et al*. 1999). However, some species exhibited anomalous distribution patterns with respect to their thermal preferences described in the literature. High water temperatures have a significant influence on salmonid behavior and growth in high desert streams (Li *et al*. 1994). Several species of coldwater fishes have been shown to behaviorally thermoregulate by locating thermal refugia several degrees cooler than ambient water temperatures (Torgersen *et al*. 1999, Ebersole *et al*. 2003). Spatial heterogeneity in water temperature is particularly pronounced in the Lower Crooked River due to groundwater inputs and may provide multi-scale thermal refugia important for the existence of coldwater fishes such as rainbow trout, mountain whitefish, and sculpins

References

Ebersole, J.L; Liss, W.J. & Frissell, C.A. (2003) Thermal Heterogeneity, stream channel morphology, and salmonid abundance in northeastern Oregon streams. *Canadian Journal of Fisheries and Aquatic Sciences* **60**: 1266-1280.

Torgersen, C.E; Price, D.M; Li, H.W. & McIntosh, B.A. (1999) Multiscale thermal refugia and stream habitat associations of chinook salmon in northeastern Oregon. *Ecological Applications* **9**: 301-319.

Li, H.W; Lamberti, G.A; Pearsons, T.N; Tait, C.K. & Buckhouse, J.C. (1994) Cumulative effects of riparian disturbances along high desert trout streams of the John Day Basin, Oregon. *Transactions of the American Fisheries Society* **123**: 627-640.

Zaroban, D; Mulvey, M; Maret, T; Hughes, R. & Merritt, G. (1999) Classification of species attributes for Pacific Northwest freshwater fishes. *Northwest Science* **73**: 81-93.

Torgersen, C.E; Faux, R.N; McIntosh, B.A; Poage, N.J. & Norton, D.J. (2001) Airborne thermal remote sensing for water temperature assessment in rivers and streams. *Remote Sensing of Environment* **76**: 386-398.

The role of thermal landscapes in resource selection by black-tailed deer

J. G. Kie, R. T. Bowyer

Department of Biological Sciences, Idaho State University, Pocatello, ID 83209-8007 USA
e-mail: kiejohn@isu.edu

Introduction

An important question in ecological studies of large mammals is to what degree and in what manner do thermoregulatory constraints influence habitat selection individuals (Parker and Gillingham 1990)? Animal response undoubtedly varies among different populations across broad geographic areas and likely depends on pelage resistances, degree of acclimation, and other factors (Mysterud and Østbye 1999). To illustrate this question, we studied habitat use by black-tailed deer (*Odocoileus hemionus columbianus*) on winter range in northern California, USA. Vegetation types used by deer included open woodland-grassland savannas, deciduous woodlands, and dense thickets of live oak (*Quercus wislizenii*) cover. The climate was Mediterranean, with temperatures rarely dropping below freezing.

Methods and results

During warm, sunny days, temperatures from black-body devices were higher than ambient air temperatures in habitats other than live oak, but were closer to ambient temperatures in dense live-oak cover (Fig. 1). Deer were more likely to occur in or near ($\leq$ 150 m) live oak than were random locations, spending 80% of their time in or near live oak during day and 70% of their time in that habitat at night. Deer were more likely to occur in or near live oak when weather was warm, dry, sunny, and calm.

The most parsimonious logistic regression model for whether deer would occur in or near live oak was based on the interaction between wind speed and relative humidity (AIC = 283), which had an 18% probability of being the best model (AIC weight, w_i = 0.18). Five other models, however, could not be distinguished from the best model based on the criterion ΔAIC $\leq$ 2 (Table 1).

We formulated a resource selection function (RSF) using conditional logistic regression, blocking by individuals, to distinguish between deer locations and random points based on whether the point was in or near live-oak cover. The RSF was significant (P = 0.004), and indicated that a point in or near live-oak cover was more likely to be a deer location than a random point.

We then calculated similar RSFs after splitting the data into 2 subsets: calm, where wind speed was $\leq$ the median value, and windy, where wind speed was > the median value. When it was windy, habitat was not a significant predictor of deer locations versus random points (P > 0.05). When it was calm, not only was habitat was a significant predictor (P = 0.035), but the model preformed substantially better than did the model for all wind conditions based on AIC scores. We concluded that black-tailed deer in winter pelage were using live-oak thickets to ameliorate heat gain on calm, sunny days with low humidity, although recognizing that other factors such as risk of predation may play a role as well.

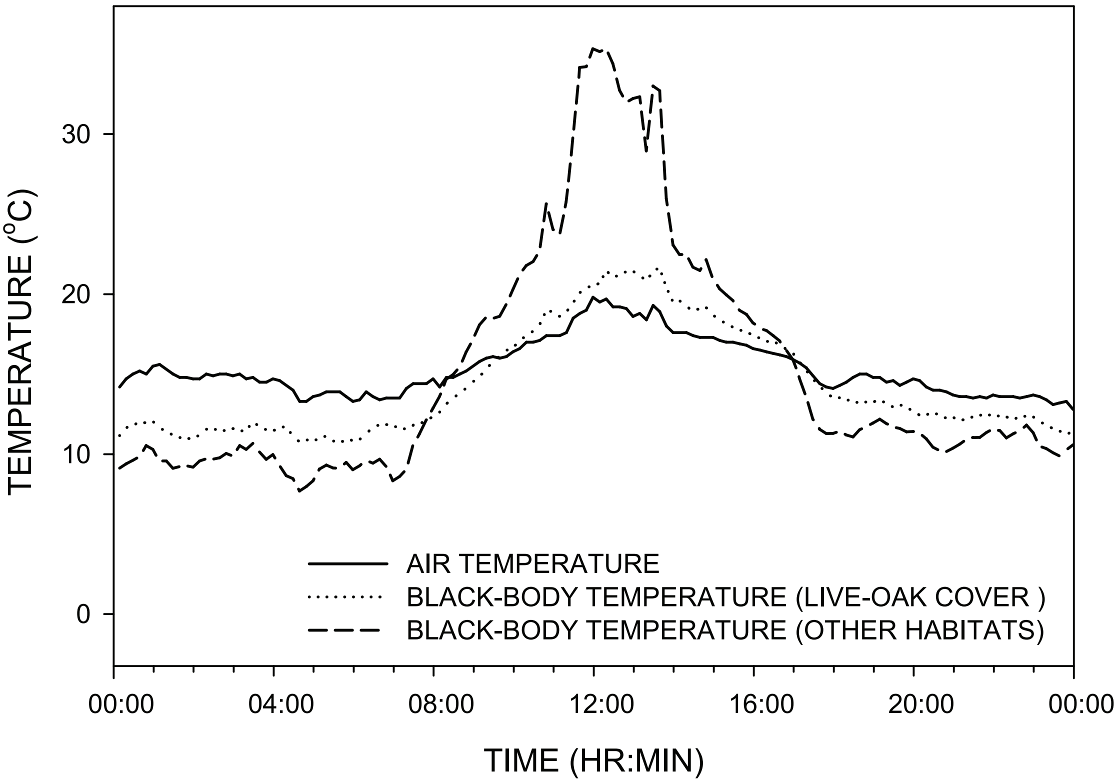


Figure 1. Comparison of air temperature and thermocouple temperatures inside black-bodies placed in live-oak cover and non-cover habitats on a representative sunny day (15 February 1991).

Table 1. Best 6 of 22 different logistic regression models distinguishing deer locations in or near live oak cover versus other habitats, ranked by AIC values and AIC weights (w_i). Variables were: Air (air temperature, 0^C), Rh (relative humidity, %), Solar (solar radiation, watts * m^{-2}), and Wspeed (wind speed, m * min^{-1}). These 6 models were indistinguishable based on the criterion ΔAIC < 2. Individual (Id) was forced into each model to account for variability among individual animals.

Model	*AIC*	wi
*Rh*Wspeed Id*	*283.139*	*0.180*
Wspeed Id	*284.274*	*0.131*
Air Id	*285.442*	*0.129*
*Air*Wspeed Rh*Wspeed Id*	*283.781*	*0.111*
*Wspeed Air*Wspeed Id*	*283.810*	*0.102*
*Solar*Wspeed Rh*Wspeed Id*	*284.118*	*0.057*

References

Mysterud, A., & E. Østbye. (1999) Cover as a habitat element for temperate ungulates: effects on habitat selection and demography. Wildlife Society Bulletin **27**:385-394.

Parker, K. L., & M. P. Gillingham. (1990) Estimates of critical thermal environments for mule deer. Journal of Range Management **43**:73-81.

3.4 Open Session 9: Ecological Networks

Assessing functional connectivity by simulating migration areas for amphibians: a tool for conservation management of landscapes

A forest habitat network approach to directing native woodland improvement and expansion on the Argyll islands, Scotland

D G Moseley[1], R Worrell[2], B Black[3], D Ray[1]

[1]Forest Research, Ecology Division, Northern Research Station, Roslin, Midlothian, Scotland, e-mail: darren.moseley@forestry.gsi.gov.uk
[2]Upper park, Aberfeldy, Perthshire, Scotland, PH15 2EH
[3]Argyll Woodlanders, Whin Bank, Lunga Drive, Ardfern, by Lochgiphead, Argyll, Scotland,

Introduction

Many of the native woodlands along the west coast of Scotland are biologically rich in bryophytes, lichens and filmy ferns, owing to the mild oceanic nature of the climate. Yet the resilience of these communities may be threatened by the effects of fragmentation and climate change. The impact of habitat fragmentation and isolation on woodland biodiversity is widely recognised (UK Biodiversity Group, 1995; Peterken, 2002), requiring a range of methods of buffered consolidation, restoration and improvement, and new woodland expansion to deal with habitat decline. This paper describes a study located on the coastal islands of Argyll, Scotland, to provide information on native woodland improvement and expansion opportunities that may increase the functional connectivity of native woodlands, that will not jeopardise open ground habitats and functional networks, and which targets land most suitable for woodland establishment.

Methodology

An assessment was made to identify woodlands with a high biodiversity taking particular account of three areas, 1) the floristic quality of lower plants, 2) the structural diversity of the stands, and 3) a high deadwood component. This methodology allowed the identification of woodland habitats which will provide a source for dispersal into neighbouring habitat, and which must be protected and enlarged by buffered expansion.

A habitat network approach, using a spatial model from Forest Research's suite of tools called "BEETLE" (Biological and Environmental Evaluation Tools for Landscape Ecology) (Watts *et al.* 2005) was used to assess the distribution of native broadleaved woodland habitat patches within the landscape, and predict the dispersal ability of woodland species to other woodland patches through the intervening landscape matrix. Where the woodland patches are sufficiently close to allow dispersal, they are assumed to form a functionally connected network. The model calculates distribution of functional networks comprised of woodland habitat patches, plus parts of the matrix through which woodland species are able to disperse, determined by a permeability weighting profile of the matrix mosaic. This represents a focal species (Lambeck, 1997) approach to model habitat requirements and dispersal abilities of species encountered in different woodland types. In this study a 1000 m maximum dispersal distance was set, representing moderately mobile species, and was reduced according to the matrix permeability, with more modified habitat types having a greater resistance to dispersal.

Results

The approach determined the functional connectivity of existing broadleaved woodlands and indicated possibilities for their improvement, expansion, or linkage, and opportunities for converting coniferous stands to native broadleaved woodland. The model outputs are a series of maps indicating opportunities and constraints:

Opportunities

1. Target management to improve the biodiversity quality of woodlands adjacent to high quality woodland to form larger networks of high biodiversity quality woodland (Table 1).
2. Restore and convert conifer stands to native woodland, where conifers separate patches of broadleaved woodland. This will reduce the isolation of broadleaved woodland and, over time, link patches of woodland within larger networks (Table 1).
3. Expand existing broadleaved woodland by natural regeneration on open ground to link neighbouring woodland patches into a network across the zone extending up to 500 m from the edge of each patch. This represents the area and limit of new woodland establishment by regeneration (the first 50 to 100 m) and planting (beyond 50 to 100 m).
4. Link neighbouring networks by planting new "stepping stone" woodland between patches within existing networks to allow dispersal through the matrix and the new woodland patch.

Table 1. Opportunities for improvement of broadleaved (BL) woodland and conversion of conifer woodland to native broadleaved woodland to reduce broadleaved woodland fragmentation on a selection of the Argyll Islands.

Island	Improvement		Conversion	
	Total area (ha)	% BL woodland area on island	Total area (ha)	% BL woodland area on island
Mull	803	14.6	1915	34.8
Islay	80	3.0	358	11.7
Shuna	60	20.0	0	0.0
Lismore	7	5.0	<0.1	<0.1

Constraints

Land considered unsuitable and excluded from the expansion and linkage opportunities included land with high wind exposure, peat bog, and sites designated for conservation (*e.g.* wetland, geological, and aquatic habitats). Site suitability of remaining land areas would need to be identified through an Ecological Site Classification (Pyatt *et al.*, 2001; Ray, 2001), followed by a site survey.

Discussion

This work has highlighted the opportunities for improving native broadleaved woodland networks on the larger islands, many of which have large established broadleaf and conifer woodlands (Mull and Islay). It has also determined where resources can be targeted to achieve large gains in native broadleaved woodland biodiversity on the smaller islands with smaller areas of woodland (Shuna). The results of the study are now being used in a potential bid for state (Forestry Commission) funding for native broadleaved woodland expansion on the Argyll island and will aid strategies to improve native broadleaved habitat connectivity, helping to address issues of habitat fragmentation and isolation.

References

Lambeck, R. J. (1997) Focal species: a multi-species umbrella for nature conservation. *Conservation Biology,* **11**, pp. 849-856.

Peterken, G.F. (2002) *Reversing the Habitat Fragmentation of British Woodlands.* WWF-UK, Godalming, Surrey.

Pyatt, D. G; Ray, D; & Fletcher, J. (2001) *An Ecological Site Classification for Forestry in Great Britain :Bulletin 124*, Forestry Commission, Edinburgh.

Ray, D. (2001) *Ecological Site Classification Decision Support System V1.7*, Forestry Commission - Edinburgh.

UK Biodiversity Group (1995) *Biodiversity: The UK Steering Group Report - Volume I: Meeting the Rio Challenge (Annex A-E).* English Nature, Peterborough.

Watts, K; Humphrey, J; Griffiths, M; Quine, C. & Ray, D. (2005) *Evaluating Biodiversity in Fragmented Landscapes: Principles.* Information Note 73, Forestry Commission, Edinburgh.

Landscape management approach – vital to conservation in India

P.K. Mathur

Dept. Landscape Level Planning and Management, Wildlife Institute of India,
P.Box # 18, Chandrabani, Dehra Dun – 248 001 (Uttarakhand), India.
e-mail: mathurpk@wii.gov.in

Introduction

India owing to its strategic geographical location at the confluence of three biogeographical realms, varied landforms, and climatic conditions harbors diverse natural ecosystems. Natural areas along with associated rich floral and faunal assemblages make India as one of the 12 mega diversity countries. With just 2.4% land area, >one billion people and >15% world's livestock, India accounts for 7-8% of recorded species and covers 20.6% area under various forests (FSI, 2005). Country has established a network of protected areas (PAs) comprising 94 national parks and 501 wildlife sanctuaries covering 4.7% area (Anon., 2006) and is committed to maintain its natural heritage while pursuing economic development. Wide ranging measures at policy as well as programmatic levels have been adopted those are instrumental in ensuring sustainable livelihoods and conservation of biodiversity. However, PAs amidst human dominated landscapes pose management challenges for wildlife and local communities due to rigid enforcement of wildlife law, small average size, traditional resource dependence and developmental needs. Much of the endangered wildlife (e.g. elephant, lion, tiger) exists outside PAs in the adjacent natural habitats or in human dominated matrix. Local communities often suffer due to prevailing strict PA rules and contentious wildlife damage problems. Landscape approach to planning and management of wildlife resources is being validated. Paper summarizes select pioneering case studies carried out in difficult landscapes across the country and highlights the relevance of this approach to conservation in the context of country's wide array of natural resources, land use, growing demands and developmental needs.

Case studies

Study on the transhumance and silvopastoral dependence in the Great Himalayan National Park Conservation Area (GHNPCA) adopting a landscape level assessment approach found that (a) mountain people rely on the whole landscape for their livelihoods; consequently, policies and institutions for mountain forests and agro-forestry must recognize interactions between agricultural land uses, forests and livestock; (b) every strategy for ensuring that mountain people derive sustainable livelihoods from their forests must be tailor-made for the local physical, biological, cultural and political environment – and ways of responding to change must always be included (Mathur and Mehra, 2005). Exclusion of traditional silvopastoral use in GHNP and subsequent active protection may lead to an overall recovery of forests and pastures. This way, the legal role of a national park would be fulfilled. However, it is difficult to predict how this recovery would affect the overall diversity. Further, the restriction of access to nearly 65% area of GHNPCA is likely to increase livestock pressure on the remaining area and this is expected to accelerate degradation of those remaining silvopastoral resources.

Recent researches and management experience in managing Gir forests, the last surviving wild abode of Asiatic lion (*Panthera leo persica*) amply illustrated that the conservation of last surviving wild population of lion along with the management of newly established meta-populations in the peripheral forests seems to be possible by adopting a regional planning approach on a larger landscape while addressing requirements of local communities and rapid development in the surrounds of Gir.

Findings of a recently concluded major project aimed to address the requirement of managing Indian forests for biological diversity and productivity based on ecological assessments in four pilot conservation areas (CA) that represent priority Indian ecosystems revealed that conservation of biodiversity along with sustainable livelihoods is possible by thinking broadly across major landscape areas i.e. beyond the boundaries of the specific PA or forest areas of interests (Lehmkuhl *et al*., 2006). Think "outside the box" explains that the broad context within which the management area resides that greatly affects conditions within the area and success of management actions. Further, study recommended for considering the spatial or temporal cumulative effects of land use, conditions, and trends within, among, and beyond the boundaries of immediate interests. Study also advocates integrating management plans across administrative boundaries and between forest and wildlife management. Extensive study on vegetation assessment in *Terai* Conservation Area as a part of the project further concluded that the adoption of landscape management approach is critical for maintaining diversity of vegetation in TCA as floral diversity varied considerably in individual constituent areas (PAs and managed forests) and each forest type assessed.

Conclusion

Selected case studies amply illustrate that small PAs neither conserve the entire array of representative biodiversity nor they provide adequate habitat to wide ranging faunal species. It is clear that India is moving towards wildlife and forest conservation at a broader spatial scale and by incorporating more land use conditions than ever before. Better use and focus of concepts of landscape ecology and conservation biology within boundaries of PAs and managed forests, and outside to community, revenue, and other lands are of paramount significance to help ensure protection and restoration of forests and other natural areas in India for future generations.

References

Anonymous (2005) State of Forest Report 2003, Forest Survey of India (Ministry of Environment & Forests), Dehra Dun, pp. 1–134.

Anonymous (2006) India's Third National Report to Convention on Biological Diversity, Executive Summary, Ministry of Environment & Forests, Government of India, New Delhi, pp. 1–21.

Lehmkuhl, J.F.; Mathur, P.K.; Sawarkar, V.B.; Holthousen, R.S.; Marcot, B.G. & Raphael, M.G. (2006) Managing Indian forests for biological diversity and forest productivity. J.A. McNeely, T.M. McCarthy, A. Smith, L. Olsvig-Whittaker & E.D. Wikramanayake (Eds). *Conservation Biology in Asia*, Society for Conservation Biology Asia Section and Resources Himalaya Foundation, Kathmandu, Nepal, pp.92–114.

Mathur, P.K. & Mehra, B.S. (2005) Transhumance and silvopastoral dependence in the Great Himalayan National Park Conservation Area – a landscape level assessment. M.R. Mosquera-Losada, J. McAdam and A. Rigueiro-Rodriguez (Eds). *Silvopastoralism and Sustainable Land Management,* CABI Publishing, Oxfordshire, U.K., pp. 357–358.

Designing a general plan for reserved territories based on landscape cover analysis

M.Y. Puzachenko[1], I.A. Onufrenya[2], D.N. Kozlov[3], Y.G. Puzachenko[1]

[1] A.N. Severtsov Institute of Ecology and Evolution RAS, 119071 RF Moscow, Leninsky prospect 33,
e-mail: puzak@orc.ru
[2] World Wide Fund for Nature, 109240, RF Moscow, Nokoloyamskaya, 19-3
[3] Lomonosov Moscow State University Faculty of Geography, 119899 RF Moscow, Leninskiye Gory 1

The modern concept of territorial forms of nature reservation is based on ecological network, which has its theoretical basis on island biogeography – large "islands" connected with each other by a system of smaller islands of various size which among other play a role of "stones" which overcome areas useless for sustainable survival. IUCN defines an Ecological Network as a coherent system of natural and/or semi-natural landscape elements that is configured and managed with the objective of maintaining or restoring ecological functions as a means to conserve biodiversity while also providing appropriate opportunities for the sustainable use of natural resources (IUCN & Syzygy, 2005).

In accordance with existing perceptions Econet includes the following structural parts: 1) core areas, which conserve general biodiversity in natural landscapes, 2) corridors or stepping stones which allow species to disseminate and migrate between core areas, decreasing isolation and improving connectedness of natural systems, 3) recovery territories, usually close to core areas, which extend core area network to optimal size, 4) buffer zones protecting network from potential negative influence and permitting all types of activities not contradicting with biological diversity conservation aims. Evidently, the main idea on which this construction bases needs hierarchical organization of network. Three levels of eco-network hierarchical organization are: 1) objects of international and national significance, 2) national and regional level and 3) local level. According to general aims and criteria Econet is component of approach to sustainable development organization on the basis of landscape planning and management. Operational criteria for selection of all four types of Econet are very diverse and determined by: geographic conditions, history of region economy development, how fully a region is studied, availability of scientific staff, which can realize wide range of work for specific projects and funding possibilities. When solving this task for Russia and CIS countries, we have to consider certain difficulties.

The approach developed uses the following criteria: 1) landscape cover as a multiple landscapes reflection is organized hierarchically and this hierarchy should naturally be reflected in Econet, 2) on any hierarchical level, species biodiversity is a function of spatial diversity of ecosystem types and their territorial combinations, 3) due to fractal properties and hierarchy the relatively homogenous complexes of ecosystems exist on any level and they coincide with areas of ecological optimum for most of habiting species, 4) global geodynamics determines structures at different scale which generate quasi-linear forms with ecosystems that may differ from their surroundings and are usually expressed by relief and by remote sensing data. They form a network of natural corridor ecosystems. The crosses of corridors are "nodes" which are characterized by maximum diversity of landscapes (we should state here that most cities are situated in such "nodes").

These criteria, basing on the theory of landscape and landscape ecology allow the development of a system of measurement that enables us to select quantitatively functional elements of Econet and to assess their potential quality.

Hierarchical levels of organization were extracted using 2-dimensional Fourier spectral analysis of digital elevation model and satellite imagery bands. Basing on classified multispectral remote imagery (SPOT, VEG2000, GeoCover, MODIS) we develop maps of ecotope types. Usually it is possible to determine their physical meaning but in is not necessary in general case. In all cases, natural ecosystems within specific climatic conditions are characterized by the ultimate absorption of solar radiation or by specific absorption spectrum. Such classifications can be used to assess landscape diversity with implementation of various metrics (diversity, evenness, fragmentation, number of borders, fractal dimension etc.). Each of these metrics reflects landscape spatial structure various aspects which have different functional meaning. At the same time, many of them correlate with each other. Leaving aside methods of their integration we should note that each hierarchical level of organization contains ecosystems with various potential landscapes diversity and with various functional values. Further, using special procedure we can outline linear elements (potential corridors) and nodes. The status of nodes can be determined by the number of linear elements which form them. Integration of measured properties of spatial structures including territories of potential reservation and linear systems allows the design of a general scheme. Further, individual analysis of each potential object is processed and descripted. Proposed technology has been applied in designing general Econet scheme for Southern Siberia Mountains, south of Eastern Siberia, south of Far East, South Urals, Yakutia, North Caucasian region, vast Asia region, including all CIS countries. Detailed description can be found in paper about Yakutia Econet (Puzachenko, 2004, 2005).

When estimating the efficiency of the practical use of developed technology we can say that on the first stage technology and its results evokes a more or less negative reaction. After, the work begins and the study becomes progressively more useful and leads to a design stage. Finally, this experience demonstrates wide possibilities in landscape planning because of designing on the basis of remote sensing information, digital elevation models and field data. Algorithms of relief and remote sensing information were realized in programs made by Gleb Aleschenko. The research is made with support of WWF grants.

References

Puzachenko Yu.G., Puzachenko M.Yu., Onufrenya I.A., Alishenko G.M. (2004) Elaboration of scheme of protected area distribution on the basis of the remote information (by the example of Yakutia). *Geography and natural resources, №1, pp. 10-24.*

Puzachenko M., Puzachenko Yu., Kozlov D., Krever V., Onufrenya I., Alishenko G. (2005) Use of the SPOT VGT-S10 product to discriminate and evaluate ecosystems for ecological aptness and for the design of an ecological network. *Proceedings of the Second International VEGETATION User Conference, European Communities. pp. 439-449.*

IUCN & Syzygy (2005) *Ecological network.* from: http://iucn-ce.org/ecological-networks/GLOBALECONETCD

3.5 Open Session 10: Landscape modelling and population ecology

Absent or non-detected? an application of occupancy models in fragmented landscapes

A. Mortelliti, L. Boitani ,

University of Rome "La Sapienza", Department of Animal and Human Biology – Viale dell'Università 32, 00185, Rome, Italy.
e-mail: alessio.mortelliti@uniroma1.it

Introduction

Research focusing on species distribution (e.g. metapopulation dynamics) often deals with presence/absence data. Whilst presence is easy to confirm, species absence rather than non-detection is problematic, since detection probability – the probability of detecting at least one individual of the species on a particular sampling occasion - is often less than one. These issues have received growing attention, a major contribution was brought by Mackenzie (2002, 2003) who incorporated detection history into a maximum likelihood estimation model, permitting researchers to model detection probability and proportion of sites occupied as a function of site/sampling covariates. We applied these models on data collected during a survey on the distribution of Insectivores, Carnivores and Rodents in a fragmented landscape in the Province of Siena, central Italy.

Our objective is to determine a sampling protocol to infer species absence in a site (woodland patch). We begin by modeling detection probability and an estimate of the proportion of sites occupied as a function of site characteristics, time or environmental variables. Once we determine detection probability we calculate the sampling effort, required to infer a species' absence. We will here show results concerning three species Bank vole (*Myodes glareolus*), Red squirrel (*Sciurus vulgaris*) and Beech marten (*Martes foina*).

Materials and Methods

Rodents were livetrapped using Sherman traps transects, with number of transects proportional to patch size. Carnivores distribution was studied combining various techniques: scent station surveys, track and camera trap surveys and interviews with local people. Baited hair tubes were used to determine red squirrel distribution (number of tubes proportional to patch size).

We ran analyses using program PRESENCE (available for download at http: // www.mbr-pwrc.usgov/software.html), utilising multiple season and single season models, including covariate effects. For each species we defined a set of a priori models with varying covariates that could explain the patterns of patch occupancy. Models were first ranked according to AICc values. A multimodel inference approach was followed to account for model selection uncertainty, thus model averaging was used to estimate parameters (Burnham & Anderson, 2002). Values of detection probability were converted into an estimate of sample size (number of repeated visits) using the formula proposed by Reed (1996): $N = ln\ (\alpha\ level\ /\ ln\ (1 - p)$. α was fixed at 0.05 and p being detection probability. Reported values refer to our sampling effort, so are not meant to be generalised.

Results and Discussion

Terrestrial rodents

Myodes glareolus showed a seasonal variation in detection probability (p spring = 0.44; p summer = 0.31, p autumn = 0.08; p winter = 0.09; Table 1) that could reflect many possible causes, such as variation in density. Some sites were only seasonally occupied, due to both colonisations and local extinctions (colonisation probability = 0.19; extinction probability =

0.13). From a sampling design perspective, the high values for required sampling size (number of days of trapping) obtained for autumn and winter (37 and 33 days respectively; versus 5 and 8 for spring and summer respectively) suggest that reliable data at reasonable costs can be collected only during spring-summer. Overall, the main point is that combining information on detection probability and sample size estimation (together with colonisation/extinction probability) we were able to identify colonisation/extinction events in each habitat patch, differentiating them from cases of non-detection.

Arboreal rodents

Red squirrel detection probability, using baited hair tubes, was relatively high (p = 0.56); consequently the distribution estimate we obtained was relatively unbiased since the naïve estimate (number of sites where the species was found) and estimate of proportion of sites occupied are very close (Table 1). With our sampling protocol, 40 days of sampling with 4 visits at regular intervals are sufficient to infer squirrel absence.

Carnivores

Despite low values of detection probability and consequently high required sample size values, our estimate of beech marten distribution was relativelly unbiased since the naïve estimate and proportion of sites occupied are very close (Table 1).

Overall, we strongly suggest the utilisation of this modeling approach since it provides a good framework to determine sampling protocols and to evaluate the reliability of presence/absence data, fundamental for a non-biased species distribution in patchy landscapes.

Table 1. Summary of the parameter estimates for the first 2 ranked (according to AIC_c) occupancy models obtained through analyses with program PRESENCE. Psi= proportion of sites occupied; naïve estimate = proportion of sites where the species was actually found; *w* = Akaike weights.

Model	AIC_c	ΔAIC	w	naive	Psi
Myodes glareolus					
Psi, gamma(),eps(),p(seas.)	284.62	0.00	0.20	0.24	0.24
psi,gamma(dist500),eps(),p(seas)	285.38	0.76	0.14		0.24
Sciurus vulgaris					
Psi(logha)p()	54.44	0.00	0.88	0.32	0.32
Psi()p(logha)	60.27	5.83	0.04		0.73
Martes foina					
Psi(sum500),p()	149.7	0.00	0.66	0.4	0.5
Psi()p()	152.67	2.97	0.11		0.5

References

Burnham, K.P. & Anderson, D.R. (2002) *Model selection and multimodel inference – a practical information – theoretic approach*. 2nd ed. Springer-Verlag, New York.

MacKenzie, D. I., Nichols, J.D., Lachman, G.B, Droege, S., Royle, J.A. & Langtimm, C.A. (2002) Estimating site occupancy when detection probability is less than one. *Ecology* **83**, 2248-2555.

MacKenzie, D. I., Nichols, J.D., Hines, J. E., Knutson, M.G. & Franklin, A.B. (2003) Estimating site occupancy, colonisation, and local extinction when a species is detected imperfectly. *Ecology* **84,** 2200-2207.

Reed, J. M. (1996) Using statistical probability to increase confidence of inferring species extinction. *Conservation Biology* **10**, 1283-1285.

The importance of movement behavior in setting landscape connectivity

B.J. Goodwin

University of North Dakota 1 – Department of Biology, 10 Cornell Street Stop 9019, Grand Forks, ND, 58202-9019,USA.
e-mail: brett.goodwin@und.nodak.edu

Introduction

Interest in landscape connectivity has increased over the last few decades (Goodwin, 2003). Despite the proliferation of landscape connectivity studies, few published papers have explored how organism movement behavior impacts landscape connectivity (but see Bowne *et al.*, 2006; Stevens *et al.*, 2004). Many published papers equate landscape connectivity solely with measures of landscape structure and ignore the influence of movement behaviour (Winfree *et al.*, 2005). To apply connectivity metrics judiciously, it is important to understand the influence of movement behavior on different connectivity metrics.

Approach

To explore how measures of connectivity respond to changes in movement behavior I used an individual based, spatially explicit simulation model of the movements of individuals through landscapes. Landscapes consisted of habitat and two matrix patch types. For all simulations habitat was held at a constant proportion (5%) and in a constant pattern (5 equally sized patches evenly distributed across the landscape) and the amount of one of the matrix patch types was varied. Connectivity was measured as dispersal success, search time, landscape wide average habitat patch immigration rate, central habitat patch immigration rate, and landscape wide average habitat cell immigration rate. I varied movement behavior (propensity to move, step lengths, turning angles, edge crossing behavior, perceptual range, conspecific attraction) in one of the matrix patch types. By simulating the movements of individuals through landscapes I could determine the influences of movement behavior on connectivity. Furthermore, since habitat amount and arrangement were held constant impacts of movement behaviour on connectivity would suggest that measures of connectivity based solely on landscape structure will be unreliable.

Findings and conclusions

Results from the simulations illustrate how variation in movement behavior can dramatically impact measures of landscape connectivity, by as much as 500% (Fig. 1). Furthermore, movement behavior in the matrix element had a stronger impact on connectivity than movement behavior in the habitat element. Finally, movement behaviours that led to either very slow movements or very fast movements through the matrix element had significantly greater impacts on landscape connectivity. Based on these simulation results it seems prudent to consider movement behavior when determining landscape connectivity since connectivity measures based solely on landscape structure may be misleading. These results argue for more effort investigating organism movement in landscapes and, particularly, which aspects of the landscape might greatly aid or hinder movement.

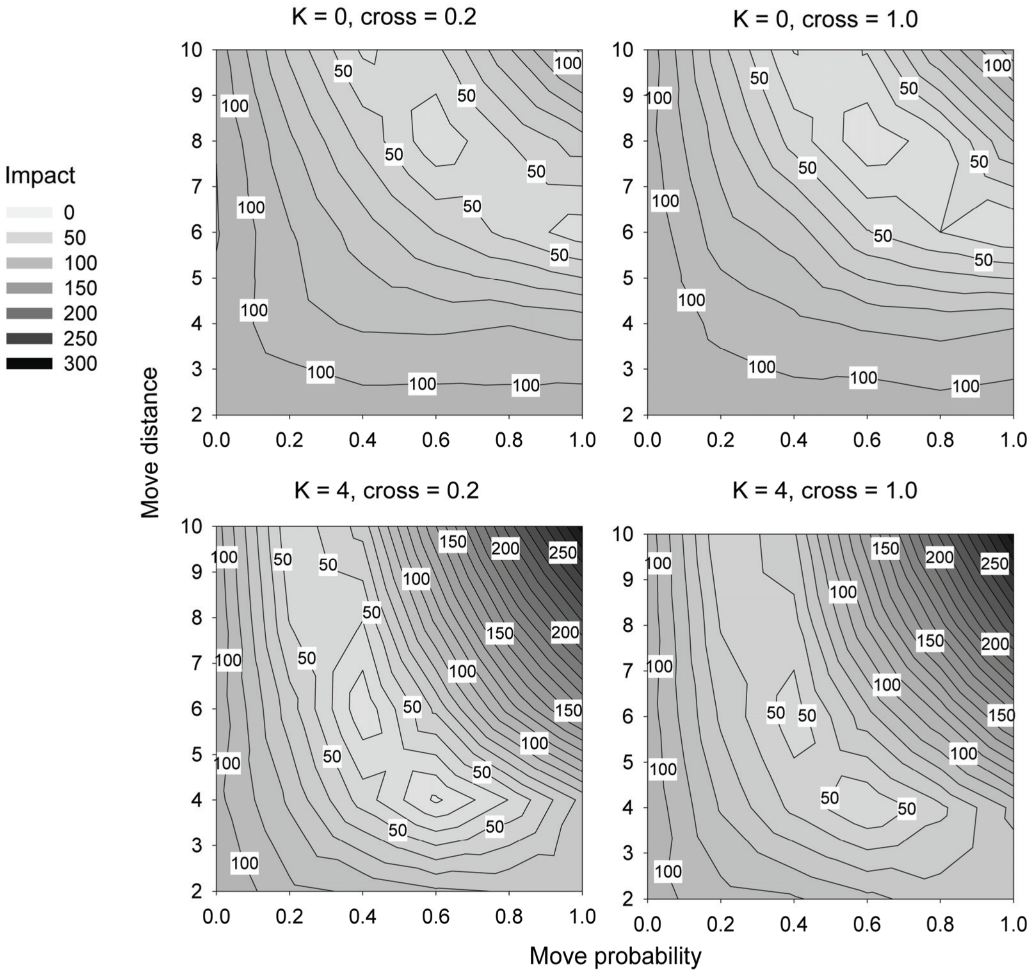


Figure 1. Influence of the movement behvior in a matrix element upon the impact of changing the amount of that element in the landscape on connectivity. Impact refers to the maximum change in connectivity (in this case immigration) as the proportion of the landscape consisting of the matrix element varies. In all cases habitat proportion and pattern does not vary. Movement behaviour consisted of: move probability (probability of an individual moving during a time step), move distance (median step-length drawn from an exponential distribution), K (concentration parameter in a von Mises distribution where K = 0 produces random motion and higher values of K concentrate turn angles in the forward direction producing straighter movement paths), and cross (probability of crossing between matrix elements).

References

Bowne, D.R.; Bowers, M.A. & Hines, J.E. (2006) Connectivity in an agricultural landscape as reflected by interpond movements of a freshwater turtle *Conservation Biology* **20:** 780-791.

Goodwin, B.J. (2003) Is landscape connectivity a dependent or independent variable? *Landscape Ecology* **18**: 687-699.

Stevens, V.M.; Polus, E.; Wesselingh, R.A.; Schtickzelle, N. & Baguette, M. (2004) Quantifying functional connectivity: experimental evidence for patch-specific resistance in the Natterjack toad (*Bufo calamita*) *Landscape Ecology* **19:** 829-842.

Winfree, R.; Dushoff, J.; Crone, E.E.; Schultz, C.B.; Budny, R.V.; Williams, N.M. & Kremen, C. (2005) Testing simple indices of habitat proximity *American Naturalist* **165:** 707-717.

Effects of landscape complexity in agent-based population models

J. Nabe-Nielsen[1,4], R. Sibly[2,4], C. J. Topping[3,4], M. C. Forchhammer[1,4], K. Sudharsan[3,4]

1Section for Climate Effects and System Modelling, National Environmental Research Institute, University of Aarhus, Frederiksborgvej 399, PO Box 358, Roskilde, Denmark
e-mail: nabe@dmu.dk
2School of Animal and Microbial Sciences, University of Reading, Whiteknights, Reading, UK
3Department of Wildlife Ecology & Biodiversity, National Environmental Research Institute, University of Aarhus, Grenåvej 14, DK-8410 Rønde, Denmark
4Centre for Integrated Population Ecology (CIPE), www.cipe.dk

Introduction

How are animal populations affected by the size, shape and spatial arrangement of landscape patches? This central ecological question has proved intractable to classic experimental methods and hard to parameterise when using theoretical approaches. Agent-based models (ABMs) provide a promising way forward, allowing detailed modelling of the behaviour of individual animals in realistic landscapes (Grimm *et al.* 2005; Wiegand *et al.* 1999). Changes in landscape composition affect landscape fragmentation and patch quality, which in turn causes animals to change behaviour. Here we analyze how animal population dynamics are affected for four contrasting species using an agent-based model where the behaviour of each individual is directly affected by realistic local temporal variations in patch quality. Spatially explicit Agent-based models allow us to experimentally alter landscape composition and directly measure effects on population dynamics while controlling for other sources of variation.
The aim of this study is to investigate how populations of four evolutionarily distinct species: field vole (*Microtus agrestis*), skylark (*Alauda arvensis*), a carabid beetle (*Microtus agrestis*) and a spider (*Erigone atra*) are influenced by variations in landscape complexity in an existing agricultural landscape in Denmark. Our analyses reveal effects of landscape functional connectivity (Bélisle 2005) and edge effects (Urban 2005) on the population dynamics of these species.

Methods

The population dynamics is modeled in a series of increasingly simple landscapes using the agent-based model ALMaSS (Topping *et al.* 2003). In the 10x10-km reference landscape around Bjerringbro in Denmark all fields, forests, creeks etc. are mapped at a 1-m^2 resolution. The behaviour and physiological status of each individual is modelled to reflect dynamic variations in the landscape, whereas the over-all response of each population is an emergent property.
The landscape modifications we study are designed to address three important aspects of landscape complexity: the effects of patch shape, patch location and patch size. First the patch shape is randomized by creating artificial patches with random shapes around the original patch centres and with the same size as the original patches. This allows us to study whether the linear elements that may serve as corridors (e.g. hedgerows and field boundaries) affect population dynamics. The second simplification is to randomize patch location while retaining the original sizes of the patches. This permits us to analyse whether populations are affected by the spatial arrangement of the patches, as may occur in species that are affected by landscape fragmentation or that depend on synergetic effects between different types of patches. Finally both patch types and sizes are allowed to vary. This allows us to quantify the importance of the present allocation of land to fields, forests and other patch types in the agricultural landscape.

Here we characterize stability of populations in terms of the rates at which they return to equilibrium sizes after disturbance. This is a property of the relationship between population size and population growth rate (Sibly *et al.* 2005) A landscape that allows a population to rapidly return to equilibrium after being perturbed to low numbers is favourable for the species.

Results and discussion

Variations in landscape complexity result in changed equilibrium population sizes, but the amount and direction of the change varies among species. The relationship between population growth rate and population size is relatively unaffected by variations in landscape complexity, and it is always negative in the vicinity of the equilibrium population size. If a species is perturbed to a particular density in two different landscapes, its population size therefore increases faster in the landscape where its equilibrium population size is highest. Both vole and skylark have higher equilibrium population sizes, and higher return rates, in randomized landscapes. This is because areas that were only suitable as corridors in the original landscape are transformed to primary habitat when patch shape is randomized. Our analyses also suggest that high return rates may not be sufficient to ensure long-term survival of a species. If corridors are transformed to primary habitat this may result in increased population growth in many patches, while preventing the long-distance dispersal that is necessary for re-colonizing remote patches after large local disturbances.
By predicting population consequences at different spatial and temporal scales the study helps advance ecology science. Our results contribute to the on-going discussion about the importance of local population survival for the maintenance of species on the landscape-scale. The methods developed here can be used to guide management decisions in order to increase land use sustainability.

References

Bélisle, M. (2005) Measuring landscape connectivity: The challenge of behavioral landscape ecology. *Ecology* **86:** 1988-1995.

Grimm, V.; Revilla, E.; Berger, U.; Jeltsch, F.; Mooij, W.M.; Railsback, S.F.; Thulke, H.H.; Weiner, J.; Wiegand, T.; DeAngelis, D.L. (2005) Pattern-oriented modeling of agent-based complex systems: Lessons from ecology. *Science* **310:** 987-991.

Sibly, R.M.; Barker, D.; Denham, M.C.; Hone, J. & Pagel, M. (2005) On the regulation of populations of mammals, birds, fish, and insects. *Science* **309:** 607-610.

Topping, C.J.; Hansen, T.S.; Jensen, T.S.; Jepsen, J.U.; Nikolajsen, F. & Odderskær, P. (2003) ALMaSS, an agent-based model for animals in temperate European landscapes. *Ecological Modelling* **167:** 65-82.

Urban, D.L. (2005) Modeling ecological processes across scales. *Ecology* 86: 1996-2006.

Wiegand, T.; Moloney, K.A.; Naves, J. & Knauer, F. (1999) Finding the missing link between landscape structure and population dynamics: a spatially explicit perspective. *American Naturalist* **154:** 605-627.

The use of Mahalanobis Typicalities to model the distribution of species with different response curves to environmental gradients.

F. Sangermano, J. R. Eastman

Clark University, Graduate School of Geography and Clark Labs - 950 Main St., Worcester MA, 01610, USA.
e-mail: fsangermano@clarku.edu

Introduction

Several studies have compared the performance of different algorithms for modeling species distributions, with varying results among species, areas and scales of analysis (eg. Elith *et al*. 2006). Review papers on species distribution modeling (e.g. Austin, 2002; Guisan and Zimmermann, 2000) indicate the necessity of taking into account ecological theory in the modeling process. In this work we present a procedure for modeling species distributions called Mahalanobis Typicalities and discuss the results of a test in which it is used to model the habitat suitability and distributional range of virtual species with different response curves (normal, skewed, bimodal and mixed) to environmental gradients.

Methods

Mahalanobis Typicalities (Eastman, 2006) express the degree to which the values of a set of environmental variables at a location are typical of known instances of a specific species. They are derived from the Mahalanobis Distance [$\mathbf{M^2 = (x- \mu_i)^t V_i^{-1} (x- \mu_i)}$]; where x is the vector of environmental measures at a location, μ is the vector of the mean environmental measures for all known instances of the species in question and V is the variance/covariance matrix. Typicality is the probability of any location having a Mahalanobis Distance greater than or equal to that observed at the location of interest. Locations having attributes identical to the multivariate centroid have a Typicality of 1.0, with less typical locations approaching a Typicality of 0.0 at the limits of the distribution (Eastman, 2006). The other techniques used in this paper are Maximum Entropy (MaxEnt), Genetic Algorithm for Rule-set Production (GARP), Ecological Niche Factor Analysis (ENFA), BIOCLIM and DOMAIN. Details of these techniques can be found for example in Elith *et al.* (2006), Phillips *et al*. (2006), and Hirzel *et al* (2002). MaxEnt was run with both the Linear option (MaxEnt-Linear) and the Automatic options (MaxEnt-Auto). GARP habitat suitability was calculated as the average of 100 runs.

Four virtual species were generated with normal, skewed, mixed and bimodal response to environmental gradients. The root mean square error (RMS) and mean absolute error (MAE) were calculated to evaluate the performance of the model in predicting habitat suitability. Maximum Kappa (KIA max) and the area under the Receiver Operating Characteristic (ROC) plots (AUC) were calculated to assess the performance of the models in predicting the species distribution.

Results and discussion

The performance of Mahalanobis Typicalities under a Normal response curve was almost perfect (RMS = 0.03, MAE = 0.02), and decreased with non-normal responses. The worst prediction from this method was for the bimodal response (RMS = 0.28, MAE = 0.25), followed by the skewed response (RMS = 0.11, MAE = 0.07). Typicalities proved to be fairly tolerant to mixed skewed/normal responses (RMS = 0.07, MAE = 0.04). Comparing the results of the Mahalanobis Typicalities procedure with the other methodologies, significant differences were found. In all cases, MaxEnt-Linear was not capable of identifying the degree of suitability. MaxEnt-Auto however, had a better performance. Typicalities perform best for mixed and normal response curves with RMS = 0.07 and 0.03 respectively, while MaxEnt-

Auto was the best in the case of Skewed responses (RMS = 0.05, MAE = 0.03). In the case of bimodal response curves, none of the methodologies had as good a performance. BIOCLIM had the lowest RMS (0.19) and MAE (0.16) for this response curve, followed by the Typicalities and MaxEnt-Auto (RMS = 0.36). GARP and DOMAIN were the worst performers in predicting the habitat suitability in all cases.

For normal and mixed responses, both AUC and maximum Kappa were the highest for Typicalities. For skewed response curves MaxEnt-Auto performed better than the other models. Bimodal responses are again the least accurate, ranking BIOCLIM higher for AUC and MaxEnt-Linear higher for maximum Kappa (Table 1)

Table 1: AUC and KIA max for each model under the different responses to environmental gradients. In **bold** the higher agreement

	AUC				KIA max			
	Normal	Skewed	Mixed	Bimodal	Normal	Skewed	Mixed	Bimodal
BIOCLIM	0.997	0.984	0.997	**0.795**	0.877	0.764	0.897	0.127
DOMAIN	0.951	0.964	0.928	0.726	0.472	0.653	0.515	0.065
ENFA	0.988	0.993	0.890	0.718	0.735	0.832	0.375	0.088
GARP	0.875	0.969	0.891	0.717	0.290	0.674	0.419	0.088
Typicalities	**0.999**	0.990	**0.999**	0.768	**0.930**	0.851	**0.936**	0.097
MaxEnt Auto	0.997	**0.999**	0.988	0.605	0.859	**0.940**	0.848	0.063
MaxEnt Linear	0.704	0.907	0.743	0.792	0.161	0.507	0.261	**0.196**

Conclusions

Mahalanobis Typicalities is a powerful method for modeling species distributions with presence only data. It is shown here to have excellent performance in predicting both habitat suitability and species range for normal distributions although the method is highly tolerant of mixed non-normality conditions.

References

Austin, M. P. (2002) Spatial prediction of species distribution: an interface between ecological theory and statistical modelling. *Ecological Modelling* **157:** 101-118.

Eastman, J.R. (2006) *Idrisi 15.0 The Andes Edition, Help System*. Clark University-Clark Labs, Worcester MA.

Elith, J.; Graham, C.H. & the NCEAS. **(2006)** Novel methods improve prediction of species' distributions from occurrence data. *Ecography* **29:** 129-151.

Guisan, A. & Zimmermann, N. **(2000)** Predictive habitat distribution models in ecology. *Ecological Modelling* **135:** 147-186.

Hirzel, A.H.; Hausser, J.; Chessel, D. & Perrin N. (2002) Ecological-niche factor analysis: How to compute habitat- suitability maps without absence data? *Ecology* **83:** 2027-2036.

Phillips, S.J.; Anderson, R.P. & Schapire R.E. (2006) Maximum entropy modeling of species geographic distributions. *Ecological Modelling* **190:** 231-259.

An automated procedure for the bulk re-processing of species range polygons

J.R. Eastman, F. Sangermano

Clark University, Graduate School of Geography and Clark Labs - 950 Main St., Worcester MA, 01610, USA.
e-mail: reastman@clarku.edu

Introduction

A fundamental resource for the assessment of priorities for biodiversity conservation has been the archives of species range maps drawn by specialists based on combinations of field observations and historical accounts. However, it is known that there are omissions in the extents of some of these ranges and the polygonal boundaries are drawn with varying degrees of precision. In this work we present an automated procedure to re-draw the polygons based on species distribution modeling using environmental variables. Using independent validation data, the results for a selection of species are presented

Methods

In order to develop and test the modeling procedure, we selected four species for which we had reasonably large sets of observation points for validation: *Microryzomys minutus* (n=88), *Bradypus variegatus* (n=99), *Alouatta seniculus* (n=67) and *Tapirus terrestris* (n=41). Polygon data was obtained from NatureServe's InfoNatura database (Peterson et al., 2005) and observation points from the Global Biodiversity Information Facility (www.GBIF.org). Fourteen environmental variables at 1km resolution were used to model the species (percent herbaceous, percent trees, mean annual NDVI, NDVI seasonality, maximum precipitation of the wettest month, mean annual precipitation, minimum precipitation of the driest month, precipitation seasonality, temperature annual range, mean temperature diurnal range, maximum temperature of the warmest month, minimum temperature of the coldest month and mean annual temperature. An additional input was the map of ecoregions developed by the World Wildlife Foundation (Olson et al. 2001).

In the first step of the process, the original polygon is cleaned through the calculation of the empirical probability of the ecoregion being part of the range polygon. This is calculated as the area of the ecoregion that intersects the range polygon divided by the total area of the ecoregion. This map of probabilities was used as the weight for a Weighted Mahalanobis Typicality modeling method. Areas with probabilities less than 0.5 are removed for the polygon, and the resulting refined polygon is used in the process of variable selection.

Mahalanobis Typicalities are sensitive to irrelevant variables, so we developed an additional procedure that looks at the ratio of the Standard Deviation on each variable within the refined polygon to that over the entire study region (South America in this context). If the species is constrained by an environmental variable, the variability of that variable inside the polygon should be smaller than the variability of the variable in the entire region. An arbitrary value of 0.6 was used as a threshold to select the important variables for the species in question, keeping only the variables with values less than 0.6.

The empirical probability of the ecoregions was also added to the group of environmental variables selected, as a way to help limit the predicted distribution of species to the ecoregions they are known to belong to. Then, the Weighted Mahalanobis Typicalities procedure implemented in the IDRISI software system (Eastman, 2006) was used as the method to model the species distribution. It differs from the standard Mahalanobis Typicalities procedure in that is based on a weighted mean and weighted variance/covariance matrix. It was run using the original polygon as training, the weights based on the ecoregions and the subset of variables selected. The result is a continuous map from zero to one that represents the habitat suitability for the species modeled. We threshold this suitability to generate the final range polygon considering habitat suitabilities less than 0.01 as absences of the species. A second threshold at 0.1 was also applied to see how threshold selection influenced the results. Finally, a procedure was developed to automatically evaluate the result of each species modeling by comparing the area of the new polygon to that of the original, facilitating the detection of large discrepancies between original and modeled polygon.

Results

For *A. seniculus* there were significant extensions as well as contractions of the original range. Of particular note is the fact that the original polygon followed the border of Bolivia, while the new polygon extends the range into Bolivia as it should. The high Andes are removed from the polygon. Two points in Bolivia were not captured in the original polygon but are captured in the predicted one. With a threshold of 0.01, 85% of the points are correctly classified (75% using a threshold of 0.1). For *T. terrestris*, 95% of the points were classified correctly with the 0.01 threshold. The major difference between the predicted and the original polygon is that the high Andes and parts of the southern range were removed. In addition, the range was extended into northern Argentina, where it is known to have occurred and is being re-introduced. This northern part of Argentina is missed with the 0.1 threshold, which generates a smaller polygon with an accuracy of 85%. For *B. variegatus*, there is a considerable reduction of the range, especially in the areas of the high Andes, where for temperature constraints the species is known to not occur, and the llanos of Colombia. Using the 0.01 threshold, 91% of the points were correctly classified, reducing to 78% in the case of a threshold of 0.1. For *M. minutus*, 99% of the points were correctly classified under the 0.01 threshold and 95% under the 0.1 threshold. However the lower threshold in this case produces over-prediction of the range of the species.

Conclusions

The procedure has significant merit for the automated processing of species polygons. The most sensitive parameter was the threshold used in creating a hardened polygon from the continuous typicalities. Although a 1% threshold worked well in general, careful attention must be placed on false positive errors (over-prediction). In cases were large over-prediction exists; increasing the threshold usually solves the problem.

References

Eastman, J.R. (2006) *Idrisi 15.0 The Andes Edition, Help System*. Clark University-Clark Labs, Worcester MA.

Olson, D. M; Dinerstein, E.; Wikramanayake, E,D.; Burgess, N.D.; Powell, G.V.N.; Underwood, E.C.; D'amico, J.A.; Itoua, I.; Strand, H.E.; Morrison, J.C.; Loucks, C.J.; Allnutt, T.F.; Ricketts, T.H.; Kura, Y.; Lamoreux, J.F.; Wettengel, W.W.; Hedao, P. & Kassem, K.R. (2001) Terrestrial Ecoregions of the World: A New Map of Life on Earth. *BioScience* **51:** 933-938.

Patterson, B. D.; Ceballos, G.; Sechrest, W.; Tognelli, M.F.; Brooks, T.; Luna, L.; Ortega, P.; Salazar, I. & Young, B.E. (2005) Digital Distribution Maps of the Mammals of the Western Hemisphere, version 2.0. NatureServe, Arlington, Virginia, USA.

Testing the ecological significance of gradients in habitat quality for fauna in Australian savannas

B. Price[1], C. McAlpine[1], S. Phinn[1], D. Pullar[1] and J. Ludwig[2]

[1] Centre for Remote Sensing and Spatial Information Science, School of Geography, Planning and Architecture, The University of Queensland, St Lucia 4072, QLD, Australia.
e-mail: b.price@uq.edu.au
[2] CSIRO Sustainable Ecosystems, PO Box 780, Atherton 4883, QLD, Australia

The paradigm of habitat patches as islands surrounded by a matrix of unsuitable habitat, originating from MacArthur and Wilson's (1967) theory of island biogeography, has had a pervasive influence on conservation biology, metapopulation theory and landscape ecology. Human-modified landscapes form the basis of this model where landscape structure ranges from intact, through fragmented, to relictual. The discrete patches paradigm has provided useful insights into the ecological impacts of human-induced habitat destruction on biological populations (Fahrig, 2003). However, many landscapes are not characterised by discrete patch boundaries, but instead exhibit gradients in cover type, vegetation density and structure with spatially and temporally variation. At present, ecology is lacking a quantitative approach to measuring continuous gradients in landscape structure and to test the ecological importance of these gradients for the breeding, foraging and movement behaviour of fauna species.

Intact landscapes which have not been cleared for agricultural and urban development, often exhibit continuous local scale (<10km) variation in structure related to factors such as topography, geology, moisture availability, fire history, as well as some large scale (100s-1000s of km) climatically induced gradients (Pearson, 2002; Woinarski *et al.*, 2005). Many of the tropical savanna landscapes of northern Australia which have not been converted to intensive agriculture vary continuously with no clear boundaries between vegetation types (Pearson, 2002; Woinarski *et al.*, 2005).

The inadequacy of the discrete boundary model to quantify gradients in habitat structure, or to differentiate between structure and function, suggests the need for continuous metrics to quantify landscape structure and function.

The continuous landscape concept differs from the discrete patch paradigm in that it conceptualises landscapes as having diffuse rather than discrete boundaries. The amount of habitat and its spatial configuration within the landscape remain relevant measures of landscape pattern, but must be conceived in a fundamentally different manner. Keeping in mind that species may require more than one habitat type (Fahrig, 2003; Law& Dickman, 1998; Wiens, 1997), and following Fischer *et al.* (2006), our approach is to break species habitat requirements down into needs for food, shelter, movement and reproduction. The amount of habitat equals the sum total of suitable habitat elements within a given landscape which are required throughout a species' lifespan. The spatial configuration of habitat is a measure of the distribution of those habitat elements across the landscape extent, defined from an organism perspective. Similar to the discrete model, certain landscape elements act as filters to a species' movement such as those with increased risk of predation, physiological stress and intense competition (Wiens, 1997). Habitat elements which offer food, shelter or mating opportunities represent benefits to a species while those with risk of predation, competition or physiological stress represent costs (Wiens, 1997).

In recent years remote sensing technology has been advancing at a great rate, however, ecological studies have not taken full advantage of the capabilities of this technology. Modern high spatial resolution (down to 0.6m and 0.05m) satellite and airborne remote sensing is capable of capturing fine-scale heterogeneity in habitat structure in continuously varying landscapes (Turner *et al.*, 2003). Advanced spatial analysis techniques are available to analyse the relationships between that heterogeneity and species distribution patterns and abundances to obtain measures of ecological function (Rollins *et al.*, 2004; Turner *et al.*, 2003). With new tools and advances in remote sensing we have the opportunity to develop sophisticated measures of landscape structure and function which can manage data at different scale levels and across structural gradients.

This study aims to develop and test metrics of landscape structure and function which are ecologically relevant to fauna populations in northern Australian and other landscapes with continuous variation in their structure. It takes advantage of advances in remote sensing technologies and conceptualises and quantifies landscapes in continuous or gradient-based terms that are measurable, accurate and of ecological relevance to native fauna. This work is a first step towards process-oriented measures of ecological function in landscapes with a continuous rather than discrete structure. We demonstrate the approach and ecological relevance using a case study landscape with example fauna data. The study builds on a conceptual model of continuously varying landscapes and develops an integrated spatial analysis and image processing technique to quantify these gradients from high spatial resolution (pixels < 5.0m) satellite images. Suitable continuous measures of landscape structure are identified and then tested as indicators of habitat requirements and movement behaviour of native fauna. The ecological relevance of these indicators is examined through analysis of image and faunal survey data.

References

Fahrig, L. (2003). Effects of habitat fragmentation on biodiversity. *Annual Review Ecology, Evolution and Systematics* **34**, 487-515.

Law, B. S., & Dickman, C. R. (1998). The use of habitat mosaics by terrestrial vertebrate fauna: implications for conservation and management. *Biodiversity and Conservation* **7**, 323-333.

McArthur, R. H., & Wislon, E. O. (1967). *The theory of island biogeography*, Princeton University Press, Princeton, N.J.

Pearson, D. M. (2002). The application of local measures of spatial autocorrelation for describing pattern in north Australian landscapes. *Journal of Environmental Management* **64**, 85-95.

Rollins, M. G., Keane, R. E., & Parsons, R. A. (2004). Mapping fuels and fire regimes using remote sensing, ecosystem simulation, and gradient modeling. *Ecological Applications* **14**, 75-95.

Turner, W., Spector, S., Gardiner, N., Fladeland, M., Sterling, E., & Steininger, M. (2003). Remote sensing for biodiversity science and conservation. *Trends in Ecology & Evolution* **18**, 306-314.

Wiens, J. A. (1997). The emerging role of patchiness in Conservation Biology. (S. T. A. Pickett, R. S. Ostfeld, M. Shachak & G. E. Likens, eds.),*The Ecological Basis of Conservation* Vol. Chapman & Hall, New York, pp. pp93-107.

Woinarski, J. C. Z., Williams, R. J., Price, O., & Rankmore, B. (2005). Landscapes without boundaries: wildlife and their environments in northern Australia. *Wildlife Research* **32**, 377-388.

Testing the performance of landscape structure variables as predictors of biodiversity: a case study from Dadia NP, Greece

S. Schindler[1], V. Kati[2], K. Poirazidis[3]

[1] University of Vienna, Department of Conservation Biology, Vegetation and Landscape Ecology; University of Vienna; Althanstraße 14, 1090 Vienna, Austria.
e-mail: stefan_schindler75@yahoo.es
[2] University of Ioannina, Department of Environmental and Natural Resources Management, Seferi 2, GR 30100, Agrinio, Greece
[3] WWF Greece, Dadia project, GR-68400, Dadia, Soufli, Greece.

Introduction

Variables quantifying composition and configuration of landscapes are an important tool for relating aspects of landscape structure with ecological pattern and processes. They are used for the description of changes of landscapes due to climate change and socioeconomic drivers, and for the quantification of habitat requirements of species. However, there are few integrated empirical studied testing the relations between landscape structure and biodiversity. In this study we evaluated for six taxonomic groups of organisms at five different scales 1) correlations and correlation patterns between landscape structure and species richness, and 2) the performance of sets of landscape structure variables as predictors of species richness, comparing sets of different origin.

Methods

We collected species richness data of six taxa (woody plants, orchids, Orthoptera, amphibians, reptiles, and small terrestrial birds) from 30 sampling plots at Dadia National Park, a Mediterranean forest and regional hotspot of biodiversity in north-eastern Greece (Kati *et al.* 2004a,b,c, Kati and Sekerlioglu 2006). Using a raster map of 9 landcover categories and a resolution of 5 m, we clipped in an Arc GIS environment the surrounding areas of 20, 50, 100, 200 and 500 ha of each sampling plot. For all these areas we computed 53 landscape level variables of landscape structure, using the software FRAGSTATS. In a first analysis, we grouped the landscape structure variables into the six categories area, shape, isolation, contrast, texture and diversity and tested for significant relations between the landscape variables and the species richness of the 6 taxa, calculating partial Spearman correlation coefficients. Then we evaluated pattern of correlations of the different taxa, metric groups and scales. In a second analysis we compared different sets of variables as predictors of species richness. These sets were based on A) correlation analysis of the landscape variables, B) on expert knowledge and C) on random choice. We applied multiple linear regressions to examine the performance of the different landscape variable sets as predictors of the observed species richness. Additionally we performed multiple linear regression using all variables in a forward procedure to define D) an optimal set of predictors and to evaluate its performance.

Results

Concerning the correlation matrices, we found out that the scale affected the number of landscape metrics that had a significant correlation with the species richness of the different taxa. Woody plants were predicted better by landscape metrics at the scales 50-100 ha, while reptiles and birds at the scale 500 ha. Other taxa like orthoptera and amphibians performed best at the lowest scale (20ha), while there was no significant correlation between the species richness of orchids with any landscape variable at any scale. Finally, the correlations of the total species richness (the sum of the number of species of each taxon), were stable from 20 until 100 ha and declined towards 500 ha (fig. 1).

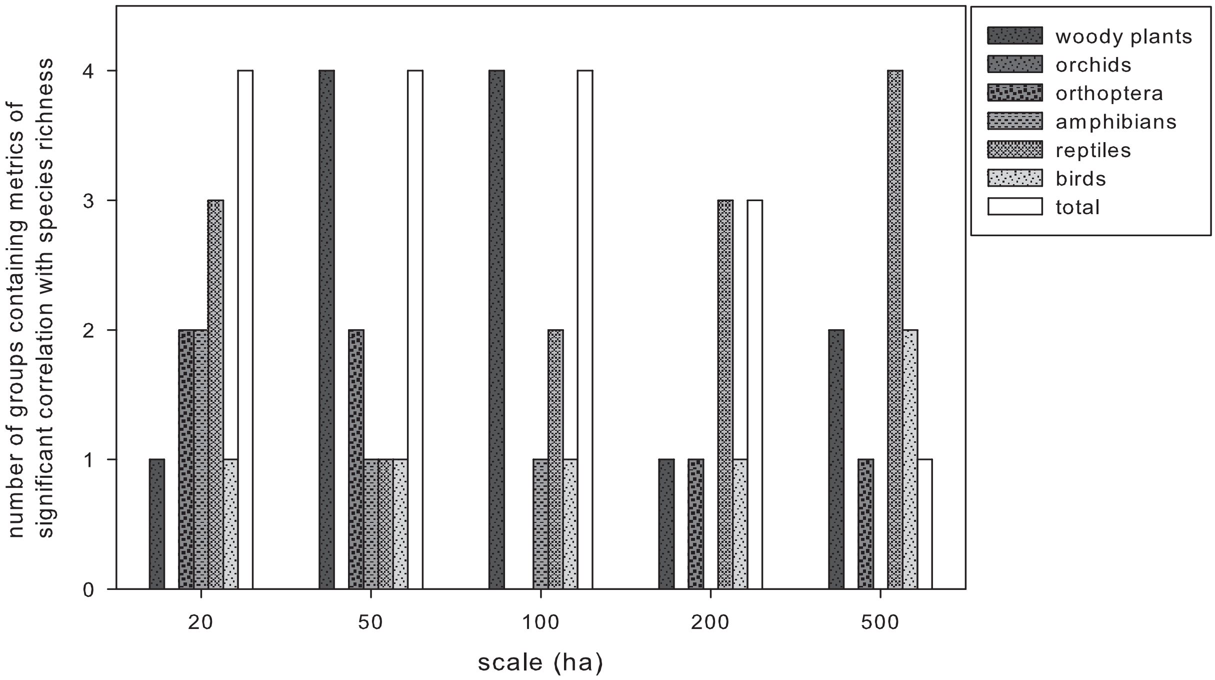


Figure 1. Relations between landscape structure, organism groups and scale expressed by the number of variable groups (out of the six groups “area”, “shape”, “contrast”, “isolation”, “texture”, and “diversity”) containing at least one landscape metric of significant partial correlation with the species richness.

When comparing the performance of the sets of variables, we could not detect any significant differences between the sets obtained by correlation analysis, expert knowledge and random choice (A-C). On the other hand, the optimal set (D) was explaining up to 46.5 % of the remaining variance, performing much better than any of the other sets for each taxon and scale. These results lead to the conclusion that a priori definition of sets of variables could be problematic when trying to model the relations of landscape structure and biodiversity and that a preliminary analysis of the performing of different variables and sets should be completed.

References

Kati, V.; Devillers, P.; Dufrêne, M.; Legakis, A.; Vokou, D. & Lebrun, Ph. (2004a) Hotspots, Complementarity or Representativeness? Designing optimal small-scale reserves for biodiversity conservation. *Biological Conservation* **120:** 475-484.

Kati, V.; Devillers, P.; Dufrêne, M.; Legakis, A.; Vokou, D. & Lebrun, Ph. (2004b) Testing the value of six taxonomic groups as biodiversity indicators at a local scale. *Conservation Biology* **18:** 667-675.

Kati, V.; Dufrêne, M.; Legakis, A.; Grill, A. & Lebrun, Ph. (2004c) Conservation management for Orthoptera in the Dadia reserve, Greece. *Biological Conservation* **115:** 33-44.

Kati, V. & Sekercioglu, C.H. (2006) Diversity, ecological structure, and conservation of the landbird community of Dadia reserve, Greece. *Diversity and Distributions* **12:** 620–629.

The interest of modeling the effect of habitat loss and fragmentation on population dynamics at different nested observation scales.

J.B. Pichancourt[1], P. Auger[2], F. Burel[1]

[1] **CAREN, CNRS** – Campus de Beaulieu 35042 Rennes cedx, France.
e-mail: jbpichancourt@gmail.com
[2] **IRD, GEODES –** centre de recherche d'Ile de France 32, avenue Henri varagnat Bondy cedex 93143 France.

Introduction

Our goal is to propose a framework to study population dynamics at different nested observation scales in a landscape. We present an application of its interest to understand the impact of some landscape changes as habitat loss and fragmentation on the population dynamics of a forest ground beetle (*Abax parallelepipedus: Coleoptera, carabidae).* This work is the follow up of two previous papers (Pichancourt *et al.,* 2006a and b).

Material and methods

In a landscape, different nested observation scales can be defined and linked using aggregation/zoning methods for landscape spatial units (Openshaw and Taylor, 1979). This method allows us to link four classical nested observation scales used in landscape ecology, from the most spatially explicit to the most spatially implicit: 1) the micro-habitat scale, 2) the habitat-patch scale, 3) the habitat-class scale and 4) the landscape scale (McGarigal *et al.*, 2002). At each scale, one model of population dynamics can be built: 1) a grid cell model, 2) a multipatch or metapopulation model, 3) a habitat-class model, and 4) a landscape scale demographic model. To hierarchically link them across scales, we use a method of variables aggregation (Bravo de la Parra et al., 1995) applied to spatial matrix population models (Hunter and Caswell, 2005). This avoids aggregation errors between nested variables and parameters. We propose a synthetic view of the structure and dynamics of *A. parallelepipedus* population along gradients of habitat loss and fragmentation at different scales. Here we present the link between two observation scales: habitat-classes and landscape scale. In the simulated landscapes, the proportion of woods and crops vary, whilst it is fixed for hedgerows (5%).

Results

Population analysis at the landscape scale

We show that population viability at the landscape scale is affected by habitat loss and fragmentation. A critical threshold of population viability appears to depend on the habitat amount and fragmentation rate. For more than 44% of wood land cover, the population is viable whatever the fragmentation rate. Below the 44% threshold, extinction depends on fragmentation rate. A sensitivity analysis of the population viability to demographic parameters shows that they are all important for habitat loss and fragmentation gradients. Fecundity is the parameter most affected by habitat loss and fragmentation (f = 2.81 with 100% of wood land cover, f = 2.42 with 44% of wood land cover). Adult survival is less affected (s = 0.45 to s = 0.435), and survival of Larvae/pupae is not affected, because it is an immobile stage at this scale.

Analysis at the habitat-class scale

The demographic parameters (in each class of habitat) and the movement parameters (at the boundary between two classes of habitats) were fixed at this scale in the model, so they cannot vary. But we show with a sensitivity analysis on population viability, that the relative importance of the different habitat-classes and boundaries (via the there associated parameters) vary according to habitat loss and fragmentation. The more wood land loss or fragmentation, the more population viability is sensitive to adjacent habitats (crops or hedgerows), then to inner boundaries (between wood land and hedgerows or crops), and finally to the non adjacent boundary (between crops and hedgerows). This evolution has consequences for the definition of the best targets (i.e. habitats and/or boundaries) for landscape management or for biological data collection (for instance to improve parameter estimation).

Discussion

The aggregation methods for dynamic systems and for geographic spatial units can be combined in a general hierarchical theoretical framework to understand population dynamics at different observation scales in landscape ecology. Each model represents a particular observation scale and offers a piece of information to fully understand the landscape effects on population structure and dynamics. In our example, the landscape scale is important in the understanding the overall demographic sensitivity of this species to global spatial changes. The habitat class level emphasizes the relative/complementary roles of source and sink for the different classes of habitats and boundaries. For future work, we propose this framework to link the four nested scales and the models described above. In this way, we provide an example of Wu's prospects (Wu, 1999) on the importance of the hierarchical view of landscape ecology to enhance a full understanding population dynamics and structure.

References

Hunter, C.M. and H. Caswell. 2005. The use of the vec-permutation matrix in spatial matrix population models. Ecological Modelling 188:15-21.

Bravo de la Parra, R., Auger, P. and Sanchèz, E., 1995. Aggregation methods in discrete models. J. Biol. Syst. 3: 603-612.

McGarigal K, Cushman SA, Neel MC, Ene E. 2002. FRAGSTATS: spatial pattern analysis program for categorical maps.

Openshaw, S. and Taylor, P. 1979. A million or so correlation coefficients: three experiments on the modifiable area unit problem. In Statistical Applications in the spatial sciences, pp. 127- 144. Edited by Wrighley, N. Pion: London

Pichancourt J-B, Burel F, Auger P. 2006a. Assessing the effect of habitat fragmentation on population dynamics: An implicit modelling approach. - Ecol. Mod 192: 543-556.

Pichancourt J-B, Burel F, Auger P. 2006b. Assessing the impact of habitat fragmentation on population dynamics: An elasticity analysis. - C.R. Biologie 329: 31-39

Wu, J. 1999. Hierarchy and scalling: extrapolating information along scaling ladder. Canadian Journal of Remote sensing 25: 367-380.

Patchy responses to a patchy landscape: the spatial structure of habitat selection

S.J. Mayor[1,2], D.C. Schneider[1], J.A. Schaefer[1,3], S.P. Mahoney[2]

[1]Memorial University of Newfoundland, Department of Biology, St. John's, NL, Canada.
E-mail: smayor@trentu.ca.
[2]Institute for Biodiversity and Ecosystem Science and Sustainability, Government of Newfoundland and Labrador, P.O. Box 8700, St. John's, NL, A1B 4J6, Canada.
[3]Trent University, Biology Department, 1600 West Bank Dr., Peterborough, ON, K9J 7B8, Canada.

The caribou's-eye-view

Habitat selection, the disproportionate use of available resources, is a multi-scaled phenomenon. Selection depends on the scales perceived by organisms, and our ability to detect selection depends on analytical scale. However, conventional multi-scaled studies of selection have been limited by the use of discrete, arbitrary scales because a quantitative basis has not existed for evaluating how animals perceive the availability of habitat. We examine selection from the perspective of woodland caribou (*Rangifer tarandus caribou*) in the maritime barrens of Newfoundland, Canada, by allowing their response to winter habitat define the scale domains of selection.

Spectrum of selection

We unite habitat selection research with spatial and geostatistical analyses to investigate the spatially structured response of mobile animals to a heterogeneous landscape by caribou. When habitat components are correlated across scales interpretations of correlations between organisms and habitat can be impeded, so we developed new two new approaches to quantify habitat selection as a reduction in variance.

We employ spatial continua to represent patterns of heterogeneity across scales by developing two new analytical approaches – one based on lagging, and a second based on coarse-graining (Fig. 1). Variogram analysis operates in the distance domain and compares variability between pairs of samples at given separation distances (or lags) (Matheron, 1960). Blocked quadrat variance, a form of coarse-graining, operates in the frequency domain and compares variability among contiguous blocks in different sized grids, in relation to the size of those blocks (Grieg-Smith, 1952). Employing spatial continua avoided assumptions of the spatial extent of behavioural levels, thereby enabling these levels to be customized to the specific ecology of the taxon under investigation. We applied these techniques at four levels of habitat use (population winter range, travel routes, feeding areas, and feeding microsites), each nested within available habitat at coarser levels.

Spatially structured habitat selection

By comparing the spatial structure of habitat components in used and available sites (at several levels of behaviour) we went beyond describing patterns of spatial variability in the environment to evaluating the behavioural processes resulting from those patterns. We stepped from quantifying the spatial structure of habitat to quantifying the spatial structure of habitat selection.

Caribou consistently selected favourable (and avoided poor) habitat such that preferred habitat components were less variable in selected sites than in the available environment. Selection was strongest for *Cladina* lichens (the herd's primary winter food resource) and snow depth (an indicator of the energetic costs of foraging and moving) at lag distances up to 13 km (Fig. 2a). Within this range, selection decreased with lag, but avoidance of deep snow occurred at all lags and was accomplished at several behavioural levels (Fig. 2b).

Caribou responded to habitat heterogeneity at all scales, and this response was greatest at the scales of highest patchiness (Fig. 3). Our results implicate habitat heterogeneity as an underlying cause of multi-scaled habitat selection.

Implications for limiting factors

When habitat components are selected at different spatial scales, the scales of selection for each resource may reflect the relative importance of escaping the effects of limiting factors (Rettie and Messier 2000). However, caribou selected habitat variables across overlapping scaling domains, suggesting that caribou selected for *Cladina* cover and soft, shallow snow to make a trade-off between the potentially limiting effects of forage abundance and accessibility.

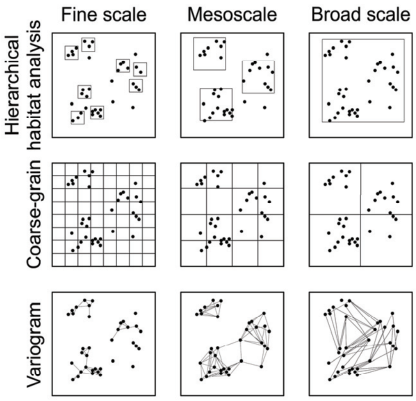


Figure 1. Comparison of analytical approaches for multiscale habitat selection research. Points represent sampling locations. Top row shows conventional hierarchical approach.

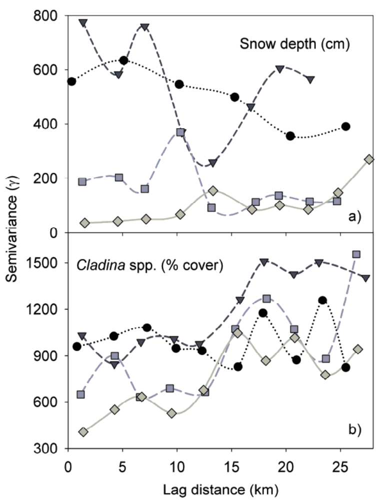


Figure 2. Variograms, with habitat selection represented by the discrepancy between semivariance at crater (♦), feeding area (■), and travel route (▼) levels relative to the winter range (●) level.

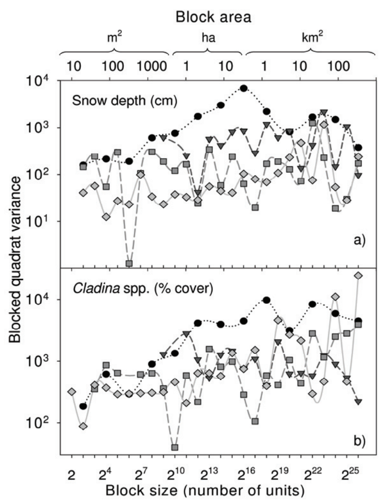


Figure 3. Blocked quadrat variance, with habitat selection represented by the discrepancy between semivariance at crater (♦), feeding area (■), and travel route (▼) levels relative to the winter range (●) level.

References

Greig-Smith P (1952) The use of random and contiguous quadrats in the study of the structure of plant communities. Annals of Botany, New Series **16:** 293-316.

Matheron G (1960) Principles of geostatistics. Economic Geology **58:** 1246-1266.

Rettie WJ, Messier F (2000) Hierarchical habitat selection by woodland caribou: its relationship to limiting factors. Ecography **23:** 466-478.

3.6 Open Session 11: Landscape modelling and bird populations

Conservation of understory birds in fragmented landscapes: relative importance of habitat cover and configuration

A. C. Martensen & J. P. Metzger

Depto. of Ecology, Bioscience Institute, University of São Paulo, Rua do Matão, 321, travessa 14, 05509-900, São Paulo, SP, Brazil.
e-mail: acm@ib.usp.br

Introduction

Habitat loss and fragmentation are considered key factors currently threatening biodiversity (Wilcox and Murphy, 1985, Fahrig, 2003). There is a current debate in the literature (see revision in Fahrig 2003), where the effects of habitat cover and configuration are discussed, and there is no agreement at present. Some authors have suggested a major importance in habitat amount variables (McGarigal & McComb 1995, Drolet et. al. 1999, Trzcinski et. al. 1999), whilst others have suggested a larger importance of habitat configuration (Andrén 1994, Fahrig 1997, Villard et. al. 1999, Develey & Metzger 2006). There is a further hypothesis, where the relative importance of these variables may change along the habitat conversion gradient. Some authors even go further and have suggested a threshold point where configuration aspects could have a larger importance (around 20%, Andrén 1994, Fahrig 1997, 2001 e 2003, Flather & Bevers 2002).

Objective & Methods

In this context, our objective was to analyze the influence of the extent habitat and its configuration in the bird community, modeling the influence of the percentage of forest in three different radii (300, 500 and 800 m) as a measure of habitat amount; and fragment size and connectivity in different spatial scales, as configuration metrics. We sampled 34 fragments with different sizes and connectivity values, split equally in two regions of 10000 ha each, with different proportions of habitat (10 and 30%, that was also used in the habitat amount analyzes as two categories, and were chosen because of the threshold point suggested above) in the Atlantic Plateau of São Paulo, with the same forest quality and structure conditions. Connectivity variables taken in consideration were different scales of perceiving connectivity, diverse distances through open habitats (20, 40, 60 and 80 m) and the amount of habitat linked by a corridor of < 100m of width. As bird metrics we used community richness and abundance and species abundance. The sizes of the fragments were given by the area of the fragment that has width > 100 m, in addition to the areas with width < 100 m that do not connect to other forests areas. The areas < 100 m of width that connect to other forest areas were considered in the connectivity metric that accounts for the amount of habitat linked by corridors. The other connectivity metrics were given by the amount of habitat accessible for an individual of a species that is capable of crossing 20, 40, 60 and 80 m of open habitat. Matrix heterogeneity was not considered, since it was very similar. Comparisons within regions were made with the observed values of richness and abundance, since effort in all sampling spots from the same region was very similar. However, for comparisons between regions, we did 9908 bootstraps of 1000 individuals in each case, and then compared the obtained simulated results. We used AICc obtained from likelihood regressions with Poisson error distribution and the evidence ration, following Burnham and Anderson (2002) to compare the models.

Results

Our results showed the frequent presence of the variable representing the two different regions (10 and 30% different proportions of forest), both in their influence as a covariable and as an interaction, showing that bird community behavior differs from region to region, and that landscape parameters also vary from region to region. We observed the whole gradient from the positive affected by a smaller amount of habitat in the landscape, such as *Conopophaga lineata* and *Basileuterus leucoblepharus.* These are edge species which are not severely affected whereas the drastically negatively affected species are mainly terrestrial insectivores, trunk insectivorous, frugivorous/omnivorous and small insectivorous species. These species performed consistent through the different metrics, responding positively in relation to the extent of habitat and in relation to fragment size and connectivity, in an opposite way to the edge species. Some particularly affected species were principally affected by corridor connectivity, especially *Sclerurus scansor*, a terrestrial insectivore and *Lepidocolaptes fuscus* and *Sittasomus griseicapillus*¸ two trunk insectivorous species.

Discussion

Our results showed that in regions where a large proportion of forest is still present, bird community composition and distributions are mainly related to connectivity variables and also to habitat amount, whilst in areas where a lower amount of forest is present, fragment size was more important.

Management policies should therefore be different in areas with different amounts of forest, in some cases favoring the enhancement of fragment size and in others connectivity. Nevertheless, while increasing fragment size or connectivity, the amount of habitat automatically increases. Therefore, depending on the extent of the restoration, the focus should be on connectivity.

Nevertheless, some species seem to respond differently according to the analyzed scale for all variables. For example *L. fuscus* responds well to the extent of habitat at the smaller scales, but poorly at all other scales. This suggests that for different analyzed scales, we can obtain different relative influences, varying according to the species perception of landscapes.

References

Andrén, H. 1994. Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat - A Review. Oikos 71(3): 355-366.

Burnham, K. P., & Anderson, D. R. 2002. Model selection and multimodel inference: A practical information-theoretic approach. New York: Springer-Verlag.

Develey, P. F. & Metzger, J. P. 2006. Birds in Atlantic forest landscapes: effects of forest cover and configuration In: Emerging Threats to Tropical Forests ed. W. F. Laurance. Chicago : University of Chicago Press.

Drolet, B.; Desrochers, A. & Fortin, M. J. 1999. Effects of landscape structure on nesting songbird distribution in a harvested boreal forest. Condor 101: 699-704.

Fahrig, L. 1997. Relative effects of habitat loss and fragmentation on population extinction. Journal of Wildlife Management 61: 603-610.

Fahrig, L. 2001. How much habitat is enough? Biological Conservation 100: 65-74.

Fahrig, L., 2003. Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution and Systematics 34, 487-515.

Flather CH, Bevers M. 2002. Patchy reaction diffusion and population abundance: the relative importance of habitat amount and arrangement. American Naturalist 159:40–56

McGarigal, K. & McComb, W. C. 1995. Relationship between landscape structure and breeding birds in the Oregon Coast Range. Ecological Monographs 65: 235-260.

Trzcinski, M.K., Fahrig, L., Merriam, G. 1999. Independent effects of forest cover and fragmentation on the distributionof forest breeding birds. Ecological Applications 9: 586-593.

Villard, M. A., K. Trzcinski, and G. Merriam. 1999. Fragmentation effects on forest birds: relative influence of woodland cover and configuration on landscape occupancy. Conservation Biology 13: 774-783.

Wilcox, B.A., Murphy, D.D., 1985 Conservation strategy: the effects of fragmentation on extinction. American Naturalist 125 (6), 879-887.

Understory birds and forest cover: a strong association in a highly forested region in the Atlantic forest, Brazil

C. Banks, J.P. Metzger

Universidade de São Paulo, Instituto de Biociências, Departamento de Ecologia, Rua do Matão 321, trv 14, postal code 05508-900, Cidade Universitária, São Paulo – SP, Brazil.
e-mail: banks@ib.usp.br

Introduction

Habitat loss has been indicated as the major factor contributing to species extinction, while the influence of fragmentation is not as well established since both positive and negative outcomes have been reached (Fahrig, 2003). These effects may depend on several factors, such as the amount of habitat cover in the landscape and species behavior. It has been proposed that over 20-30% of forest cover the effects of fragmentation are reduced or inexistent (Fahrig, 2003). In highly forested areas it is expected to find more sensitive species, with greater area requirements and less ability to cross open areas, while in intensively fragmented landscape (Stotz *et al.,* 1996). This project aimed to study how habitat loss and fragmentation affect understory birds in an Atlantic Forest region located in the Plateau of São Paulo, Brazil.

Methods

We studied two landscapes of 10.000 ha each, one with 45% of overall forest cover (fragmented landscape) and one with > 90% of forest cover (forested landscape). In the fragmented landscape, we chose 19 sampling points ranging from 20 to 80% of forest cover within a 800 m radius (approximately 200 ha), considering different fragmentation levels, measured by the Matheron Index. Understory species usually have area requirements of approximately 10 ha (*Stotz et al.* 1996), so this area should comprise home range of several individuals. We also sampled four sites in a 100% forest cover context in the forested landscape. Each site was located at least 50 m from forest edges and distant to each other by a minimum of 1200 m. The understory bird community was sampled with the use of mist nets for 510 net-hours in each site. We used linear regressions to analyze how forest cover percentage and fragmentation affected species richness and abundance of the overall assemblage of birds, insectivorous, frugivorous, nectarivorous and forest interior bird species.

Results

In total 1613 birds of 91 species were captured, including 1222 individuals of 72 species at the fragmented landscape and 367 individuals of 61 species at the forested landscape. Among patches, forest cover positively affected the richness of the overall bird assemblage, frugivorous and forest interior birds, and the abundance of the forest interior birds. When continuous forest sites were included in the regression models, forest cover continued to positively affect the same variables, except for forest interior species abundance. Fragmentation measured by the the Matheron Index positively affected the overall bird species richness. However, when continuous sites were included, fragmentation instead negatively affected the abundance of nectarivorous birds (Table 1).

Discussion

As predicted (Fahrig 2003, Develey & Metzger, 2006), forest cover consistently affected species richness and abundance. In addition, the squared multiple R shows that a great part of the variability in species richness and abundance is explained by the forest cover percentage in an 800 m radius neighborhood. This shows that in highly forested regions, the estimation of habitat cover in an area of 800 m radius could be a good predictor of the overall species richness and of forest interior species richness, those of greatest value for conservation. Conversely, fragmentation yielded weaker and contrasting results. The overall species richness among forest patches was positively affected by fragmentation, but due to an interaction with forest cover. This result indicates that more forested and fragmented sites have higher richness since they are able to comprise forest interior species and edge habitat species in the same place. Hummingbirds, which are thought to be benefited by habitat loss and fragmentation (Stouffer & Bierregaard, 1995), in this study, had its abundance negatively affected by the Matheron Index. It is possible that these birds are more sensitive than previous studies indicate. Therefore, in highly forested regions such as this, fragmentation is in fact less important to predict species richness and abundance than the amount of forest cover. Although it benefits edge habitat species, the effects of fragmentation, in this region, are not strong enough to endanger more sensitive species.

Table 1. Linear regression results for the overall bird assemblage, nectarivorous, insectivorous, frugivorous and forest interior bird species, in relation to forest cover percentage (% cover) and the Matheron Index (Frag). Squared multiple R and probability of type I error (P) are separated for forest fragments only (19 sampling areas) and for forest fragments and continuous forest sites (23 areas). When independent variable was significant, it is indicated inside parenthesis whether effects were positive or negative. Inside brackets it is indicated the total richness and abundance of each bird assemblage.

	Forest fragments			Continuous forest and fragments		
	r^2	% cover	Frag	r^2	% cover	Frag
Overall bird species						
Richness [91]	0.288	0.027 (+)	0.043 (+)	0.414	0.04 (+)	0.437
Abundance [1613]	0.004	0.911	0.807	0.257	0.973	0.319
Nectativorous birds						
Richness [9]	0.241	0.592	0.238	0.283	0.556	0.115
Abundance [124]	0.173	0.157	0.821	0.321	0.144	0.023 (-)
Insectivorous birds						
Richness [58]	0.157	0.118	0.156	0.231	0.127	0.486
Abundance [987]	0.009	0.712	0.775	0.111	0.714	0.786
Frugivorous birds						
Richness [19]	0.296	0.02 (+)	0.086	0.415	0.015 (+)	0.187
Abundance [312]	0.002	0.947	0.951	0.24	0.898	0.274
Forest interior species						
Richness [45]	0.493	0.003 (+)	0.277	0.796	0.002 (+)	0.97
Abundance [365]	0.39	0.024 (+)	0.803	0.775	0.149	0.071

Financial support was provided by CNPq («No_Proc_Inst») for field work and a PhD scholarship.

References

Develey, P.F. & Metzger, J.P. (2006) Extinction thresholds in Atlantic forest birds: effects of landscape cover and configuration. In: Laurance, W. & Peres, C. (Eds.). Emerging Threats to Tropical Forests. University of Chicago Press, Chicago.

Fahrig, L. (2003) Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution and Systematics, 34:487-515.

Stotz, D. F.; J. W. Fitzpatrick; T. A. Parker III and D. K. Moskovits, (1996) Neotropical Birds: Ecology and Conservation. Chicago Press

Stouffer, P. C. & Bierregaard, R.O. (1995) Effects of forest fragmentation on understory hummingbirds in Amazonian Brazil. Conservation Biology 9(5):1085-1094.

Modelling the influence of landscape structure on the incidence pattern of bird species living in fragmented Brazilian Atlantic forest

D. Boscolo[1], J.P. Metzger[2], K. Frank[3].

[1,2] Departamento de Ecologia, Instituto de Biociências, Universidade de São Paulo - USP, Rua do Matão, trav. 14, nº 321, Cid. Universitaria, São Paulo, Brazil, zip: 05508-900.
[1]e-mail: danilob@ib.usp.br
[3] Helmholtz zentrum für Umweltforschung – UFZ, Ökologische Systemanalyse-OESA, PF 500135, 04301 Leipzig, Germany.

Introduction

Habitat loss and fragmentation are among the most important threats to biodiversity conservation. They reduce habitat availability, increase isolation and generate patchy environments. At highly fragmented landscapes, changes in habitat spatial structure may profoundly affect species survival, leading several populations to higher chances of local extinction (Wiens, 1995; Lindenmayer *et al.*, 1999; Meyer and Cameron, 2003). Proposing efficient conservation strategies for such species relies initially on understanding how the structure of fragmented landscapes may influence their incidence pattern (Cushman and McGarigal, 2004). The objective of the current study was to understand the influence of forest spatial distribution on the occurrence of three Brazilian Atlantic Forest bird species (*Chiroxiphia caudata, Xiphorhynchus fuscus* and *Pyriglena leucoptera*) found in fragmented environments in order to model their incidence pattern based on patch size, connectivity and the surrounding landscape structure.

Methods

Presence/absence data

Four fragmented landscapes from the Atlantic plateau of São Paulo, Brazil, were used for the current study. Data on the birds' presence/absence pattern were collected at the central point of 80 forest patches (20 at each landscape) with the use of playback techniques. The methodology used enabled a large number of sites to be surveyed with great precision, while reducing the risk of false absence records (Boscolo *et al.*, 2006).

Incidence models

Patch size and other eight indices describing the landscape structure inside an 800 m radius circle surrounding each sampled point were estimated using FRAGSTATS™ (McGarigal *et al.*, 2002). Multivariate logistic models were used to analyse the relationship between the incidence pattern of the birds and the landscape structure. Such models were generated using backward stepwise regressions and the minimal adequate ones were selected by the lowest Akaike's Information Criterion (AIC).

Results and Discussion

The minimum adequate models of each species contained only two (*C. caudata* and *P. leucoptera*) or three (*X. fuscus*) of the original explanatory variables (Tab. 1). Bird incidence was in general positively affected by higher habitat cover and functional connectivity and by smaller inter-patch distances. These results indicate that the studied species are able to overcome short distances through the matrix. This allows the birds to supplement their habitat needs in highly fragmented landscapes by including several nearby patches in their home-ranges, a process called landscape supplementation (Dunning *et al.*, 1992). Broad conservation strategies concerning small passerine birds living in fragmented Atlantic forest should focus firstly, but not exclusively, on increasing patch density and connectivity, in order to reduce the average distance between forest remnants, essential for the persistence of a wide range of species. This is especially important for places where human activity is intense and the implementation of large reserves is not possible. In such cases, the promotion of forest networks and stepping-stones between patches might be the most effective restoration strategy. The generated models can also be used to produce habitat maps based on the birds' perception of the landscape, which are useful to be applied in spatially explicit population analysis.

Table 1. Final multivariate models for all species. β**:** regression coefficient for each selected variable; χ^2: test values with significance in brackets; AIC: Akaike's information criterion; R^2: model's predictive power. See McGarigal *et al.* (2002) for detailed variable descriptions.

Species	**Explanatory variables**	β	χ^2(p)	AIC	R^2
C. caudata	· Patch size	0.1597	32.32 (<0.001)	46.289	0.563
	· Mean Euclidian distance to the nearest patch	-0.0325			
X. fuscus	· Patch density	0.8086	30.18 (<0.001)	64.984	0.475
	· Percentage of patch connections considering a functional linkage distance of 150 m	0.1908			
	· Mean Euclidian distance to the nearest patch	0.0211			
P. leucoptera	· Patch density	0.1212	27.09 (<0.001)	89.365	0.384
	· Proportion of forest	0.0845			

Financial support was provided by FAPESP (n. 05123-4) and CNPq (n. «No_Proc_Inst» and 200848/2005-4).

References

Boscolo, D; Metzger, J.P. & Vielliard, J.M.E. (2006) Efficiency of playback for assessing the occurrence of five bird species in Brazilian Atlantic Forest fragments. *Anais da academia brasileira de ciências* **78:** 629-644.

Cushman, S.A. & McGarigal, K. (2004) Patterns in the species-environment relationship depend on both scale and choice of response variables. *Oikos* **105:** 117-124.

Dunning, J.B; Danielson, B.J. & Pulliam, H.R. (1992) Ecological processes that affect populations in complex landscapes. *Oikos* 65: 169-175.

Lindenmayer, D.B; McCarthy, M.A. & Pope, M.L. (1999) Arboreal marsupial incidence in eucalypt patches in south-eastern Australia: a test of Hanski's incidence function metapopulation for pacth occupancy. *Oikos* **84:** 99-109.

Meyer, A.L. & Cameron, G.N. (2003) Landscape characteristics, spatial extent, and breeding bird diversity in Ohio, USA. *Diversity and Distributions* **9:** 297-311.

Wiens, J.A. (1995) Habitat fragmentation: island vs landscape perspectives on bird conservation. *Ibis* **137:** 97-104.

Airborne Laser Scanning data provide three-dimensional information for analyses of woodland bird habitats

H. Hashimoto[1], J. Imanishi[2] and Y. Morimoto[2]

[1] Faculty of Agriculture, Meijo University, 501 Shiogamaguchi 1, Tenpaku-ku, Nagoya City, 468-8502, Japan.
e-mail: hihashi@ccmfs.meijo-u.ac.jp
[2] Graduate School of Global Environmental Studies, Kyoto University, Kyoto City, 606-8502, Japan

Introduction

Woodland bird species habitats are affected by the vertical forest structure and by topography. We analyzed woodland birds - habitat relationship in a hillside forest in Kyoto City, central Japan, from a landscape ecological perspective using a multilayer GIS map created from two types of remote sensing data.

Method

Study area

The study area is the Kamigamo Experimental Station of Field Science Education and Research Centre Kyoto University, a hillside secondary forest in Kyoto City, central Japan. This forest consisted from mainly evergreen coniferous trees and deciduous broad-leave trees.

Bird data

Bird data were collected using an hour line census during the breeding seasons and the wintering seasons of 2002-2004. Bird survey was conducted twelve mornings without rain.

Environmental variables

Remote sensing data we used were airborne laser scanning data (RAMS library data) obtained in the spring of 2001 and a high spatial resolution satellite image by Quick Bird obtained in the autumn of 2003. Density of RAMS data is approximately a laser flux per a 2 m x 2 m space, and it records maximally five pulses per a laser flux.

We created maps of maximum tree height, mean vegetation height, slope gradient and slope aspect from the airborne laser scanning data, and the percentages of vegetation cover maps of evergreen trees, deciduous trees and shrub (under 5 m tall) from the Quick Bird satellite image and laser scanning data. These indices were calculated in each 30 m x 30 m grid. Therefore, a GIS based vegetation and topography map consisted from seven raster layers was derived. The procedure for creating DEM from laser scanning data was followed Yonedu and Hasegawa (2004). Tree height was calculated from 5 m x 5 m grid of DSM and DEM.

Maximum tree height, mean vegetation height, and the percentages of evergreen trees, deciduous trees and shrub in each 90 m x 90 m grid were also calculated from the GIS map as environmental variables.

Data analysis

A GIS based vegetation and topography map and bird data were overlaid (Figure 1), and habitat preferences of each species were analyzed.

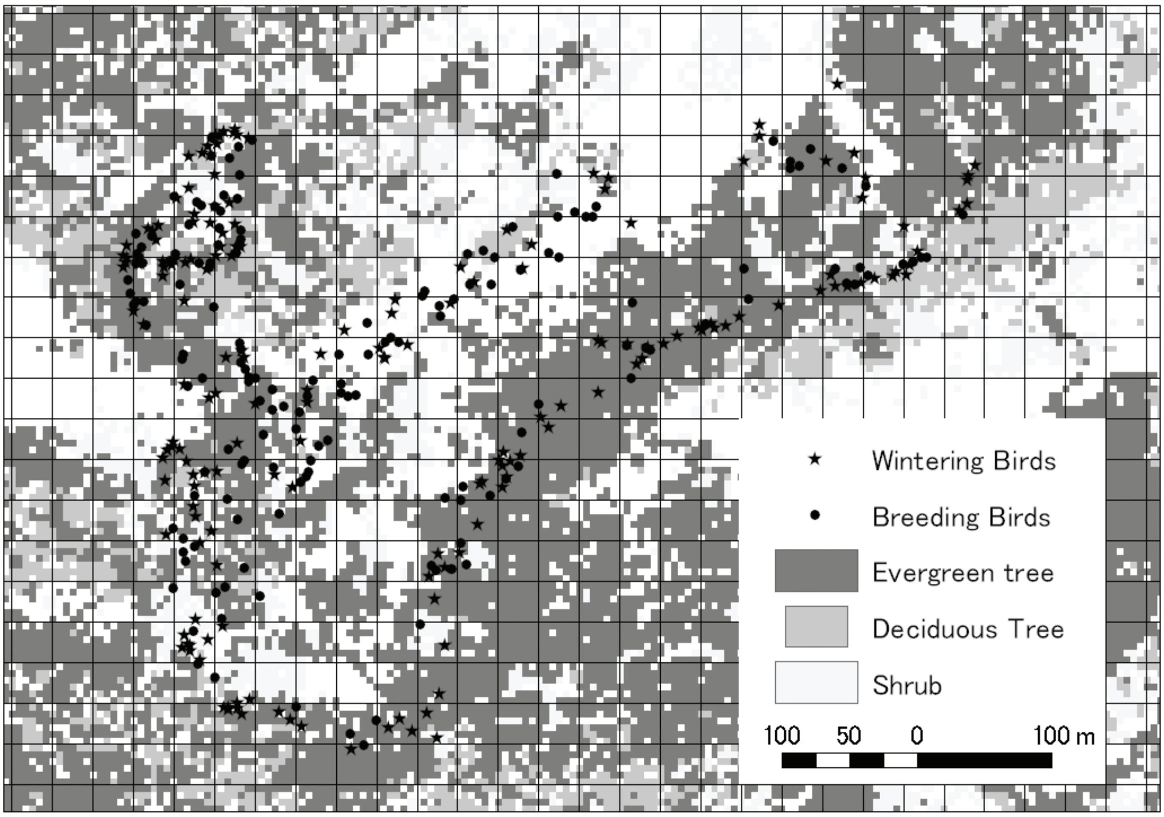


Figure 1. A GIS based vegetation map and bird data. A grid size is 30 m x 30 m.

Results & Discussion

The results of overlaying vegetation and topographic map and bird data, habitat preferences of some species were quantified. For instance, Jungle Crows *Corvus macrorhynchos* preferred steep slope, Black-faced Buntings *Emberiza spodocephala* in wintering season and Bush Warblers *Cettia diphone* in breeding season need some area of shrub vegetation.

Application of laser scanning data for bird habitat evaluation was proposed by Hinsley *et al.* (2002). Laser scanning data provide us three-dimensional information such as vegetation height and topographic information also. Especially vegetation height is very important for evaluating woodland bird habitat. Although field measurement of tree height in broad area is difficult, airborne laser scanners can easily measure tree height distribution in broad area.

Although obtaining high resolution of laser scanning data is very expensive, library data have already prepared around urban area in Japan, and we can easily purchase them. Although there are several limitations in use of library data (i.e. we cannot design scanning year and season), laser scanning data provide us useful three-dimensional information of forest vegetation for evaluating woodland bird habitats in landscape level.

References

Hinsley, S.A.; Hill, R.A.; Gaveau, D.L.A. & Bellamy, P.E. (2002) Quantifying woodland structure and habitat quality for birds using airborne laser scanning. *Functional Ecology* **16:** 851-857.

Yonedu, K & Hasegawa, N. (2004) A filtering method for creating DEM from airborne LiDAR in mountainous forests. *Abstracts for 115th meeting of the Japanese Forestry Society***:** 476. (in Japanese)

Effects of landscape patterns and resource distribution on frugivorous birds in the Central Andes of Colombia: tracking ecological thresholds

J. E. Mendoza[1], G. H. Kattan[2], J. de Jong[3]

[1] Swedish Biodiversity Centre – Swedish University of Agricultural Sciences, Uppsala, Sweden and Alexander von Humboldt Institute, Diag. 27 #15-09, Bogotá, Colombia.
e-mail: jemendoza@humboldt.org.co
[2] Fundación EcoAndina/Wildlife Conservation Society Colombia Program, Av. 2 oeste #10-54. Cali, Colombia.
[3] Swedish Biodiversity Centre – Swedish University of Agricultural Sciences, Bäcklösavägen 10, Box 7007 S-750 07 Uppsala, Sweden

Introduction

Understanding wildlife distributional patterns and their relationship with landscape characteristics and resource distribution is key for their conservation, especially in rural landscapes. Theoretically, there are threshold values in habitat amount and configuration, below which species persistence is compromised. Searching for ecological thresholds is one of the most promising avenues to ensure the conservation of many species (Hugget, 2005). In this sense, the recognition of empirical thresholds existing in landscapes is a major step forward in understanding community level responses to landscape changes (Radford *et al*. 2005). We analyzed the response of forest frugivorous bird species to the distribution of key fruiting trees (*Cecropia*, *Ficus* and *Miconia*) and landscape characteristics of forest patches (habitat amount, edge length, number of land covers, number of patches) at three different spatial scales, local (3 ha), middle (312 ha) and landscape (2500 ha), in the Central Andes of Colombia to look for evidence of statistically significant ecological thresholds.

Methods

We used data from four 2,500 ha rural landscapes with different fragmentation levels (80%, 46%, 35% and 25% forest cover) between 1,700 and 2,100 m on the western slope of the Central Andes. Data on species richness and abundance of frugivorous birds were collected in point counts (50m radius) in forest patches, and abundance of key fruiting trees were collected in 4 adjacent 50x4m transects. To evaluate relationships between bird species abundance and distribution, and potential explanatory variables (landscape characteristics, and fruiting tree abundance and richness) at the three ecological scales, we ran canonical correspondence analyses (CCA). We combined stepwise logistic regressions and receiver operation characteristic (ROC) curves to detect thresholds in species occurrence (Guénette & Villard, 2004, 2005). For this, we used single specific explanatory variables to test the bird responses. Because we found significant spatial autocorrelation in our variables (Moran's Index between 0.16 to -0.22), and to reduce the likelihood of committing Type I errors, we used a conservative level of significance in our analysis (α = 0.01). However, for threshold identification, marginally significant values (α = 0.02) were also considered.

Results

We found a consistent response of the explanatory variables across scales. Axis 1 in the CCAs grouped landscape variables, which explained 28-40% of the variance in bird species richness. Amount of suitable habitat was always opposite to edge length, number of land covers and number of patches in this axis. All forest interior bird species were positively correlated with this variable. Axis 2 in CCAs represented fruiting resources distribution at all scales. The three first eigenvalues explained 43% of total variability at local scale, 59% at middle scale and 79% at the landscape scale.

At the local scale (3 ha), out of 23 bird species abundant enough to be included in the analysis, 14 sensitive species showed a significant relationship to at least one variable. Nine species showed a negative relationship to edge length and number of land covers, and 13 were positive to variables like patch area, amount of suitable habitat amount and abundance of *Ficus*. Curves of the expected number of sensitive species (based on their ROC-derived thresholds) showed that forest patches of 98 ha are necessary to conserve species negatively affected by habitat alteration such as *Penelope perspicax, Mionectes olivaceus,* and *Aratinga wagleri*. Habitat heterogeneity was detrimental for species like *Aulacorhynchus prasinus, Penelope perspicax, Pharomachrus auriceps* which need less than 1.5 kinds of land covers within 3 ha to ensure their presence. Furthermore, the presence of these forest interior species seems to depend on edge lengths being shorter than 127.55 m.

At the middle scale (312 ha), 6 sensitive species showed a positive relationship to amount of suitable habitat and *Ficus* abundance, whereas 2 species showed a negative relationship to number of land covers. Arrangements of minimum 84 ha of forest, and fewer than 3.5 land covers will ensure the presence of *Euphonia xanthogaster*. For *Penelope perspicax* and *Pyroderus scutatus*, forest patches of 212 and 207 ha respectively are needed to ensure their presence. At the landscape scale no significant relationships were found because of the small number of replicates.

Conclusions

The community of frugivorous bird species responded more strongly to landscape characteristics than to *Cecropia*, *Ficus* and *Miconia* abundance and richness. large-bodied bird species, which are highly endangered, require large forest patches with few edges to be conserved. Our study shows the relevance of local and middle scales in bird species responses of tropical mountain ecosystems to landscape changes. The conservation of species negatively affected by habitat alteration is a great challenge in these ecosystems, and frugivorous birds are one of the most vulnerable guilds to landscape transformation processes. Our work is one of the first initiatives to identify ecological thresholds related with habitat requirements for tropical species and provide tools for conservation strategies, landscape planning and ecological restoration initiatives which have sensitive bird species as targets or phase indicators.

References

Guénette, J. S. and Villard, M. A. (2004). Do empirical thresholds truly reflect species tolerance to habitat alteration? *Ecological Bulletins* 51:163-171.

Guénette, J. S. and Villard, M. A. (2005). Thresholds in forest bird response to habitat alteration as quantitative targets for conservation. *Conservation Biology* 19:1168-1180.

Hugget, A.J., (2005). The concept and utility of ecological thresholds in biodiversity conservation, *Biological Conservation* 124: 301–310.

Radford, J.Q., Andrew, A.F. & Cheers, G.J. (2005). Landscape thresholds of habitat cover for woodland – dependent birds. *Biological Conservation* 124:317-337.

Continent-scale patterns in temporal dynamics of avian assemblages

M. Maron[1,2], P.K. Dunn [1,2] and A. Apan[1,3]

[1] Australian Centre for Sustainable Catchments, University of Southern Queensland, Toowoomba, Queensland 4350, Australia.
e-mail: maron@usq.edu.au
[2] Faculty of Sciences, University of Southern Queensland, Toowoomba, Queensland 4350, Australia.
[3] Faculty of Engineering & Surveying, University of Southern Queensland, Toowoomba, Queensland 4350, Australia.

Introduction

A common method of characterizing the bird assemblages of sites in landscape ecological research is to conduct a series of snapshot-type surveys, often over less than one year (Maron *et al.* 2005). However, highly mobile taxa such as birds show substantial inter-annual variability in species richness and community composition (e.g. Holmes *et al.* 1986), and this may have implications for the veracity of snapshot-derived patterns. The environmental correlates of inter-annual variability in bird assemblages are not well known, although it seems likely that more climatically stable regions support less dynamic avian assemblages (Jarvinen 1979). We conducted a continent-scale study to investigate associations between environmental factors and annual bird assemblage turnover rates in Australia. Correlates of inter-annual bird assemblage variability have rarely been investigated at this scale as long-term data from across a broad area are required. However, the availability of long-term, large-scale databases from volunteer-based monitoring initiatives provides opportunities for comparisons across large areas. For example, data from the North American Breeding Bird Survey revealed increased annual turnover in landscapes with smaller forest patches (Boulinier *et al.* 2001).

Methods

We used Birds Australia Atlas data from the period 1998-2005 to examine bird assemblage variability in regularly surveyed 2-ha sites across Australia. Only sites which had been surveyed for a minimum of three consecutive years and in all seasons per year (autumn, winter, spring, summer) were included in the analysis. For sites with multiple surveys per season, data for one survey per season in each year were randomly selected for inclusion. We excluded sites in close proximity so that all were at least 1km distant from one another. Apparent annual turnover (T) for each pair of consecutive years was calculated by expressing the number of compositional changes (new presences and new absences) as a proportion of the total 'species pool' as follows (after Maron *et al*. 2005):

$$T = \frac{E + C}{S_{tot}} \times 100$$

where E = number of species occurring in the first but not the second year, C = number of species occurring in the second but not the first year, and S_{tot} = total number of species recorded across both years. The mean of T for each site is hereafter referred to as 'turnover'.

Data collected by the volunteer observers about the site included the area of the vegetation patch in which the 2-ha site was situated, grazing and logging history, distance to permanent water, conservation status, degree of isolation, latitude, and longitude. We used data from the Australian Bureau of Meteorology to add information on mean annual rainfall and the annual rainfall variability index. Stepwise multiple regression using Akaike's Information

Criterion and weighted by the number of year-pairs available for a site was used to develop predictive models for both turnover and mean annual species richness.

Results & discussion

The final multiple regression model for turnover included the variables rainfall variability and distance to permanent water, with mean annual turnover higher in areas of higher rainfall variability and further from water. However, there was a large number of missing values for distance to water, and the overall explanatory ability of the model was low (R^2 = 0.06). More variable rainfall patterns result in increased year-to-year vegetation change, particularly in the arid zone which comprises much of Australia. Nomadic behaviour in birds is likely to be more prevalent in areas of higher rainfall variability (Wiens 1991) and such behaviour was probably a major contributor to the pattern of higher bird community variability in sites with higher rainfall variability.

The final model for mean annual species richness was able to account for 26% of the variation in species richness and suggested higher species richness for sites with higher average annual rainfall, lower annual rainfall variability and at lower latitudes. Sites with higher mean species richness were more likely to have more stable bird communities.

Mean apparent annual turnover across all sites was 55%. This is broadly comparable with the 63% apparent turnover recorded for birds in a series of woodland sites in southeastern Australia (Maron et al. 2005) and the 52-60% observed by Collins et al. (2000) for breeding birds in tallgrass prairie in the USA. The substantial interannual variability recorded suggests that bird assemblages in Australia should not be viewed as stable or equilibrial but as fluctuating substantially, particularly in areas of high climatic variability and low species richness. The generally high turnover recorded even in fairly climatically stable regions suggests that pictures of avian assemblages based on a few surveys over one year are substantially incomplete.

References

Boulinier, T; Nichols, J. D; Hines, J. E; Sauer, J. R; Flather, C. H. & Pollock K. H. (2001) Forest fragmentation and bird community dynamics: Inference at regional scales. *Ecology* **82:** 1159-1169.

Collins, S. L. (2000) Disturbance frequency and community stability in native tallgrass prairie. *American Naturalist* **155:** 311-325.

Holmes, R. T; Sherry, T. W. & Sturges, F. W. (1986) Bird Community Dynamics in a Temperate Deciduous Forest: Long-Term Trends at Hubbard Brook. *Ecological Monographs* **56:** 201-220.

Jarvinen, O. 1979. Geographical gradients of stability in European land bird communities. *Oecologia* **38:** 51-69.

Maron, M; Lill, A; Watson, D. M. & Mac Nally, R. (2005) Temporal variation in bird assemblages: how representative is a one-year snapshot? *Austral Ecology* **30:** 383-394.

Wiens, J. A. (1991) Ecological Similarity of Shrub-Desert Avifaunas of Australia and North America. *Ecology* **72:** 479-495.

Response of two diurnal raptors, the Common Buzzard (*Buteo buteo*) and the Eurasian Kestrel (*Falco tinnunculus*), to agricultural intensity in three landscape units of Western France

N. Michel[1], V. Comor[2], Y. Rantier[2], Y. Delettre[2], F. Burel[2], A. Butet[2]

[1] Lab Ecology, Systematics and Evolution. Orsay University. CNRS. Bat. 360. Orsay France
e-mail: nadiamichel@hotmail.fr
[2] Centre Armoricain de Recherche en Environnement, UMR CNRS 6553 « Ecobio »,
Université de Rennes 1, 35042 Rennes France

Introduction

In front of agricultural intensification, there has been a wide decline in biodiversity. Several floral and faunal groups have been concerned by a reduction of abundance in farming landscapes. In particular, the period of intensification of farm management coincides with the decline of many farmland bird species (Fuller et al., 1995). In this study, we focused on two diurnal raptor species, the Common buzzard (*Buteo buteo*) and the Eurasian kestrel (*Falco tinnunculus*). The Common Buzzard (*Buteo buteo*) seem to be recovering in Europe from low populations due to past persecution and pesticide effects, while the Eurasian Kestrel (*Falco tinnunculus*) do not show similar positive trends (Hagemeijer and Blair, 1997). The populations of those two species in intensively-cultivated areas may be regarded as important ecological indicators and the monitoring of their trends as an important conservation task (Boano and Toffoli, 2002).

Methods

We carried out a one year survey of the abundance of these two species in several observation points in three agricultural landscapes of Western France (BOC1, BOC2 and POL) differing by their level of agricultural intensification The three sites are known to be on a gradient of land-use intensity (BOC1<BOC2<POL) and hedgerow network density (BOC1>BOC2>POL). We also made an estimation of the prey availability by trapping small mammals in hedgerows of the same sites during one year (7 trapping sessions).

Results & Discussion

The local abundance and biomass of small mammals differed between the three sites: they were significantly more numerous in the hedges of the most intensified site than in hedges of the two others. On the contrary, at the landscape scale, small mammal biomass was the lowest in the most intensified site because of the fragmentation of the hedgerow network, then in the medium site and it was the highest in the more preserved site (BOC1>BOC2>POL)(Figure 1).

It appeared that the two raptor species responded differently to agricultural intensification (Figure 1 & 2): the abundance of the Common Buzzard significantly decreased with the reduction of semi-natural elements such as hedgerows, woodlots and grasslands, as well as with the decrease of small mammal availability at the landscape scale (Suetens 1989). The abundance of the Eurasian kestrel showed the same tendency, but the correlation was not significant. We also showed that the Common Buzzard was very dependant to woody habitats, whereas the Eurasian kestrel was much more associated with grasslands (Suetens 1989) (figure 1).

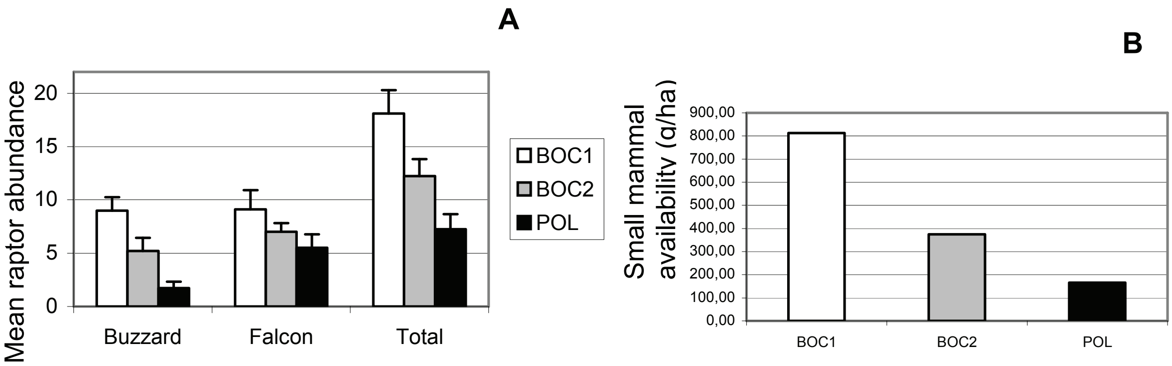


Figure 1. (A) Mean abundances of buzzards and falcons (± SD) (separated and combined), and (B) small mammal availability in hedgerows (g/ha) in the three landscape units.

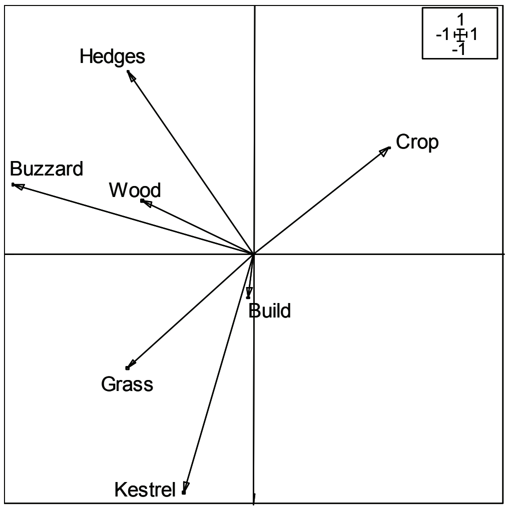


Figure 2. Projection of raptor species and landscape variables on the co-inertia plane (co-inertia analysis of landscape and faunal data) (F1= 98%; F2= 2%).

References

Fuller, R.J., Gregory, R.D., Gibbons, D.W., Marchant, J.H.W., Baillie, S.R. & Carter, N., (1995). Population declines and range contractions among lowland farmland birds in Britain. Conservation Biology, 9: 1425-1441.

Hagemeijer, W.J.M. & Blair, M.J., (1997). The EBCC atlas of European breeding birds. T & A.D. Poyser Ed., London, U.K.

Boano, G. & Toffoli, R., (2002). A line transect survey of wintering raptors in the western PO Plain of northern Italy. Journal of Raptor Research 36: 128-135.

Suetens, W., (1989). Les Rapaces d'Europe. Perron Editions

Effects of biogeographical factors on bird species sensibility to habitat fragmentation in the Atlantic Rainforest

R.G. Pimentel, E. Hasui, M.C. Ribeiro, J.P. Metzger

Landscape Ecology and Conservation Laboratory – LEPAC, Department of Ecology, Institute of Biosciences, University of São Paulo, Rua do Matão - travessa 14 nº 321 CEP 05508-900, São Paulo, Brazil.
e-mail: rafaelgpimentel@yahoo.com.br

Introduction

Habitat loss and fragmentation are the main factors acting on species decline and local extinctions. Nowadays, there is a vast literature concerning this issue, what allows some factors that exert influence on organisms during the fragmentation process to be identified (Laurance et al., 2002; Henle et al., 2005). Size and connectivity of the remaining patches are two factors that have been already discussed on their influence on organisms. On the other hand, there are some other factors that are still poorly known. Among these factors are the influences of biogeographical effects on species vulnerability to fragmentation. Some authors suggest that populations situated in the periphery of the total distribution of species are more sensitive than those situated in the centre (Gaston, 1990; Kattan et al., 1994). However, there is a lack of empirical evidences that support this model.

Objective

The present study aims to verify which factors best explain the sensibility of populations in a fragmented landscape, considering the habitat availability, connectivity of the patches and the localization in relation to total geographic distribution

Materials and Methods

Study area

The study area comprises a vast territorial extension of ca. 1.2 million of km^2 in the southeastern part of Brazil (14°17´-29°25´S; 39°40´-54°37´W). The predominant biome of the study area is the endangered Atlantic Rainforest. The selection of this area is based on a center of bird endemism, proposed by Silva et al. (2004). The vastness of this study area tends to comprise a high biogeographical variation.

Biological data

Data of species occurrence and abundance have been compiled in a database. These data have been obtained from the literature (i.e. papers and thesis) and museum records. This database comprises ~26,000 points of occurrence for 160 bird species.

Species distribution model

As part of this project will be generated potential distribution models for the bird species. For this purpose will be utilized only species occurrence data from the database. These models will be made for species which present more than 30 records. The potential distributions of birds will be modeled utilizing the GARP software. GARP utilizes genetic algorithm to select a set of association rules between species occurrence and environmental variables, and thus predict the species distribution (Stockwell and Peters, 1999). Thematic maps of the whole study area in a scale of resolution of 1:250,000 will be used as environmental variables. The probability of occurrence, obtained from the modeling procedure will be the biogeographical variable utilized in the posterior analyses.

Analysis of the effects of area, connectivity and biogeographical factor

To analyze the influence of biogeographical factors, area and connectivity on species abundance, multiple regression models will be built, having species abundance as dependent variable and as independent variables the area and connectivity of the patches and biogeographical factor. Species abundance data will be taken from the database. For the purpose of compare and estimate the best models generated by the multiple regressions, we will utilized the Akaike´s Information Criteria (AIC).

We will also conduct a landscape-level analysis. Landscape will be defined as an area with ca. 10,000 ha, containing at least 10 sampling points. In this landscape-level analysis a vulnerability index will be created as a function of the abundance of species in the sampled patches over the area of these patches. Then, this vulnerability index will be included as dependent variable in a multiple regression that will have the biogeographical factor, percentage of habitat and an aggregation index of remaining patches in the landscape as independent variable. AIC will also be used to estimate the best models.

Final Considerations

With this research we pretend to improve the comprehension of the factors that lead to a differential sensibility of species after the habitat fragmentation process. Besides, understanding differential sensibility of species mediated by biogeographical factors may help the selection of priorities areas for conservation and restoration in one of the most threatened biomes in the planet, the Atlantic Rainforest.

References

Gaston, K.J. (1990) Patterns in the geographical ranges of species. *Biological Reviews* **65:** 105-129.

Henle, K.; Davies, K.F.; Kleyer, M.; Margules, C. & Settele, J. (2004) Predictors of species sensitivity to fragmentation. *Biodiversity and Conservation* **13**: 207-251.

Kattan, G.H.; Alvarez-López, H. & Giraldo, M. (1994) Forest fragmentation and bird extinctions: San Antonio eighty years later. *Conservation Biology* **8(1):** 138-146.

Laurance, W.F.; Lovejoy, T.E.; Vasconcelos, H.L.; Bruna, H.E.M.; Didham, R.K.; Stouffer, P.C.; Gascon, C.; Bierregard, R.O.; Laurance, S.G. & Sampaio E. (2002) Ecosystem decay of Amazonian forest fragments: a 22-year investigation. *Conservation Biology* **16(3):** 605-618.

Silva, J.M.C.; Sousa, M.C. & Castelletti C.H.M. (2004) Areas of endemism for passerine birds in the Atlantic Forest, South America. *Global Ecology and Biogeography* **13**: 85-92.

Stockwell D. & Peters D. (1999) The GARP modeling system: problems and solution to automated spatial prediction.

Effects of forest landscape composition and structure on forest bird species richness in the Mediterranean at two different spatial scales

A. Gil-Tena, O. Torras, S. Saura

Departament d'Enginyeria Agroforestal. ETSEA. Universitat de Lleida. Av. Alcalde Rovira Roure, 191. 25198. Lleida. Spain.
e-mail: ssaura@eagrof.udl.es

Introduction

In the Mediterranean region there is a lack of knowledge on how forest landscape characteristics are related to different components of biodiversity. The required research in this topic should be tackled at different landscape scales, since ecological processes do not occur at a single scale, and forest management affects biodiversity in a wide range of scales, not only at the stand level. In this study we analyzed the influence of forest landscape characteristics on forest bird species richness at two different spatial scales and determined the most relevant factors for explaining forest bird species distribution.

Material and methods

The study area was Catalonia (a region of about 32,000 km^2 in NE Spain). Bird species richness was obtained at two spatial scales (1 km^2 and 100 km^2) from census carried out by volunteers within the Catalan Breeding Bird Atlas (1999-2002) and the Spanish Breeding Bird Atlas, and the forest landscape characteristics were extracted from the recent Spanish Forest Map (scale 1:50,000), developed within the Third Spanish National Forest Inventory. We considered a sample of 2,923 1 x 1 km UTM cells scattered throughout Catalonia and the whole lattice of 283 10x10 km UTM cells. The forest landscape variables were related to forest composition and structure (forest area, development stage, canopy cover, forest tree species diversity, etc.) and to forest configuration (fragmentation and shape indices). Analyses were performed separately for specialist, generalist and total species richness at the two scales of analysis.

Results and discussion

Too high forest canopy cover (above a threshold of 70 %) did not favour ($p<0.01$) species richness (see Figure 1), since too closed canopies may not allow the development of shrub strata which provide relevant forage and nest sites. Landscape characteristics explained more variation at broader scales (see Table 1) and this could be due to the greater data variability at 1 km^2 or to a better match with the home range of some forest bird species at the scale of 100 km^2. Agreeing with Mitchell *et al.* (2001), we found that specialists were more associated than generalists to forest landscape characteristics since the former use or appear in a greater extent in forest landscapes. As in previous researches forest area was the variable with a higher explanatory power (McGarigal and McComb, 1995; Trzcinski *et al.*, 1999; Radford *et al.*, 2005). Moreover, forest configuration had a minor effect on bird species richness compared to other composition variables like tree species diversity, which favoured bird species at both spatial scales. The relevance of some variables at one scale but not at the other (such as the development stage and the percentage of coniferous species) highlighted the need to consider different spatial scales for an adequate and integrated analysis and forest landscape management in the Mediterranean.

Table 1. Stepwise multiple regression analysis for total forest bird species richness and forest composition and structure variables. β: standardized coefficient; p: significance.

1 km^2	**Partial R^2**	**β**	**p**
Forest area	0.399	0.435	<0.0005
Forest development stage	0.064	0.240	<0.0005
Tree species diversity	0.024	0.156	<0.0005
Canopy closure diversity	0.001	0.043	0.005
Coniferous species percentage	0.001	-0.042	0.013
10 km^2	**Partial R^2**	**β**	**p**
Forest area	0.444	0.529	< 0.0005
Tree species diversity	0.103	0.473	< 0.0005
Coniferous species percentage	0.072	0.298	< 0.0005

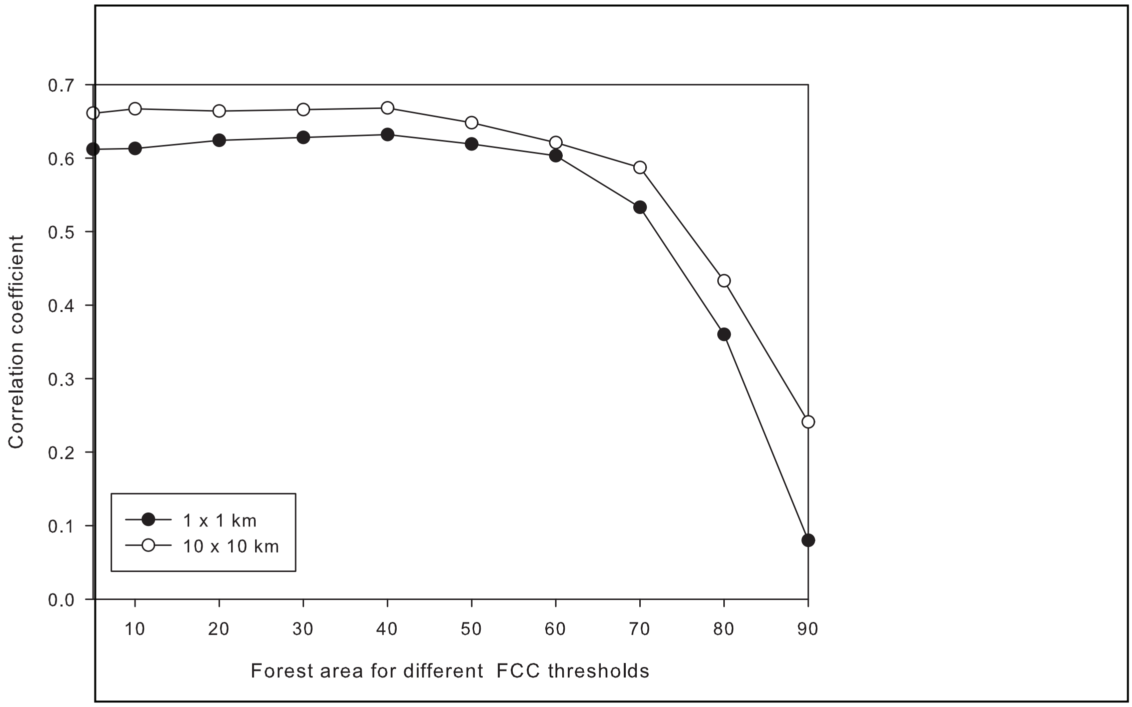


Figure 1. Correlations between forest bird species richness and forest area (m^2), defined as the area of land with a forest canopy cover (FCC) above a certain FCC threshold for the 1 x 1 km and the 10 x 10 km UTM cells.

References

Mitchell, M.S; Lancia, R.A. & Gerwin, J.A. (2001) Using landscape-level data to predict the distribution of birds on a managed forest: Effects of scale. *Ecological Applications* **11:** 1692-1708.

McGarigal, K. & McComb, W.C. (1995) Relationships between landscape structure and breeding birds in the Oregon Coast Range. *Ecological Monographs* **65:** 235-260.

Radford, J.Q; Bennett, A.F. & Cheers, G.J. (2005) Landscape-level thresholds of habitat cover for woodland-dependent birds. *Biological Conservation* **124:** 317-337.

Trzcinski, M.K; Fahrig, L. & Merriam, G. (1999) Independent effects of forest cover and fragmentation on the distribution of forest breeding birds. *Ecological Applications* **9:** 586-593.

Relative and independent effects of habitat amount, fragmentation, matrix quality, and road density on forest bird diversity

A.C. Smith[1], L. Fahrig[1], C. Francis[2]

[1] Geomatics and Landscape Ecology Research Laboratory, Carleton University, Ottawa, Ontario, Canada, K1S 5B6.
e-mail: adam_c_smith@sympatico.ca
[2] Environment Canada, National Wildlife Research Centre, Carleton University Ottawa, Ontario, Canada, K1A 0H3.

Introduction

The limited resources available for biodiversity conservation must be allocated towards conservation measures that will have the greatest impact. Habitat loss has a consistently strong, negative effect on biodiversity but in contrast, the effects of habitat fragmentation are about as likely to be positive as they are negative (Fahrig, 2003). In addition, multiple ecological processes responsible for configuration effects may have different effects on individual species within disparate ecological neighbourhoods and therefore fragmentation effects may be particularly scale dependent (Krawchuck and Taylor, 2003).

Methods

In order to determine what landscape factors most strongly influence forest bird diversity, we assessed the relative strength of the effects of amount of forest, habitat fragmentation, matrix composition, and roads on the species richness of forest birds in North American Bird Conservation Region 13 (Southern Ontario, Canada). To investigate the scale dependency of these relationships we compared the relative effects of the predictor variables measured within landscapes of different sizes (1-20 km radii) after controlling for local effects. We used bird data collected during the recent, Ontario Breeding Bird Atlas project and province-wide landcover data.

We used hierarchical variance partitioning to estimate the total independent influence of the five correlated predictor variables (Chevan and Sutherland, 1991) on the species richness of all forest dependent bird species and on a subset of species that in previous studies have shown significantly negative effects of fragmentation.

Results and Implications

Landscape Effects at 20 km

Landscape context explained an increasing proportion of the variation in forest bird species richness up to distances of 20km (Figure 1). To our knowledge, no previous study has shown effects of landscape context for any species at such a broad scale. These results suggest that forest birds in this region are sensitive to landscape features at distances much greater than are generally considered. It also highlights the fact that comparisons of the relative effects of local and landscape variables are scale dependent and may be highly biased.

Habitat Amount Stronger than Fragmentation or Matrix

Within landscapes of less than 30% forest cover, the amount of forest in the landscape explained significantly more variation in species richness of fragmentation sensitive birds than did either fragmentation measure or the amount of hostile matrix in the landscape at a 20km scale. Surprisingly, this group of presumably fragmentation sensitive species were much more strongly affected by the amount of habitat in the surrounding landscape than by either measure of fragmentation. The amount of habitat also had a consistently positive influence on species richness at all scales (85 – 99% of partial regression coefficients were positive). In addition, this subgroup did not respond consistently to either fragmentation metric with the exception of forest edge measured in relatively small landscapes (25 – 50% of partial regression coefficients were positive).

From these results we conclude that there should be one major conservation priority for forest birds in this region: the protection and/or restoration of forests. Managing the configuration of forest habitat to conserve forest bird diversity is likely a waste of precious resources.

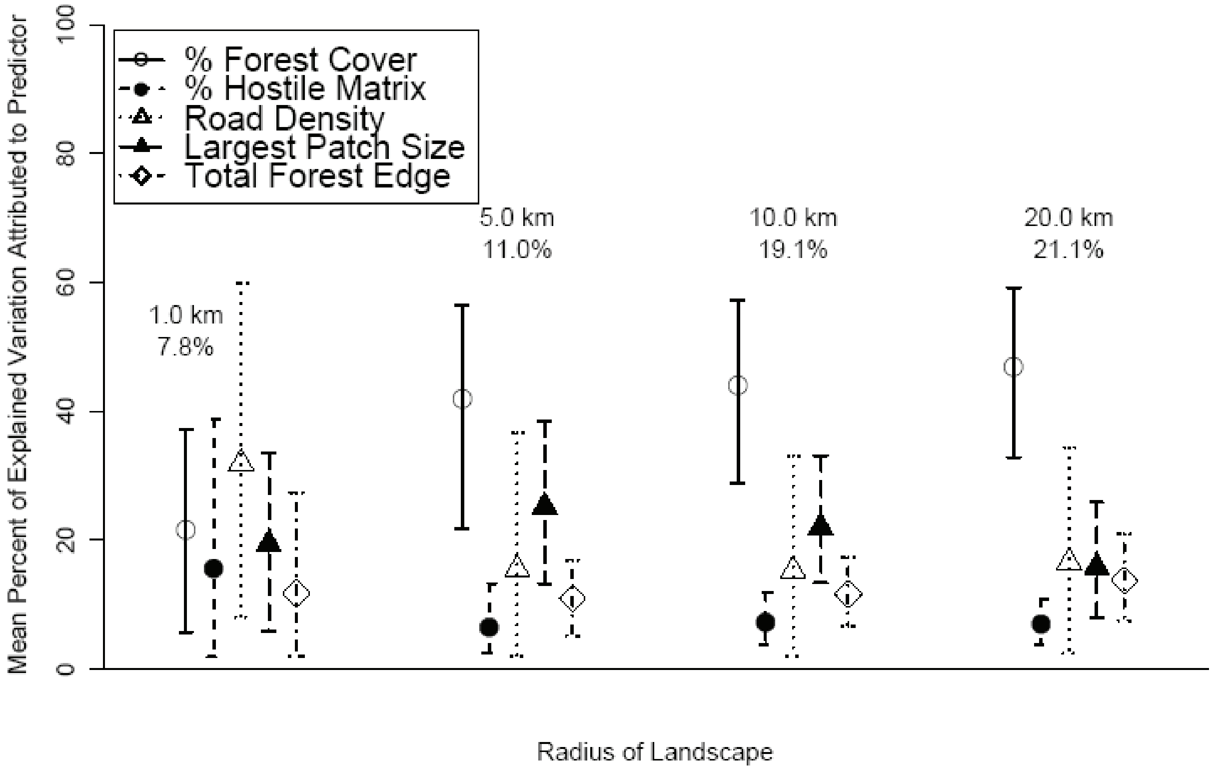


Figure 1. Average percent of explained variation within poisson regression models (n = 500 bootstrapped samples) that can be independently allocated to one of five correlated landscape predictor variables using hierarchical variance partitioning, within landscapes of increasing radius. Error bars indicate 90% confidence limits and printed percent values within the plot indicated the proportion of total variation in the response explained by the model containing all five predictors.

References

Chevan, A; & Sutherland, M. (1991) Hierarchical partitioning. *The American Statistician* **45:** 90-96.

Fahrig, L. (2003) Effects of habitat fragmentation on biodiversity. *Annual Review of Ecology, Evolution and Systematics* **159:** 40-56.

Krawchuck, M; & Taylor, P. (2003) Changing importance of habitat structure across multiple spatial scales for three species of insects. *Oikos* **103:** 153-161.

Birds respond to large landscapes more than to "islands"

M.A. Cunningham[1,2], D.H. Johnson[2]

[1]Vassar College, 124 Raymond Ave., Poughkeepsie NY 12604, USA.
e-mail: macunningham@vassar.edu
[2]Northern Prairie Wildlife Research Center, United States Geological Survey, Biological Resources Division, Jamestown, ND, 58401 USA.

Introduction

The "island-matrix" model has long been used to describe fragmented habitat areas. This model, or metaphor, has been useful but also has inherent flaws, including the assumption that researchers can accurately characterize habitat patches and boundaries, that species use only one habitat type, and that matrix is a dangerous, or at best neutral, component of a landscape. Recently, landscape ecologists have sought alternatives to the island-matrix framework in modeling fragmented landscapes (Villard 1998, Haila 2002, Kupfer *et al*. 2006). As an alternative, we find that a useful, parsimonious method of characterizing landscapes is to calculate percentage of habitat within buffers around sample points. While this method still assumes that the researcher can meaningfully differentiate habitat types, if avoids critical assumptions that multiple patches are functionally separate and that a single patch is internally similar. This approach is simultaneously sensitive to the extensiveness of individual patches and to a patch's surrounding environment. It can easily be calculated at a range of scales, and for most species in our study area, habitat responses changed little as scales of analysis increased.

<u>Habitat responses in an oak savanna landscape</u>

We examined responses of woodland and grassland birds to percentage tree cover on >3,000 transect segments in a mixed grassland-woodland landscape in eastern North Dakota, USA (Cunningham and Johnson 2006). We evaluated probability of occurrence in response to percentage tree cover in the landscape. A majority of species responded similarly at a range of scales (figure 1). Even when proximate landscape conditions were held constant, most of these species selected disproportionately wooded or open conditions in large landscapes. Thus large landscapes had influence independent of proximate landscape conditions. At the same time, there was interaction between scales. Many woodland birds, for example, selected for more wooded proximate conditions when in open landscapes than when in wooded landscapes. In contrast, species had little response to patch size (figure 2).

In addition to the advantages noted above for this approach, our method allows consideration of species that rely on more than one habitat type. In a study of 40 woodland species occupying an oak savanna habitat, 17 species preferentially occupied mixed habitat and were most abundant at 30-50 percent tree cover. Many species also occupied more than one habitat type, although there was a spectrum of preferences from strong interior to strong edge-association.

Conclusions

These results suggest that percentage cover is a useful alternative to the "island-matrix" approach in modeling fragmented landscapes, especially where (1) the "matrix" is not absolutely unsuitable, (2) species move readily among fragments, or (3) where species use multiple habitat types, either opportunistically or as obligates.

For presence/absence data, our observations indicate that landscape composition provides a parsimonious, easily reproduced approach. Patch size, on the other hand, predicts occurrence much more weakly, a finding consistent with ambiguous results in previous studies.

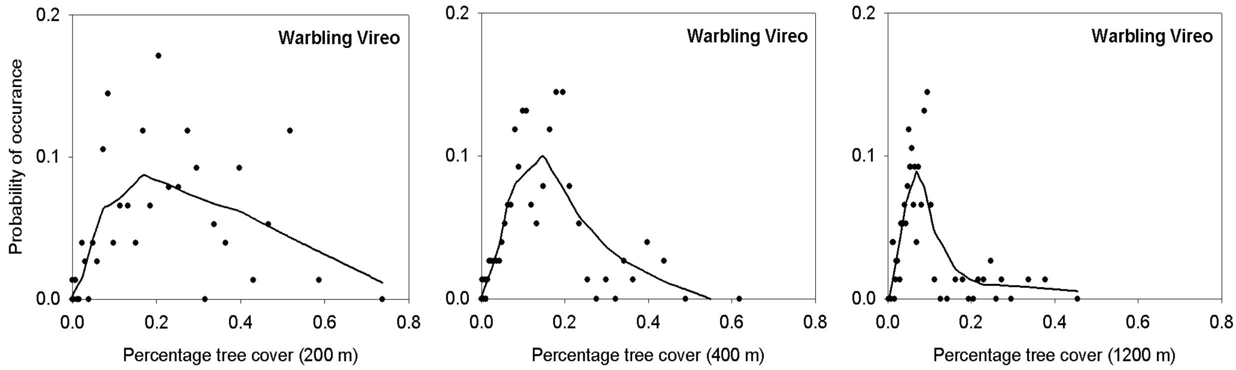


Figure 1. An edge species' response to increasing percentage tree cover, at three scales (200, 400, and 1200 m radius around sampled transects). Of 40 species, 28 had similar responses at increasing scales, though thresholds, peaks, asymptotes, and slopes might shift.

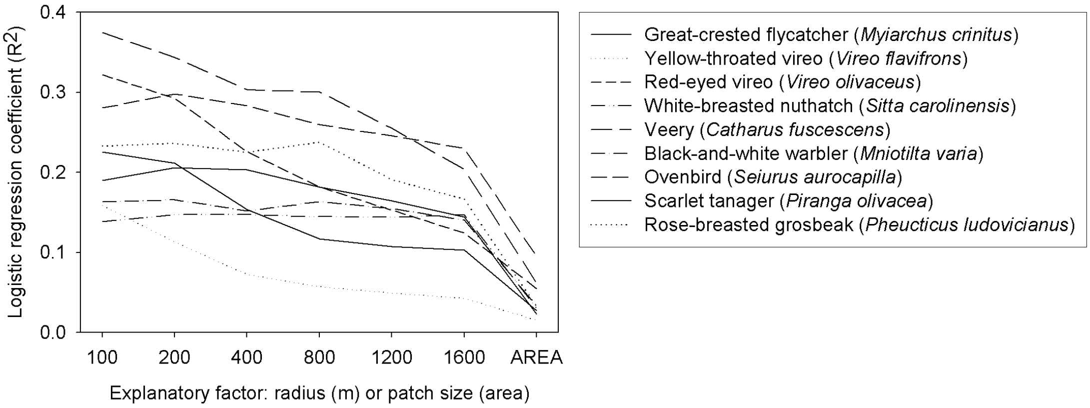


Figure 2. Strength of percentage tree cover and patch size in predicting presence/absence for interior woodland species.

References

Cunningham, M.A. & Johnson, D.H. (2006) Proximate and landscape factors influence grassland bird distributions. *Ecological Applications* **16**: 1062-1075.

Haila, Y. (2002) A conceptual genealogy of fragmentation research: From island biogeography to landscape ecology. *Ecological Applications* 12: 321-334.

Kupfer, J.A.; Malanson, G.P.; & Franklin, S.B. (2006) Not seeing the ocean for the islands: The moderating influence of matrix-based processes on forest fragmentation effects. *Global Ecology and Biogeography* **15**: 8-20.

Villard, M.A. (1998) On forest-interior species, edge avoidance, area sensitivity, and dogmas in avian conservation. *Auk* **115:** 801-805.

3.7 Open Session 12: Landscape modelling and mammal, amphibian and insect populations

Landscape change and extinction debt: measuring long-term change in the mammal fauna of forest fragments

A.F. Bennett[1,] A. Haslem[1] & R. Mac Nally[2]

[1]Landscape Ecology Research Group,
School of Life and Environmental Sciences, Deakin University,
Burwood, Victoria 3125, Australia.
e-mail: Andrew.Bennett@deakin.edu.au
[2]Australian Centre for Biodiversity: Analysis, Policy and Management
School of Biological Sciences, PO Box 18, Monash University, Victoria 3800, Australia

Introduction

The consequences of landscape change are not always immediately apparent. In rural environments, patches of native vegetation have a critical role in the conservation of biodiversity but a major gap in understanding is the way in which faunal assemblages in such patches change through time. Theory suggests that following isolation, remnant patches will experience a gradual loss of species through time, but that there will be a time-lag before the full consequences of isolation and landscape change are realized (i.e. there is an extinction debt, *sensu* Tilman *et al*. 1994). The potential for an extinction debt in rural landscapes has profound implications for nature conservation; it implies that species currently present will not necessarily persist in the longer term.

In 1976–1980, mammal surveys were undertaken in two large sets of forest patches in study areas in Gippsland (Suckling 1980, 1982) and Western Victoria (Bennett 1987, 1990), both in temperate south-eastern Australia. In this study, we re-surveyed the terrestrial mammals in these patches to directly measure potential change in the fauna over a 20+ year period, and to test predictions concerning the types of species most vulnerable to decline.

Methods and Results

Field surveys were carried out in 36 forest patches in W Victoria (0.3 to 85 ha in size) and in 32 patches in Gippsland (0.5 to 57 ha). Survey techniques and survey effort were closely matched to that documented for the historic surveys, and involved trapping, spotlight transects, hair-sampling tubes, direct observation, and records of tracks and signs. Substantial change has occurred to forest vegetation in both regions. In W Vic, the overall extent of tree cover has not changed but a wildfire in 1983 burned 87% of the area. In Gippsland, establishment of plantation forestry is a major change in land use. In both study areas, a number of the original forest patches have been cleared or further fragmented.

Species richness of native mammals in forest patches showed little change over the 20-year period, but in both study areas there were regional changes in the overall status of the mammal fauna. A marked increase in the frequency of occurrence of the Common Wombat *Vombatus ursinus* in Gippsland; and the Common Brushtail Possum *Trichosurus vulpecula* and Koala *Phascolarctos cinereus* in W Victoria, masked a regional decline in occurrence of several rarer species (e.g. Southern Brown Bandicoot *Isoodon obesulus*, Long-nosed Potoroo *Potorous tridactylus*).

Predictions were made (before commencing the study) of the vulnerability of each species to long-term decline, based on relative abundance, capacity to move through the rural landscape and sensitivity to disturbance (feral predators, grazing by stock). For each study area, there was a significant correlation between predicted vulnerability and actual change in the status of native mammal species. The most vulnerable species were those present historically in low abundance, dependent on native forest vegetation, and sensitive to predation and loss of understorey cover. Turnover in the identity of species in forest patches over the 20-year period was greatest in small (<5 ha) patches.

Discussion and Conclusions

Understanding the long-term dynamics of faunal populations in rural environments is complex because landscape structure and patterns of human land-use are not static. In addition to faunal changes that may be due to time-lag effects from biogeographic change (e.g. overall forest extent, patch size, isolation), the effect of ongoing patterns of land use and environmental disturbance must also be recognised. We highlight four conclusions from this study concerning the conservation of native fauna in rural landscapes.

1. Networks of natural vegetation have a key role in the long-term persistence of wildlife in farmland environments. Here, small forest patches (most < 20 ha) have maintained populations of at least 10 species of native mammal over a 20-year period.

2. The status of native fauna in remnant habitats in rural environments is dynamic. In this study, several species experienced a long-term increase in frequency of occurrence in forest patches, some showed little change, while others experienced decline and possible local extinction.

3. Patch-level and landscape-level assessments of the fauna provide complementary insights. In both study areas there was little change over the 20-year period in species richness at the patch level, but at the landscape level long-term change in the fauna was evident. The overall status of the mammal fauna in each area has deteriorated: at least four species in W Victoria and six species in Gippsland have declined or are now scarce, such that their future persistence for the next 20 years is not assured.

4. The differential vulnerability of species to long-term change is influenced by their ecological characteristics. Here, native mammals most vulnerable to decline were those that initially occurred in low abundance, are dependent on forest understorey vegetation, and are sensitive to predation by feral predators (i.e. Red Fox *Vulpes vulpes*).

References

Bennett, A.F. (1987) Conservation of mammals within a fragmented forest environment: the contributions of insular biogeography and autecology. D.A. Saunders, G.W. Arnold, A.A. Burbidge & A.J.M. Hopkins (Eds.). Nature Conservation: The Role of Remnants of Native Vegetation, Surrey Beatty & Sons, Chipping Norton, pp. 41-52.

Bennett, A.F. (1990) Land use, forest fragmentation and the mammalian fauna at Naringal, south-western Victoria. *Australian Wildlife Research* **17**: 325-347.

Suckling, G. C. (1980) The effects of fragmentation and disturbance of forest on mammals in a region of Gippsland, Victoria. PhD thesis, Monash University, Victoria.

Suckling, G. C. (1982) Value of preserved habitat for mammal conservation in plantations. *Australian Forestry* **45**: 19-27.

Tilman, D., May, R.M., Lehman, C.L. & Nowak, M.A. (1994) Habitat destruction and the extinction debt. *Nature* **371**: 65-66.

Pond or landscape characteristics – which is more important for common toads (*Bufo bufo*)? A case study from central Romania

T. Hartel[1], S. Nemes[2], L. Demeter[3], K. Öllerer[1]

[1] Institute of Biology – Romanian Academy, Splaiul Independenței 296, Bucharest, Romania.
e-mail: asobeka@yahoo.com
[2] School of Mathematical Sciences, University of Gothenburg, Göteborg 41296, Sweden
[3] Sapientia Hungarian University of Transylvania, Department of Technical and Nature Sciences, P-ța. Libertății 1, 530104 M-Ciuc, Romania.

Introduction

The primary anthropogenic factor causing amphibian decline in Europe is habitat loss and fragmentation (Stuart *et al*., 2004). In order to implement efficient conservation measures on a regional level, baseline data are needed regarding local distributions and the factors influencing habitat use of different amphibian species. Here we explore the effects of aquatic and terrestrial habitat variables on the abundance (adult counts) of the common toad (*Bufo bufo*) in 43 permanent ponds in central Romania surveyed between the years 2000 and 2005.

Materials and Methods

Study area

The Târnava Mare Valley is located in central Romania. The area selected for this study covers approximately 2600 km² and is situated in the middle section of the valley. Important land use types in the area include: deciduous woodland (33%), shrubland (5%), pastures and grassland (41%), orchard (2%), vineyard (1%), marsh (1%) and urban area (1%). Two large roads and one railway run through the valley. An other highway is planned to be constructed through this valley in the near future.

Data collection

The surveys were made between the years 2000-2005. Ponds were located using 1:25 000 scale topographic maps. Adult toad counts were gathered for 43 populations (here we considered adults breeding in one pond as being a population) in the afternoon and at night from the end of March till the second half of April.

We measured four aquatic habitat variables and seven landscape related variables at each sampled site. The aquatic variables were: area (m²), percentage of emergent aquatic vegetation cover (*Phragmites* sp., and *Typha* sp.), percentage of shallow water (< 50 cm depth) and presence / absence of non-predatory and predatory fish. Landscape variables included: distance of pond from forest (m), the percentage of forest cover, the presence/absence of green connecting corridors, pastures and grassland cover (%), arable land cover (%), and the presence/absence of high traffic roads.

Data analysis

The predictor variables are continuous and discrete binary variables. The nonlinear iterative NIPALS–PCA (Nonlinear Iterative Partial Least Squares-Principal Component Analysis) algorithm was used to explore the relationship between the environmental factors and toad counts. Statistical analyses were performed with Matlab 7.01.

Results

Common toads were present in 81.4% of the surveyed sites. Out of the 43 ponds sampled, 18.6% lacked fish, 30.2% had only non-predatory fish, while 51.1% contained both predatory and non-predatory fish. 74.4% of the ponds are connected to forest through a green corridor, 32% are next to pastures and 37.2% are close to roads with heavy traffic.

Table 2. Descriptive statistics for eight pond and landscape related variables. (SD = standard deviation; CV = coefficient of variation)

Variable	Mean	SD	CV
Area (m²)	99,2	319,3	3.22
Shallow water (%)	34.5	27.7	0.80
Emergent aquatic vegetation cover (%)	32.2	24.4	0.76
Elevation (m)	395.4	72.1	0.18
Grass/pasture cover (%)	32	20.0	0.71
Forest cover (%)	34	22.0	0.73
Distance to forest (m)	298.6	339.1	1.14
Arable land cover (%)	15.8	20.2	1.27

Toad counts can be related to three landscape variables, namely the percentage of forest cover (positive association), presence/absence of roads (negative association between the high volume traffic roads and toad counts) and habitat corridors (positive relationship). These variables together with the presence/absence of fish accounted for 49% of the total variance.

Conclusions

The common toad counts in this area are significantly associated only with landscape characteristics. Our study highlights the role of landscape composition and configuration in maintaining common toad populations in this area, and confirms the negative effect of landscape fragmentation. To efficiently protect amphibians in Romania, appropriate legislation and a strong collaboration between landowners, landscape planners and herpetologists is needed.

References

Stuart, S.N; Chanson, I.S., Cox, N.A., Young, B.E., Rodrigues, A.S.L., Fishman, D.L., Waller, L.W. (2004) Status and trends of amphibian declines worldwide. *Science* 306: 1783 - 1786
Hartel, T. et al (In press 2007). Article in *Applied Herpetology*, 2007 Vol. 4(1).

Changes in Female Grizzly Bear (*Ursus Arctos*) Homerange Configuration in the Multi-use Albertan Rocky Mountain Foothills, Canada.

J. Linke[1], A. Pape[2], J. Cranston[3], G. McDermid[1], M. Hall-Beyer[1], S.E. Franklin[2], G. B. Stenhouse[3,4].

[1]Department of Geography, University of Calgary, 2500 University Drive N.W. Calgary, AB T2N 1N4, Canada.
e-mail: JLinke@ucalgary.ca;
[2]Department of Geography, University of Saskatchewan, Saskatoon, SK, S7N 4P3 Canada;
[3]Foothills Model Forest, Box 6330, Hinton, A.B T7V 1X6, Canada, [4]Alberta Sustainable Resource Department, Fish and Wildlife Division, Edmonton, A.B. Canada.

Introduction

Grizzly bear populations in Alberta, Canada are under tremendous pressure from land use changes related to development of the province's vast forest, agriculture, and petroleum resources. For example, Alberta contains roughly 70% of Canada's oil and gas reserves, and is forecasting annual production increases of 5% over the next decade (CAPP 2005). Understanding the impacts of these changes, and providing resource managers with the knowledge and planning tools necessary to ensure the long-term conservation of Alberta's grizzly bears has been the goal of The Foothills Model Forest Grizzly Bear Research Program (FMFBGRP) since 1999. In this paper, we report on a research project designed to quantify the impacts of human-induced landscape change on grizzly bear home ranges using parsimonious metrics of landscape structure (Linke and Franklin 2006), as observed through annual satellite imagery covering the years 1999 through 2003. The work is part of a broader initiative designed to understand the impacts of resource development on grizzly bear health and habitat selection.

Methods

A series of six annual Landsat 5 TM and Landsat 7 ETM+ images covering the time frame 1998-2003 were orthorectified and radiometrically normalized over a 7450 km^2 study area southeast of Hinton, Alberta, Canada. The enhanced wetness differencing index (EWDI) of Franklin *et al.* (2001) was used to produce 5 layers of *unlabelled* annual change. We then used an object-oriented image processing package (Definiens Professional 5.0), to segment the change pixels into identifiable objects, and applied a series of logical decision rules to classify change objects into landuse/disturbance categories, including wellsites, cutblocks, natural burns, and mine sites. Additional disturbance layers that were not captured by the automated change detection process, such as roads and small disturbance features, were digitized manually with the help of supplemental imagery such as IRS, SPOT and aerial orthophotos. Once assembled, we used these layers of *labelled* annual change to update a 10-class landcover map (circa 2003) of the study area produced by McDermid *et al.* (2007). A second set of decision rules were used to reclassify the change features to the appropriate landcover class, and backdate the 10-class map to each of the years 1998 through 2003. We used the updated annual landcover maps to calculate four landscape-level metrics with Fragstats 3.3 in six female minimum convex polygon (MCP) home ranges with low (G004, G016), medium (G011, G027), and high (G020, G023) exposure to human use (Linke *et al.* 2005).

Results/Conclusions

The overall study area experienced land use changes every year, with forestry, road construction, and well sites contributing the most dominant disturbance features (Table 1). However, changes varied spatially across the study area, affecting the landcover structure of the six home ranges to varying degrees, with two MCPs (G004, G016) remaining unchanged. Annual changes in metrics were observed for the remaining four MCPs, with the overall largest magnitudes being recorded in home ranges with originally medium exposure to human use (Figure 1). In conclusion, landscape metrics derived from annual maps of landcover from remote sensing are shown to be effective tools for capturing and summarizing changes in landscape structure caused by human development. The techniques presented here have been used to quantify a broad spectrum of human-induced changes to grizzly bear home ranges on multi-use lands in Alberta, Canada. The work establishes a strong foundation for on-going monitoring activities, and further investigations into wildlife habitat inferences frequently drawn from multi-temporal wildlife data sets.

Table 1. Annual extents of land uses/disturbances as derived from Landsat image change detection in the 7450 km^2 grizzly bear foothills study area between 1999 and 2003.

Disturbance Feature	1999	2000	2001	2002	2003
Forestry Cutblocks (km^2)	32.5	34.0	34.1	42.7	44.1
Mining (km^2)	2.1	0.0	2.2	2.2	0.0
Burns/Forest Fires (km^2)	0.4	0.0	0.0	0.0	0.2
Wellsites (#, km^2)	117,1.9	113, 2.1	96, 1.6	65, 1.3	68, 1.1
Roads (km)	94.4	152.5	136.2	87.8	82.3

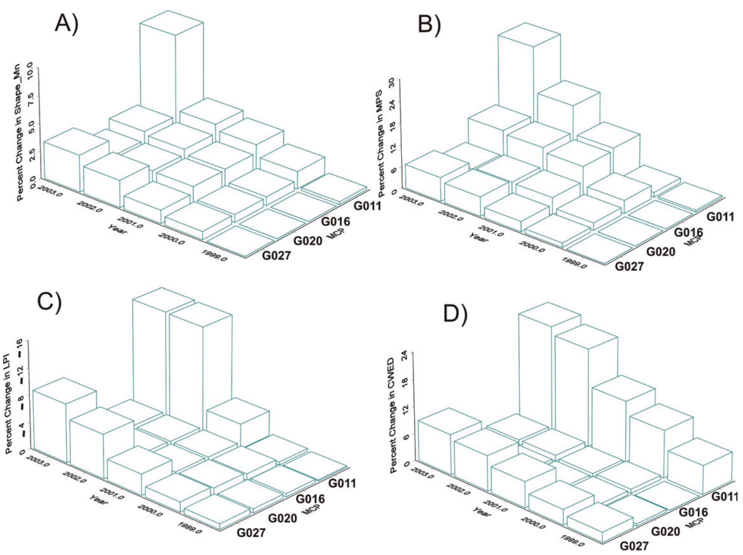


Figure 1. Percent annual cumulative changes in four female grizzly bear homeranges with medium and high exposure to human use between 1999 and 2003 as measured in relation to landcover structure in 1998 with A) mean shape index, B) mean patch size, C) largest patch index, and D) contrast weighted edge density.

References

Canadian Association of Petroleum Producers (CAPP). 2007. Canadian crude oil production and supply forecast 2005-2015. Calgary, Alberta, Canada. Retrieved on Jan. 29, 2007, from http://www.capp.ca/default.asp?V_DOC_ID=6

Franklin, S.E., Lavigne, M.B., Moskal, L.M., Wulder, M.A. and T.M. McCaffery. 2001. Interpretation of Forest Harvest Conditions in New Brunswick Using Landsat TM Enhanced Wetness Difference Imagery (EWDI). *Canadian Journal of Remote Sensing*, *27*, 118-128.

Linke, J. and S.E. Franklin. 2006. Interpretation of landscape structure gradients based on satellite image classification of land cover. Can. Journal of Remote Sensing 32(6): in press

Linke, J., S.E. Franklin, F. Huettmann and G.B. Stenhouse. 2005. Seismic cutlines, changing landscape metrics and grizzly bear landscape use in Alberta. Landscape Ecology 20: 811-826.

Space use in desert areas by guanaco (*Lama guanicoe*) and its seasonal dependence on the most productive patches.

P. Acebes[1], J.E. Malo[1], F. Suarez[1], C.E. Borghi[2], S.M. Giannoni[2] & J. Traba[1]

[1] Departamento de Ecología. Universidad Autónoma de Madrid. E-28049 Madrid. Spain.
e-mail: pablo.acebes@uam.es
[2] Museo de Ciencias Naturales. Universidad Nacional de San Juan. San Juan. Argentina.

Local habitat selection and seasonal movements are key elements in life strategies of many animal species as means to cover their vital needs. This is specially true for populations living in areas close to species' distribution extremes as their proximity to the realizable niche limit makes survival more dependent on an efficient use of available resources. In this context, we describe seasonal variability in space and habitat use by a small population of guanaco (*Lama guanicoe* Müller 1776) living at the dryest limit of its Argentinean distribution.

During the wet and dry seasons of 2005 and 2006 we GPS-located all guanaco observations obtained during systematic surveys through the Ischigualasto-Talampaya World Heritage Site (Argentina), located at the phytogeographic region of the “Monte árido”, dominated by shrubby plants such as *Larrea* spp*, Zuccagnia punctata, Atriplex* spp. and *Prosopis* spp. in addition to several cacti species *(Trichocereus, Cereus, Tephrocactus, Opuntia* spp*)*. Temperatures vary from -10º to 50ºC and annual precipitation is about 100 mm. Guanaco observations were obtained form daily surveys of the area totalling approximately 150 hours by season. Variables of the environment and the group of animals were also collected for each observation. We defined 6 different plant communities to characterize the habitat where guanacos were found: dense scrubland (dominated by shrubs such as *Zuccagnia punctata*, *Larrea cuneifolia* and *Geoffrea decorticans* with >20% plant cover), open scrubland (with shrubs like *Larrea* spp. and *Plectocarpa tetracantha*, always with <20% plant cover, and sometimes lower than 5%), treelike cacti-dominated slopes (hills covered by mixed shrubland with *Trichocereus terscheckii*), algarrobal (*Prosopis* spp associated to dry rivers), zampal (sandy areas with a low cover of *Atriplex* spp.), and peladal (barren areas).

In all we carried out 209 observations of guanaco herds with a total number of 1343 individuals (mean ± standard error; 6.43 ± 0.29 animals by observation). Mean group size varied significantly between years (ANOVA test: F = 7.05; df = 1; p=0.008), but not between seasons (ANOVA test, F = 8.72; df = 1; p=0.706). The estimation of the whole area occupied by herds (Minimum Convex Polygons) showed a high seasonal overlap between wet and dry seasons (average for two years; Cole Concordance Index >66%). Nevertheless, the analysis of the core areas (estimated using a density estimator kernel at 50%) showed a much lower seasonal overlap (average for two years; CCI <36%).

Guanacos habitat selection was significantly different than expected from availability (chi-squared= 71.41; df = 15; p<0.0001). Ivlev habitat selection index showed a somewhat relaxed selection pattern during wet seasons and a more neat one during dry seasons. Accordingly to this, guanacos showed preference for zampal and algarrobal during 2005 and 2006 wet seasons and avoidance of treelike cacti-dominated slopes and dense shrublands in 2005 and of zampal in 2006. However, in both dry seasons guanacos avoided peladal, and zampal in 2005 and algarrobal in 2006. No positive selection was recorded for dry seasons.

These fuzzy seasonal patterns were further analysed using a productivity approach. We used satellite imagery (LANDSAT 7 ETM+) to analyse guanacos habitat preferences, from a regional approach, based on a Vegetation Index (NDVI) of the area. NDVI for each guanaco location was calculated as the average in a 100 m buffer around it. NDVI estimated for dry season locations were significantly higher than for wet seasons (ANCOVA test; F=35.09; p<0.0001), apparently showing a preference towards the most productive patches of the area during dry seasons. The covariate number of guanacos per observation showed a tendency for larger herds to occupy locations of higher plant productivity.

The combined results show guanaco's flexibility in space use and habitat selection under extremely arid conditions, and rise two main points with potential conservation implications. First we detect a seasonal dependence of animals on the habitats with somewhat higher productivity, which occupy a small fraction of the area. Secondly, the smaller groups seem to be displaced to suboptimal habitats throughout the year, a behaviour coherent with a resource-defense polygyny mating system, where the number of females attracted by a male is related to the quality (productivity) of resources in the territory. In addition, they highlight the relevance of NDVI-productivity analyses to detect changes in habitat use, as a complement to standard fine scale habitat assessments.

Finally, the low density populations of the World Heritage Site seem to be really close to the arid limit of their niche and they could be easily threatened by competition with feral livestock that rely heavily on the few most productive locations and water sources of the area.

Small mammals in fragmented Atlantic forest landscapes - importance of patch size in landscapes with different amounts of remaining habitat

A.A. Buen[1], J.P. Metzger [2], R. Pardini [1]

1 Departamento de Zoologia and 2 Departamento de Ecologia, Instituto de Biociências, Universidade de São Paulo, Rua do Matão, travessa 14, 101, São Paulo, SP, Brazil.
e-mail: aa_bueno@yahoo.com.br

Introduction and Methods

Habitat fragmentation implies habitat loss, reducing patch size and increasing distance among patches. A fragmentation threshold, defined as the amount of habitat below which patch size and isolation synergistically interact with habitat loss increasing extinction rates in fragmented landscapes, was proposed based on the non-linear relationships between habitat amount and the number, size and isolation of remnants, and the review of bird and small mammal empirical studies (Andrén, 1994). However, interactions between habitat loss at the landscape scale and patch characteristics were rarely investigated, especially in tropical forests. Here, we aim to investigate if the influence of patch size on small mammal assemblages varies among landscapes with different amounts of remaining Atlantic Forest.

Three 10,000-ha landscapes with similar abiotic conditions were chosen in the Atlantic plateau of São Paulo State, Brazil, retaining 45, 30 and 15% of forest. Small mammals were sampled with a standardized protocol with pitfall traps at 50 forest patches, 15 - 20 in each landscape, randomly chosen in classes of size. We used analysis of variance and Tukey test to investigate if richness and abundance varied among landscapes, and linear regression to investigate the influence of patch size on small mammals in each of the three landscapes.

Results and Discussion

We captured 1,295 individuals of 27 small mammal species, 17 of which are endemic to the Atlantic forest and 10 are also found in open Brazilian biomes. Richness differed among the three landscapes considering the endemic ($F= 28.971$, $P< 0.001$) but not the non-endemic species. Richness of endemic species was lower in the 15% landscape compared to the more forested landscapes (Figure 1). Abundance differed among the three landscapes considering both endemic ($F= 14.516$, $P< 0.001$) and non-endemic species ($F= 6.398$, $P= 0.003$). However, while the abundance of endemic species was lower in the 15% landscape, the abundance of non-endemic species was lower in the 45% landscape (Figure 1). Richness and abundance were not influenced by patch size in the 15% landscape, whereas both richness and abundance of endemic species increased with patch size in the 30% landscape ($R^2= 0.384$, $P= 0.002$; $R^2= 0.283$, $P< 0.009$, respectively) and richness of non-endemic species decreased with patch size in the most forested landscape ($R^2= 0.241$, $P= 0.036$) (Figure 2). Five endemic species were present only in the two more forested landscapes. Among those, *Oryzomys russatus* and *Thaptomys nigrita* were rare in both landscapes, *Brucepattersonius soricinus* was more common in the 45% compared to the 30% landscape ($F= 5.058$, $P< 0.031$), and the abundance of *Delomys sublineatus* and *Marmosops incanus* did not vary among landscapes. The abundance of the last three species increased with patch size in the 30% landscape ($R^2= 0.192$, $P= 0.030$; $R^2= 0.133$, $P= 0.064$; $R^2= 0.253$, $P= 0.014$, respectively), but not in the most forested one. The abundance of the commonest non-endemic species (*Oligoryzomys nigripes*) differed among landscapes ($F= 10.456$, $P< 0.001$), was lower in the 45% landscape compared to the other two, and was not influenced by patch size in none of the three landscapes.

Our results highlight the importance of habitat amount for determining small mammal diversity in fragmented tropical landscapes. Similar-sized remnants harboured distinct assemblages in different landscape contexts, corroborating the existence of a fragmentation threshold below which patch characteristics exacerbate habitat loss effects (Andrén, 1994).

As expected, this threshold is evident only for endemic species, which are supposed to present a stronger association to forested habitats. For those, patch size was important in the 30% landscape, whereas the degree of isolation and/or average size of remnants may have, on the one hand, strengthened habitat loss effects causing the extinction of several endemic species and thus reducing the influence of patch size in the 15% landscape; and, on the other hand, allowed dispersion and connectivity among sub-populations and promoted the presence of endemic species regardless of patch size in the 45% landscape. For non-endemic species, on the contrary, richness decreased with patch size in the 45% landscape, indicating that open habitats may act as a source for these species. However, the threshold seems to vary among species, as proposed by Metzger and Décamps (1997). Two of them were uncommon even in the 45% landscape and three clearly benefited from an increase in habitat amount, being able to occupy small patches only in the landscape with the highest habitat amount, while a generalist non-endemic species dominated the 15% landscape.

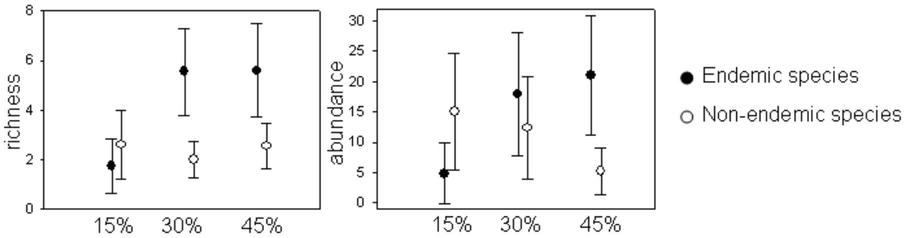


Figure 1. Mean and standard deviation of small mammal richness and abundance in forest patches of landscapes with different proportions of remaining Atlantic Forest in Brazil.

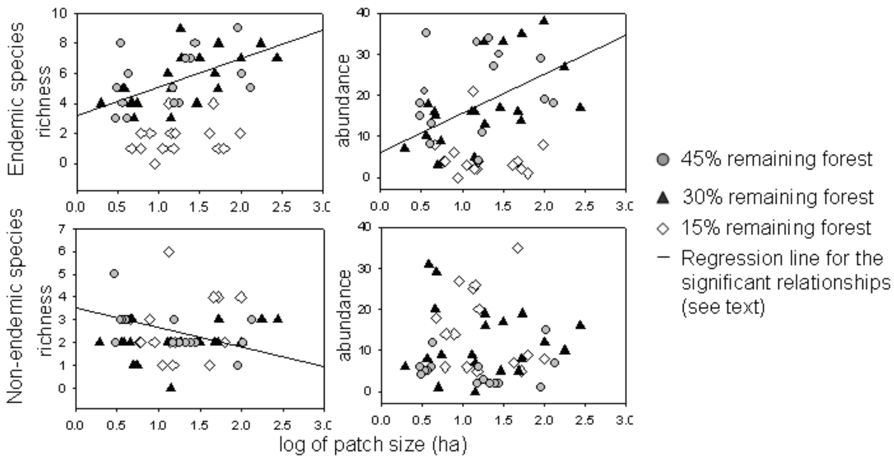


Figure 2. Variation of small mammal richness and abundance as a function of forest patch size in landscapes with different proportions of remaining Atlantic Forest in Brazil.

Acknowledgements

To FAPESP (99/05123-4, 05/56555-4), CNPq (690144/01-6) and CAPES, for support.

References

Andrén, H. (1994) Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. *Oikos* **71**: 355-366.

Metzger, J.P. & Décamps, H. (1997) The structural connectivity threshold: an hypothesis in conservation biology at the landscape level. *Acta Oecologica* **18**: 1-12.

European rabbit (*Oryctolagus cuniculus* L.) abundance at a regional scale: controlling factors

A. Saldaña, G. García-Salgado and S. Rebollo

Department of Ecology, Faculty of Sciences, University of Alcalá, Ctra. Madrid-Barcelona Km 33.6, 28871 Alcalá de Henares (Madrid), Spain.
e-mail: asuncion.saldana@uah.es

Introduction

The European rabbit (*Oryctolagus cuniculus*) is the most important small game species in the Iberian Peninsula, and a major prey for almost 30 raptors and mammalian carnivores, including several endangered species such as the Spanish imperial eagle and the Iberian lynx (Fernández 2005). For this reason, the decline of their populations in the last decades has triggered important socio-economic impacts and conservation concerns in Mediterranean ecosystems. The need to recover rabbit populations demands appropriate knowledge about factors controlling their distribution at wide scales.

The main objective of this investigation was to analyse the major environmental and human factors affecting the current distribution and abundance of European rabbits in the Central Iberian Peninsula, an area which hosts some of the most abundant native rabbit populations. This study may provide useful guidelines for developing landscape-oriented management strategies for the recovery of rabbits over broader areas.

Material and methods

The study area (Madrid province, between the coordinates 39º 53' N and 41º 9' N and 3º 3' W and 4º 34' W), covering about 8,000 km^2, exhibits a high environmental heterogeneity. Altitude ranges from 430 m to 2400 m. The climate is continental Mediterranean, with hot dry summers and cold winters. Average annual temperature and rainfall range from 4ºC to 16ºC and 400 mm to 1600 mm, respectively. The predominant soil types include Entisols, Inceptisols and Alfisols according to USDA Soil Taxonomy. Land use is mainly forestry and cattle breeding in the north, while agriculture and urban uses are dominant in the south. Natural vegetation types are mainly mountain grasslands, shrublands, and forests of *Quercus rotundifolia, Q. pyrenaica* and *Pinus sylvestris*.

Rabbit abundance was estimated through interviews with forest rangers during 2002 and 2003. Seven classes of rabbit abundance were defined on 1:25,000 maps. These data were then re-classified into four rabbit abundance classes for statistical analyses. Associations with environmental variables such as altitude, slope, mean annual temperature, annual rainfall, soil types, and land use were analysed using GIS. We explored the relationships between rabbit abundance and environmental factors by using multivariate ordination analyses (correspondence analysis) and bi-variate analyses (corrected frequencies).

Results

Rabbits were absent or had low abundances in 65% of the area. Rabbit abundance was strongly influenced by the environmental gradients of altitude, precipitation and temperature, and by the different types of soils and land uses (Figure 1). The lowest rabbit abundances were found in areas higher than 1000 m a.s.l., with slope greater than 30%, of annual precipitation above 800 mm, and mean annual temperature below 11ºC. In addition, low abundances were usually found where outcrops and Alfisols occurred, in pine forests, and in urban areas. In contrast, the highest rabbit abundances were found in areas lower than 800 m a.s.l., with slopes less than 30%, annual precipitation below 650 mm, and mean annual temperature above 13ºC. These high abundances occurred mainly on Inceptisols and

Entisols, and on land uses such as agricultural areas (rainfed and irrigated land), evergreen forests (mainly *Quercus rotundifolia),* shrublands or mosaics of these types of land uses.

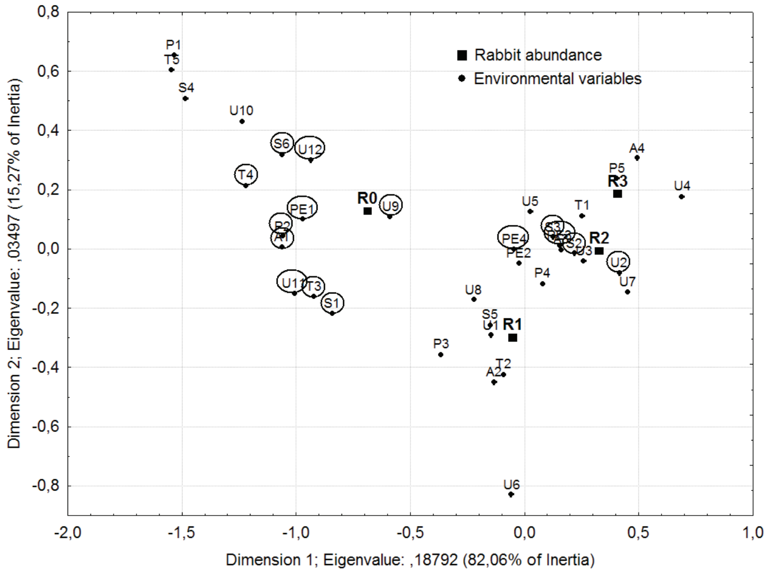


Figure 1. Correspondence analysis of rabbit abundance and environmental variables (black circles for variables with cosine greater than 0.9) **R**: rabbit abundance (R0-R3: rabbit absence to high rabbit abundance). **A**: Altitude, m (A1-A4: >1000; 1000-800; 800-600; <600). **PE**: slope, % (PE1-PE4: >30; 30-10; 10-3; <3). **S**: soil type (S1-S6: outcrops; Entisols; Inceptisols; Mollisols; Alfisols; urban areas). **T**: temperature, ºC (T1-T5: >13; 13-11; 11-9; 9-7; <7). **P**: precipitation, mm (P1-P5: >1200; 1200-800; 800-650; 650-500; <500). **U**: land use (U1: mountain grassland; U2: irrigated land; U3: rainfed; U4: mosaic; U5: shrubland; U6: juniper; U7: evergreen forest; U8: deciduous forest; U9: pine forest; U10: water body; U11: scarpment; U12: urban)

Discussion and conclusions

Our findings show a strong association between rabbit abundance and landscape structure, and also reflect the high environmental heterogeneity of the Madrid province. The highest rabbit abundance was found in mosaics, which provide abundant food and availability of shelter (Lombardi *et al*. 2003; Fernández 2005). Rabbits rejected areas with substrates where excavating warrens is difficult, such as outcrops and soils with the argillic horizon near the soil surface (Alfisols). Our results reflect the ability of rabbits to colonize different habitats and highlight the ecological plasticity of this species. However, rabbits were absent or had very low abundance in two zones of the study area: (1) the mountainous areas, due to limiting physical conditions -low temperature, high precipitation and slope, and areas with abundant outcrops-; (2) areas of urban expansion which would otherwise be suitable for rabbits. The results highlight that European rabbit populations in the Madrid province are very fragmented due to urbanization and there is an urgent need for the establishment of corridors of natural vegetation connecting the different fragments in order to increase the stability of populations. Riverine woody vegetation along rivers flowing through the region in a southerly direction may be a key element in this conservation strategy. Such zones are not suitable for urbanization because of flooding risk, but they can support high rabbit densities and would allow the exchange of individuals between different populations.

References

Fernández, N. (2005) Spatial patterns in European rabbit abundance after a population collapse. *Landscape Ecology* **20:** 897-910.

Lombardi, L., Fernández, N. Moreno, S. & Villafuerte, R. (2003) Habitat-related differences in rabbit (*Oryctolagus cuniculus*) abundance, distribution, and activity. *Journal of Mammalogy* **84**: 26-36.

Arthropod assemblage responses to agricultural intensification in heterogeneous landscapes – local testing of global patterns

S.J. Attwood[1], M. Maron[1], A.P.N. House[2], C. Zammit[3]

[1]Australian Centre for Sustainable Catchments and Faculty of Sciences, University of Southern Queensland, Toowoomba, Queensland, 4350 Australia.
e-mail: attwood@usq.edu.au
[2]CSIRO Sustainable Ecosystems, Level 3, 306 Carmody Road, St. Lucia, Queensland, 4067, Australia
[3]Natural Resource Management Policy Branch, Department of the Environment and Heritage, King Edward Terrace, Parkes, ACT, 2600, Australia

Introduction

Agricultural expansion and intensification are major threats to global biodiversity, with associated habitat loss, reduced habitat heterogeneity and other threatening processes causing biodiversity decline (Stoate *et al.* 2001; Benton *et al.* 2003). Despite this, agricultural landscapes often support complex and dynamic biological communities within a diverse array of land uses (Benton *et al*. 2003), ranging from highly modified cropping systems to native vegetation remnants. The responses of arthropods to agricultural intensification are of particular interest, as they are known to contribute to vital ecosystem processes (Tscharntke *et al*. 2005) and are considered responsive to environmental changes (Andersen and Majer, 2004). Whilst many individual studies indicate that arthropod diversity declines with increasing agricultural intensification, we investigated whether this response was consistent among habitats, taxa, management systems and global regions, and subsequently tested whether similar patterns were evident in an eastern Australian agricultural landscape.

Method

To compare the biodiversity profiles of land uses ranging from low to high intensification, we performed meta-analyses of arthropod richness and abundance responses to several agricultural intensification scenarios reported in the global scientific literature. These findings were then field-tested at a local scale, using a subset of the land uses investigated in the meta-analyses, with ants as the focal taxon. Nine gradients of increasing land-use disturbance, incorporating native woodland remnants, grazed grassland/pasture and cereal crops, were examined in southern Queensland. Ants were sampled using pitfall traps in the core of each land use, and at the interfaces between woodland/pasture and pasture/cropping.

Results

Globally, arthropod abundance displayed no clear trend with intensifying land use, but richness declined consistently and significantly as land use intensified. Richness was greater in native vegetation than agricultural land uses, greater in woodland than pasture, greater in pasture than cropping and greater in reduced-input cropping than conventional cropping. In the local-scale field-testing, ant abundance responses were variable, but ant richness declined significantly as land use intensified, consistent with the global trend (Fig.1).

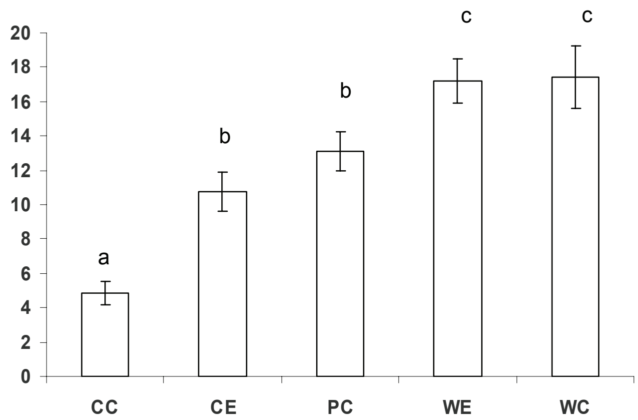


Figure 1. Mean count ant morphospecies richness in core land uses and interfaces. CC = cropping; CE = cropping/pasture interface; PC = pasture; WE = pasture/woodland interface; WC = woodland. Different letter denotes statistically significant difference.

Multivariate analyses revealed that ant assemblages within each core land use were distinct from one another. No differences were found between the woodland/pasture interface and its adjacent habitats. The pasture/cropping interface exhibited a different assemblage to cropping but not pasture.

Discussion

The observed decline in taxonomic richness may be due to frequent 'resetting of the successional clock', with high disturbance areas only supporting early-successional taxa. This was illustrated in our local-scale study, with opportunistic taxa being more prevalent in the cropping and crop/pasture interface than in other land uses. The marked richness decline in the cropping core indicates that this land use may act as an ecological filter for many taxa.

Land use type exerted a greater influence over assemblage composition than the spatial proximity of treatments or other local factors. This may be due to the limited dispersal abilities of minor worker ants, where seemingly modest areas of habitat may effectively represent the operational landscape for many taxa.

It appears that even fragmented and highly degraded woodland remnants, such as those studied, and less intensive agricultural land uses such as pasture, may play an important role in maintaining arthropod biodiversity in agricultural landscapes.

References

Andersen, A. N. & Majer, J.D. (2004) Ants show the way Down Under: invertebrates as bioindicators in land management. *Frontiers in Ecology and the Environment* **2:** 291-298.

Benton, T. G., Vickery, J. A. & Wilson, J.D. (2003) Farmland biodiversity: is habitat heterogeneity the key? *Trends in Ecology & Evolution* **18:** 182-188.

Stoate, C., Boatman, N. D., Borralho, R.J., Carvalho, C.R., de Snoo, G.R. & Eden, P. (2001) Ecological impacts of arable intensification in Europe. *Journal of Environmental Management* **63:** 337-365.

Tscharntke, T., Klein, A. M., Kruess, A., Steffan-Dewenter, I., & Thies, C. (2005) Landscape perspectives on agricultural intensification and biodiversity - ecosystem service management. *Ecology Letters* **8:** 857-874.

Influence of habitat quality and landscape structure on the distribution of *Maculinea teleius* and *Maculinea nausithous*

N. Örvössy, Á. Kőrösi, P. Batáry, L. Peregovits

Department of Zoology, Hungarian Natural History Museum Baross u. 13, H-1088 Budapest, Hungary
e-mail: orvossy@zoo.zoo.nhmus.hu

Maculinea butterflies are considered to be good indicator species, because of their special life cycle – obligate parasitism on *Myrmica* ants and larval host plant use. *Maculinea teleius* and *Maculinea nausithous* occur sympatricaly in wet meadows (Nowicki *et al.* 2005) and use the same food plant, *Sanguisorba officinalis,* but different host ant species (Thomas *et al.* 1998). Niche segregation and habitat requirements have been examined between the two species from the 80's (Thomas 1984), but are still a hotspot in Maculinea research. Thomas and Elmes (2001) found that *M. teleius* and *M nausithous* differ in food plant selection, Johst *et al.* (2006) showed difference in the effects of mowing regime on these butterflies.

M. teleius and *M. nausithous* are widespread in western Hungary, where mowing regimes maintain suitable wet meadow habitats. This area is a very mosaic landscape due to undulating surface, land ownership and management; therefore numerous different habitat patches are present. Transformation of mowing regime or abandonment cause changes in the quality of the habitats and consequently in their suitability for butterflies. Johst *et al.* (2006) simulated the effects of different mowing regimes on *M. teleius* and *M. nausithous* populations and found that traditional twice a year mowing is detrimental. Our aims were to determine how *M. teleius* and *M. nausithous* abundance depend on habitat quality and what the effects of mowing, abandonment and landscape parameters are on butterfly density.

84 habitat patches were chosen for sampling in three stream valleys (region), relying upon the presence of host plant. The habitat patches were outlined based on presumable barriers (forest, road) and difference in habitat management. Transects were used to estimate the density of the butterflies and the quality of the habitat patches. The density was calculated based on two visits per patches. Habitat quality was described by host plant density, host plant and vegetation height and coverage of shrubs. Transect lengths depended on the area of the patch; the width was 3 meters on both sides. Area and perimeter of patches were measured by GPS, year of last mowing or presence of previous mowing in the study year were also noticed. Linear regression analyses were used to determine the effects of described parameters on butterfly density, the best models were chosen by backward selection.

Table 1. Results of linear regression analyses on *M. teleius* and *M. nausithous*.

Species	model F	df	p	parameters	Beta	t value	p
M. teleius	62.15	59	**<0.01**	Perimeter/Area ratio	0.670	3.470	**0.001**
				Mowing before the survey	0.088	2.286	**0.026**
				Year of last mowing	-0.007	-2.545	**0.014**
				Height of food plant	0.002	2.222	**0.030**
				Region1	14.186	2.536	**0.014**
				Region2	14.267	2.550	**0.013**
				Region3	14.197	2.535	**0.014**
M. nausithous	15.46	48	**<0.01**	Perimeter/Area ratio	0.761	6.388	**<0.01**
				Year of last mowing	-0.005	-2.501	**0.016**
				Mowing before the survey	0.031	1.441	0.156

M. teleius in all, *M. nausithous* in most of the patches were present. In the case of *M. teleius* the best linear regression model included habitat quality factors like the host plant height and mowing regime and landscape factors, like region and perimeter/area ratio as well (Table 1).

In spite of that model *M. nausithous* density is best described by perimeter/area ratio and the year of last mowing (Table 1). Patch sizes and perimeter area ratios are different in the three regions (Kruskal-Wallis test: patch size chi-square = 16.268 df = 2, $p < 0.001$; perimeter area ratio chi-square = 13.65, df = 2, $p = 0.001$), and this difference has an effect on the density of the species.

In the study area the mowing regime has been changed in the last decade, the traditional twice a year cut does not exist anymore, the majority of the patches are mown once a year with no time considerations and several patches have been abandoned. We found that abandonment has a positive effect on both species, although this survey does not contain patches abandoned more than 15 years ago. In addition preserving wet meadow habitats probably require management to prevent succession. Further, mowing the meadows just before the flight period of Maculinea species has a negative effect on density. These results are similar with the simulation models of Johst *et al.* (2006), that less frequent mowing frequency than in traditional regime increases the survival of both species. Our result support the simulation model that the cut should be at least some weeks before the flight period, in front of the traditional mid flight period mowing.

Even though niche segregation exists in the use of food plant between the two Maculinea species (Thomas and Elmes 2001), density of food plant had no significant effect on the butterflies (Table 1). On the other hand growing host plant height increased the density of *M. teleius*, but not *M. nausithous*, which can support the niche segregation by host plant use hypothesis (Thomas and Elmes 2001).

Perimeter area ratio had the strongest impact on the density of the butterflies, particularly *M. nausithous* preferred patches with more edge, than core area (Table 1), likewise earlier MRR studies refer to it in the study area (Kőrösi 2005) and in Poland (Nowicki et al. 2005).

Our results suggest that for preserving these species both required mowing regime that differs from traditional mowing and landscape structure, especially the enormous effect of perimeter area ratio should be taken into account during management. Based on our results, on this area mowing should be more frequent in smaller patches with large edges, which are more exposed to succession and less frequent in large patches to increase butterfly density.

Research was funded by NKTH Faunagenesis project (3B023-04).

References

Johst, K; Drechsler, M; Thomas, J. & Settele, J. (2006) Influence of mowing on the persistence of two endangered large blue butterfly species. *Journal of Applied Ecology* **43:** 333–342.

Kőrösi, Á. (2005) Habitat-use of wetland *Maculinea* species – a case study. J. Settele, E. Kühn & J. Thomas (Eds). *Studies on the Ecology and Conservation of Butterflies in Europe.* Pensoft, Sofia-Moscow, pp. 132.

Nowicki, P; Witek, M; Skórka, P; Settele, J. & Woyciechowski, M. (2005) Population ecology of the endangered butterflies *Maculinea teleius* and *M. nausithous* and the implications for conservation. *Population Biology* **47:** 193-202.

Thomas, J. A. (1984) The behaviour and habitat requirements of *Maculinea nausithous* (the Dusky Large Blue Butterfly) and *M. teleius* (the Scarce Large Blue) in France. *Biological Conservation* **28:** 325-347.

Thomas, J.A; Elmes, G.W. & Wardlaw, J.C. (1998) Polymorphic growth in larvae of the butterfly *Maculinea rebeli*, a social parasite of *Myrmica* ant colonies. *Proceedings of the Royal Society of London B* **265:** 1895–1901.

Thomas, J.A. & Elmes, G.W. (2001) Food-plant niche selection rather than the presence of ant nests explains oviposition patterns in the myrmecophilous butterfly genus *Maculinea*. *Proceedings of the Royal Society of London B* **268:** 471–477.

Effect of landscape structure on Collembola communities in 30 oilseed rape fields

P. Querner, A. Bruckner, T. Drapela, D. Moser, J.G. Zaller, T. Frank

Institute of Zoology , Department of Integrative Biology and Biodiversity Research, University of Natural Resources and Applied Life Sciences, Gregor-Mendel-Strasse 33
A-1180 Vienna, Austria.
e-mail: pascal.querner@boku.ac.at

Soil animals are seldom investigated in landscape ecology although they contribute with a very high local diversity and abundance to the important nutrition cycles and the soil development processes. Are surface active Collembola assemblages more affected by the surrounding landscape than the soil living species? Do species migrate from the adjacent forest or grassland into the crop fields and from what distance? To study these questions, we sampled the surface active and the soil living springtail fauna of 30 winter oilseed rape fields in a 160 km^2 study area in eastern Austria. The proportion of non-crop area around the sites varied from 10% to 70%. Surface active Collembola were sampled with pitfall traps and the endogeic species with soil cores. All specimens were counted, identified to species level and classified as grassland, woodland or ubiquistic species. Community structure and composition were correlated with (1) local variables (soil type, soil index, cultivation intensity) and landscape variables as the (2) proportional area of crop, vineyards and semi natural habitats, (3) minimum distance to semi-natural habitats (fallow, grasslands and woodlands) and (4) landscape diversity indices at scales of 250 to 2000 m radius around the sites. Surface active Collembola were found to be influenced by the regional landscape composition more than the local soil properties. This was expected as they are larger and more mobile and can migrate from one patch to another. Passive wind dispersal is also a possible explanation. The small endogeic Collembola living in deep soil layers are less mobile and depend more on the local soil properties, than on the surrounding landscape structure.

Landscape structure and small mammal distribution – the importance of matrix quality for the connectivity of a fragmented Atlantic forest landscape

F. Umetsu [1], R. Pardini [1], J.P. Metzger [2]

[1] Departamento de Zoologia and [2] Departamento de Ecologia, Instituto de Biociências, Universidade de São Paulo, Rua do Matão, travessa 14, 101, CEP 05508-900, São Paulo, SP, Brazil.
e-mail: fabiume@yahoo.com

Introduction

If, on the one hand, theoretical metapopulation and landscape ecology models have suggested that taking into account the suitability of altered habitats for the occurrence/ dispersion of organisms is essential to understand processes in fragmented landscapes; on the other hand, this often requires detailed and long term data on the biology of species, which, particularly in the tropics, are not available and are time-consuming to gather. Using the distribution of small mammals in forest remnants and in the main types of altered habitats in an Atlantic forest landscape, we investigated how the explanatory power varies between landscape variables that incorporate or not matrix quality and the importance of spatial scale for analyzing the influence of landscape structure. We assumed that information on the occurrence of species gathered through standardized sampling in different habitat types of a heterogeneous landscape is useful as indices of matrix quality.

Methods

The fragmented landscape under study, located in Caucaia do Alto, State of São Paulo, Brazil, comprises 10,000 ha and harbors 31% of forest remnants surrounded by areas of agriculture (38%), rural/ urban areas with buildings (14%), native vegetation in initial stages of regeneration (7%), and homogeneous pine/ eucalyptus plantations (7%). The small mammal community was sampled using a standardized protocol with Sherman live-traps at 36 sites, 20 in forest fragments (2 – 275 ha) and 16 in the matrix (four in each of the four predominant altered habitats). We calculated two indices of quality for each sampled habitat, one represented by the relative abundance and one by the occurrence of each species. For each forest fragment, we calculated two landscape variables - habitat quantity and habitat connectivity based on the distance and size of surrounding habitat patches - in different spatial scales (50 – 800 m). For each variable, we calculated one metric that considers forest fragments as equally suitable and all altered habitats in the matrix as unsuitable for all small mammal species, and one that takes into account the variation in quality among habitats for each species. We compared the explanatory power of logistic regression models describing the chance of occurrence of species in the 20 fragments among metrics that consider and those that do not consider matrix quality.

Results

We analyzed the distribution of 8 small mammals (*Akodon montensis*, *Delomys sublineatus*, *Didelphis aurita*, *Marmosops incanus*, *Micoureus paraguayanus*, *Oligoryzomys nigripes*, *Oryzomys angouya* and *Oryzomys russatus*). Only *D. aurita* and *O. russatus* did not occur in any of the matrix habitats and only *A. montensis* and *O. nigripes* occurred in all. Open anthropogenic habitats harbored the smallest (2), and native vegetation in initial stages of regeneration the highest (5), number of species. While a consistent increase in the explanatory power when considering matrix quality in relation to considering the matrix as inhospitable was observed for just one species (*D. sublineatus*) among models of habitat quantity, it was observed for all six species that occurred in the matrix among models of habitat connectivity. Both for habitat quantity and connectivity, models presented higher or similar explanatory power using the index based on species occurrence in comparison to that based on species abundance. The models of habitat quantity significantly explained the chance of occurrence of just the two species that did not occur in the matrix and for which there was no difference between metrics that considered or not matrix quality (*D. aurita* and *O. russatus*). The occurrence of *O. russatus* was also significantly explained by models of habitat connectivity. However, these models, when considering matrix quality, also explained the occurrence of *M. paraguayanus*, a species that occurred in only one type of matrix habitat. Both models of habitat quantity and connectivity for the two species that did not occur in the matrix varied with spatial scale. Among the remaining species, only the models for *D. sublineatus* did not vary with spatial scale for all variables and metrics considered, while the models of the others varied depending not only on the type of landscape variable and on considering or not matrix quality, but also on spatial scale. For them, models were clearly more independent of spatial scale for habitat connectivity compared to habitat quantity models.

Discussion

For many species and spatial scales, metrics that considered the heterogeneous quality of the matrix presented a higher explanatory power for the distribution of small mammals in forest fragments. This is in accordance with the results of the few published studies that compared the performance of models considering or not matrix heterogeneity, all carried out in temperate regions (e.g., Sutcliffe *et al*. 2003; Verbeylen *et al*. 2003; Revilla *et al*. 2004). However, in those studies matrix heterogeneity was quantified based on the researcher experience or inferred from auto-ecological studies. Our study shows that it is feasible to obtain indices of matrix quality through standardized sampling in different types of matrix, which may increase the predictive power of landscape structure variables. Thus, the matrix of altered habitats not only plays a fundamental role in ecological processes, but also could be taken into account for modeling and managing human dominated landscapes, even if detailed information on the biology of species is not available. However, the increase in explanatory power between metrics that considered or not matrix heterogeneity is more consistent across species for habitat connectivity compared to habitat quantity models. This clearly indicates the importance of taking into account the distance among patches, which is a simple way of representing the chance of dispersion. It is probable that some types of matrix that do not provide a suitable habitat for small mammals allow periodical dispersion to take place. Besides the consistency across species, habitat connectivity models were also less variable across spatial scales, corroborating the findings of simulation models (Bender *et al*. 2003) and favoring the use of these metrics, since establishing appropriate scales is a difficult task. Finally, all three species with distribution in fragments significantly explained by landscape variables did not occur in matrix habitats or in just one, indicating that the importance of landscape structure is higher for species that are not widespread in the matrix.

References

Bender, D.J; Tischendorf, L. & Fahrig, L. (2003) Using patch isolation metrics to predict animal movement in binary landscapes. *Landscape Ecology* **18**: 17-39.

Revilla, E; Wiegand, T; Palomares, F; Ferreras, P. & Delibes, M. (2004) Effects of matrix heterogeneity on animal dispersal: from individual behavior to metapopulation-level parameters. *The American Naturalist* **164**: 130-153.

Sutcliffe, O.L; Bakkestuen, V; Fry, G. & Stabbetorp, O.E. (2003) Modelling the benefits of farmland restoration: methodology and application to butterfly movement. *Landscape and Urban Planning* **63**: 15-31.

Verbeylen, G; De Bruyn, L; Adriaensen, F. & Matthysen, E. (2003) Does matrix resistance influence Red squirrel (*Sciurus vulgaris* L. 1758) distribution in an urban landscape? *Landscape Ecology* **18**: 791-805.

A. Janin[1], J.P. Léna [1], C. Delacourt [2], P. Allemand [2], P. Joly [1]

[1] Ecology of Fluvial Hydrosystems and [2] Earth Sciences – University Lyon 1, 43 boulevard du 11 Novembre 1918 F-69622 Villeurbanne Cedex, France.
e-mail: agnes.janin@univ-lyon1.fr.

Introduction

Human activities generate a land conversion process resulting in landscapes composed of multiple habitats of varying quality according to the species' perception. This phenomenon, which generally reduces and fragments suitable habitats, is widely recognised as a major threat to the long-term persistence of populations. Hence, there is a growing demand for tools to predict and evaluate the impact of landuse changes. Traditional studies simplify the complexity of real landscapes by assuming a binary landscape structure which consists of a fragmented suitable habitat (the patches) embedded in a uniform non-habitat (the matrix). These studies have mainly focused on the patches, whereas considerably less attention has been devolved to the matrix. Yet, it is increasingly evident that the matrix is composed of a mosaic of habitats differing in their resistance to animal movement and thus affects landscape functional connectivity by enhancing or impeding movement (Ricketts, 2001).

In this context, we argue in favor of new approaches which integrate both the composition and the configuration of the whole landscape including the matrix. Percolation models such as *Cost Distance* models (Adriaensen *et al.*, 2003) are relevant tools to capture the landscape complexity and assess connectivity in a functional way. However, the accuracy of these models is strongly dependent on pre-existent knowledge of movement characteristics of the species considered. Unfortunately, this type of biological knowledge remains scarce. In the present work, we propose to adapt a cross-validation method to circumvent this problem: 1) we estimate the habitat resistance values required in *Cost Distance* models through a calibration procedure with no *a priori* knowledge; 2) we test the model's validity and assess the relative influence of composition and configuration of the complete landscape. We illustrate this approach through a case study conducted on the common toad (*Bufo bufo*) which is expected to harshly undergo the landscape impact because of its ground-dwelling habits and its obligatory seasonal migrations between forests and breeding ponds.

Methods

Cost Distance modelling (a toolbox in GIS-systems) provides a measurement of distance weighed by the species-specific resistance of each habitat constituting the landscape (Adriaensen *et al.*, 2003). Using this method, we built an integrative variable of landscape composition and configuration corresponding to the migration area, i.e. the area in which toads can potentially move from their pond to complete their biological cycle (Ray *et al.*, 2002, Joly *et al.*, 2003). We calibrated the resistance values of four habitat types (forest, crops, meadow and urban area) on a first dataset (Rhone-Alps, France) without *a priori* knowledge. For this purpose, we explored the relationship between migration areas, computed with a systematically explored range of resistance values, and toad occurrence. Next, we checked the validity of the selected resistance values with another dataset in the same region. We also verified that the model remained valid in a different landscape configuration (Geneva, Switzerland). To segregate the relative role of functional connectivity, we compared the predictive power of the migration area, which synthetizes composition and configuration, with that of landscape composition alone, which was assessed by the amount of each habitat surrounding the pond. All analyses were performed using logistic regressions.

Results

The calibration selected high resistance values for crops and low resistance values for meadow and forest. The validation step showed that the migration area computed using the selected resistance values had a significant impact on occurrence ($p<10^{-5}$ for Rhone-Alps and $p<10^{-4}$ for the Swiss region): the probability of presence increased with the size of the migration area (Fig.1). Moreover, for both validation datasets, our integrative variable had a significantly better predictive power than landscape composition. Indeed, even after removing the effects of the amount of each habitat type, the influence of the migration area on occurrence remained significant: $p<10^{-5}$ for Rhone-Alps and $p<10^{-2}$ for the Swiss region. The explanatory power of landscape composition was surprisingly low, particularly for the Rhone-Alps dataset in which the amount of forest had no effect at all on occurrence ($p>0.20$).

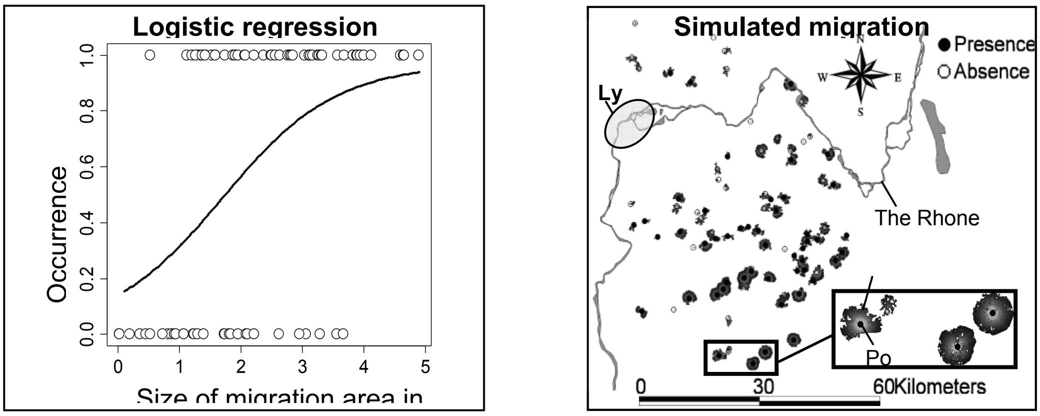


Figure 1. Toad occurrence related to migration areas for the Rhone-Alps validation dataset.

Discussion and Perspectives

The resistance values determined by calibration fully agree with current knowledge of the behavior of the common toad that avoids crops whilst it crosses large meadow and settles in forest (Ray *et al.*, 2002). Moreover, the migration areas computed with these resistance values are accurate predictors of toad occurrence since they explain significantly more variance than landscape composition alone. These results highlight the advantage, in order to reliably predict species occurrence, of capturing both the composition and the configuration of the whole landscape through a unique variable. Used here to assess the possibility for animals to complete their biological cycle, this tool can easily be adapted to design connections necessary to maintain the functioning of metapopulations.

References

Adriaensen, F; Chardon, J.P; De Blust, G; Swinnen, E; Villalba, S; Gulinck, H. & Matthyssen, E. (2003) The application of 'least cost' modelling as a functional landscape model *Landscape and Urban Planning* **64**: 233-247.

Joly, P; Morand, C. & Cohas, A. (2003) Habitat fragmentation and amphibian conservation: building a tool for assessing landscape matrix connectivity *C. R. Biologies* **326**: S132-S139.

Ray, N; Lehmann, A. & Joly, P. (2002) Modeling spatial distribution of amphibian populations: a GIS approach based on habitat matrix permeability *Biodiversity and Conservation* **11**: 2143-2165.

Ricketts, T.H. (2001) The matrix matters: effective isolation in fragmented landscapes *The American Naturalist* **158(1)**: 87-99

3.8 Open Session 13: Habitat Fragmentation and Mitigation

Landscape dynamic effecting bird diversity in an Atlantic Forest fragmented region: an evidence for time lag response.

A. Uezu[1] and J.P. Metzger[2]

[1] – IPÊ - Instituto de Pesquisas Ecológicas, Rodovia Dom Pedro I, Km 47 Caixa Postal 4712960-000, Nazaré Paulista, SP, Brazil. www.ipe.org.br. E-mail: aleuezu@ipe.org.br[1]
[1,2] – Departamento de Ecologia, Instituto de Biociências, Universidade de São Paulo, Rua do Matão, 321, travessa 14, 05508-900, São Paulo, SP, Brazil.

Introduction

In several cases, species extinction does not occur immediately after habitat fragmentation, what creates a time lag between these two processes (Tilman *et al.*, 1994; Brooks *et al.*, 1999; Hanski & Ovaskainen, 2002), making landscape dynamic an important factor to assess species threaten. An approach to evaluate such effects is to relate actual biological pattern with past landscape structures (Lindborg & Eriksson, 2004). The aim of this study was to verify the effects of historical processes of fragmentation on current richness patterns of forest birds in an Atlantic Forest region (Pontal do Paranapanema) and to estimate the time lag of species responses to structural landscape changes.

Methods

<u>Historical survey and landscape analysis</u>

We mapped the region using different types of information. For the most recent years we used Satellite images (Landsat 5) and for older ones topographic maps and aerial photographies. The maps were produced for each decade: 1957, 1965, 1978, 1984, 1993 and 2003. For each period we calculated landscape indices which represent patch size (logArea) and isolation (logProx).

<u>Bird survey</u>

Birds were surveyed using point count methodology in 21 patches plus seven sites in a control reserve (The State Park of Morro do Diabo, with 36,000 ha). Patches varied in size: seven large (>400 ha), seven medium (100 - 200 ha) and seven small (30 – 80 ha). Species richness was calculated for forest and generalist species and for different functional groups.

<u>Data analysis</u>

Model selection, based on Akaike's Information Criterion, was performed to distinguish which landscape indices, older or recent ones, explain better species richness. Nine regression models were proposed combining landscape parameters from the years of 1965, 1978 and 2003 (Figure 1), which presented the lowest correlation, and relating them with bird community parameters.

Results

Patch size of 1978 was the most important variable to explain the richness of the most sensitive groups (Table 1), what provides an evidence for a time lag of bird response to fragmentation of about 25 years. This period also corresponds to a moment of intense fragmentation process (Figure 1), when, probably, the landscape passed through the fragmentation threshold. For non-sensitive species, there is a high uncertainty, although the proximity index of 2003 was more often selected as the most important variable.

Discussion

Our results indicate that the sensitive species did not get yet into a steady state condition. More losses might occur from these groups in a near future if no landscape management is carried out to revert the negative consequences of forest fragmentation in the region. Probably, other landscapes in the Atlantic Forest are in the same or even worst condition as in many cases, human occupation started earlier than in the studied region and theoretical fragmentation threshold was reached more than 50 years ago. The present study highlight the necessity to consider the historical process of fragmentation to evaluate the real status of species threaten and to preview where the futures extinctions will occur, making possible for us to anticipate the conservation actions to avoid such losses.

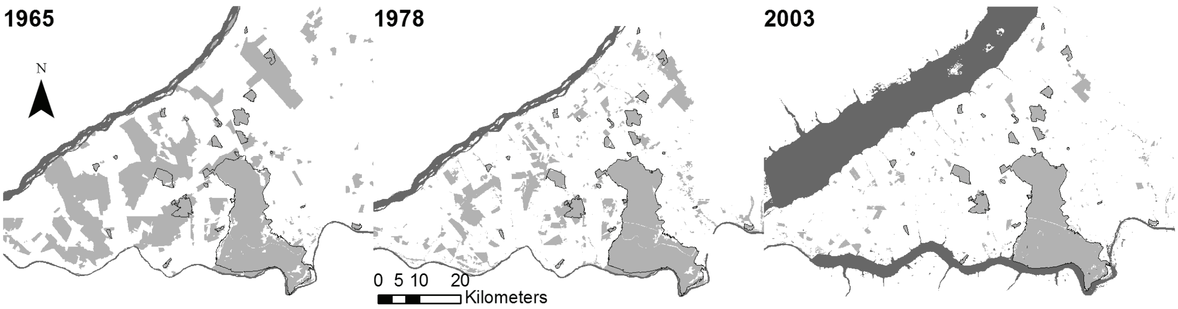


Figure 1 – Fragmentation process in the Pontal do Paranapanema region, southeast Brazil. The rivers are represented in dark gray, the forest in light gray and the black lines delineate the studied forest patches in 2003.

Table 1 – Relative importance of independent variable: sum of w AIC (chance of the model to be selected) of all models (nine), where a particular variable was present. Higher values represent more important variable. Pontal do Paranapanema, southeast Brazil.

Functional groups (sensitive)	Area65	Prox65	Area78	Prox78	Area03	Prox03
1-2 types of Forest	0,00	0,00	0,90	0,18	0,10	0,03
High sensitivity	0,03	0,01	0,56	0,11	0,40	0,13
Medium sensitivity	0,00	0,00	1,00	0,24	0,00	0,00
Limit of distribution (<100 km)	0,01	0,00	0,69	0,20	0,29	0,09
Limit of distribution (100-200 km)	0,00	0,00	0,90	0,19	0,10	0,02
Low abundance	0,00	0,00	0,96	0,22	0,04	0,01
Endemic in the Atlantic Forest	0,00	0,00	0,91	0,32	0,09	0,02
Terrestrial Frugivorous and insectivorous	0,06	0,02	0,80	0,18	0,14	0,03
Frugivorous and omnivorous from canopy	0,05	0,04	0,78	0,15	0,17	0,08
Understore insectivorous and omnivorous	0,00	0,00	0,99	0,58	0,01	0,00
Large understore Insectivorous	0,00	0,00	0,80	0,41	0,18	0,06

References

Brooks, T.; Pimm, S.L.; Oyugi, J.O., 1999. Time lag between deforestation and bird extinction in tropical forest fragments. *Conservation Biology* 13, 1140-1150.

Lindborg, R. & Eriksson, O., 2004. Historical landscape connectivity affects present plant species diversity. *Ecology* 85, 1840-1845.

Hanski, I. & Ovaskainen, O., 2002. Extinction debt at extinction threshould. *Conservation Biology* 16, 666-673.

Tilman, D.; May, R.M.; Lehman, C.L. & Nowak, M.A., 1994. Habitat destruction and the extinction debt. *Nature* 371, 65-66.

Using a consistent habitat network approach to reduce fragmentation at site to national scales.

A.E. Eycott, K. Watts

Forest Research, Alice Holt Lodge, Farnham, Surrey, GU10 4LH, UK.
e-mail: amy.eycott@forestry.gsi.gov.uk

Introduction

Improving the functional connectivity of landscapes is important for biodiversity conservation. Movement between patches is beneficial for the maintenance of structured populations and may also allow species to adjust their range in response to environmental change.

There are obligations for countries to reduce fragmentation at local, national and international scales (e.g. European Union Habitats Directive Article 10, UK Biodiversity Action Plan – EEC, 1992; UK Biodiversity Steering Group, 1995). At the local scale, there is a need to prioritise individual sites to ensure the effectiveness of site-based action. At more regional and national scales, finding areas with the greatest potential for improvement or a key role in large-scale connectivity will also focus action in a more effective manner.

Method

Habitat networks based on functional connectivity have been used to examine fragmentation (e.g. Bani *et al*., 2002; Vuilleumier and Prelaz-Droux 2006) but how such networks should be used to target action is less frequently demonstrated. There has not been a consistent, integrated approach to reducing fragmentation that can be applied across the various scales and link them up.

We use a functional approach to define habitat networks based on generic focal species and least-cost techniques (Adriaensen *et al*., 2003) to account for matrix permeability. Functional habitat networks were generated for broadleaved woodland, an important habitat suffering fragmentation in temperate Europe. The ecological permeability of the matrix was set by the degree of naturalness and complexity of vertical structure (Watts *et al*., 2005).

Locating latent networks for site based and national targeting

Once the initial functional networks had been mapped, the maximum dispersal distance was gradually increased by small increments relative to the initial dispersal distance. This allowed the identification of the functionally closest networks (Figure 1). These were termed 'latent networks' as they would potentially become single networks with only a small adjustment to the landscape, e.g. woodland planting or farming extensification.

Beyond local scale action, it is possible to identify particular regions which have a disproportionately high number of latent networks, thus offering a high potential to reduce fragmentation. Such areas could be the target of strategic action and incentive schemes.

A hierarchy of networks for different scales of planning

To complement the above method, instead of small increments in the dispersal distance, larger intervals were used. These provide a framework for action at increasingly large scales, appropriate to different elements of biodiversity or more infrequent long-distance dispersal events. Short distances identify existing functionally connected 'core' networks, moderate distances provide a framework for consolidating and expanding core networks into, and very high maximum dispersal distances form networks large enough to span near-national scales allowing the identification of potential linkages and barriers to large-scale movement. These scales represent a gradient of aspiration, starting with a need to protect existing networks and ending when species are able to adapt to climate change and shifting range margins by migration.

Conclusions

Our work addresses the need for consistency over different scales. It also addresses the need for improving connectivity while acknowledging multi-use landscapes, as it allows for guidance of solutions as well as targeting specific locations.

The issue of scale has dominated landscape research since the inception of IALE. While it is important to consolidate the existing resource (i.e. functioning habitat networks) in the face of continuing biodiversity loss, in the near future species range margins may be forced to change dramatically. However, if on the other hand we act to close only the gaps on a national scale, will the underlying networks be robust enough for species to respond?

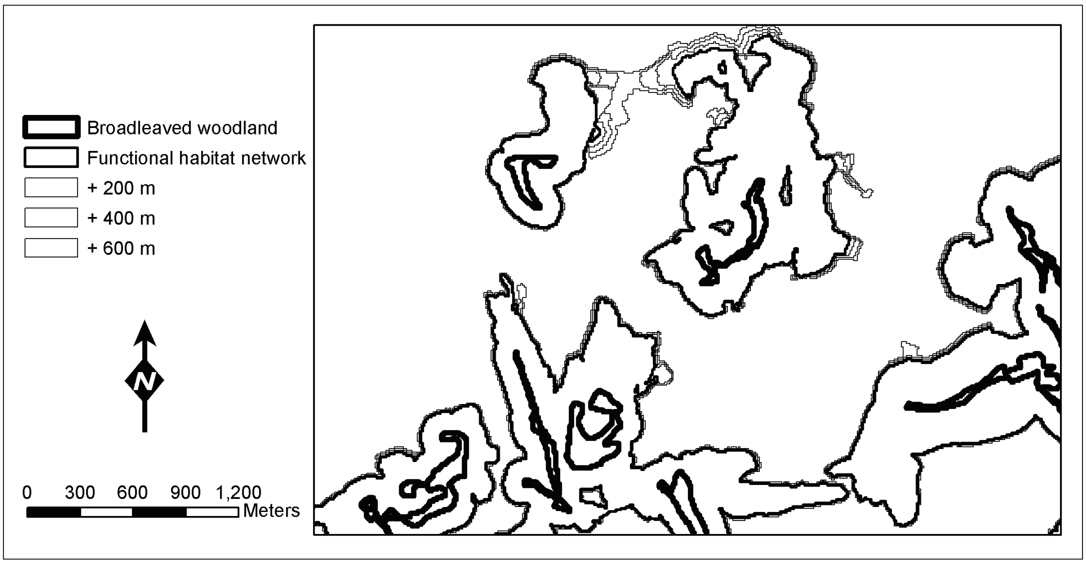


Figure 1. Increasing the maximum dispersal distance from the functional networks mapped allows the detection of functionally close networks.

References

Adriaensen, F.; Chardon, J.P.; De Blust, G.; Swinnen, E.; Villalba, S.; Gulinck, H. & Matthysen, E. (2003) The application of 'least-cost' modelling as a functional landscape model. *Landscape and Urban Planning* **64**:233-247.

Bani, L.; Baietto, M.; Bottoni, L. & Massa, R. (2002) The use of focal species in designing a habitat network for a lowland area of Lombardy, Italy. *Conservation Biology* **16**:826-831.

EEC (1992) *Council Directive 92/43/EEC of 21st May 1992 on the conservation of natural habitats and of wild flora and fauna.* HMSO, London

UK Biodiversity Steering Group (1995) *Biodiversity: The UK Steering Group Report - Volume II: Action Plans (Annex G - species action plans, habitat action plans and habitat statements).* HMSO, London.

Vuilleumier, S. & Prelaz-Droux, R. (2002) Map of Ecological Networks for landscape planning. *Landscape and Urban Planning* **58**:157-170.

Watts, K.; Griffiths, M.; Quine, C.; Ray, D. & Humphrey, J. W. (2005) *Towards a Woodland Habitat Network for Wales*. Countryside Council for Wales, Bangor, UK.

Combining ecological networks on different spatial scales leads to synergy

C.J. Grashof-Bokdam, M. van Adrichem, J.M. Baveco, M. van de Berg, P. Chardon, R. Jochem, H.A.M. Meeuwsen, P. Schippers, M. van der Veen, J. Verboom, C. Vos

Alterra, Landscape Centre, p.o box 47, 6700 AA Wageningen, the Netherlands.
e-mail: Carla.Grashof@wur.nl

Introduction

In the Netherlands, large networks of nature areas, like the National Ecological Network or Natura 2000 areas, are often under national protection. On the other hand, small networks of (semi-) natural landscape elements in agricultural or urban areas, also called green (or blue) veining, are often a responsibility of regional or local authorities. As many species use both larger nature areas and green veining as (partial) habitat, combining both networks in landscape design could lead to synergy: the amount of total habitat needed for sustainable (meta) populations could be optimized, and, if species can use both networks in an optimal way, populations may have higher sustainability or resilience in changing landscapes and in a changing climate.

In this study we focussed on networks of woody habitat on the higher sandy soils of the Netherlands. Results of field studies show what species benefit from combining networks and under what spatial conditions. Simulation modelling provides more insight in the underlying (meta) population processes of synergy between large and small networks.
Finally, the found spatial conditions will be assessed in a multi-criteria analysis in which green networks are also used for non-ecological functions like recreation.

Field studies

On a regional scale, we related the occurrence in km grids of 40 plant, butterfly and bird species of forest habitat to spatial connectivity of large and of small networks in the surroundings within the dispersal range of the studied species. Many species, e.g. the butterfly speckled wood (*Pararge aegeria),* appeared to occur more often in landscapes were both networks are spatially combined than in landscapes dominated by either large forest areas or by small forest patches and wooded banks (figure 1). We found a clear relation between synergy and the spatial character traits and habitat preferences of species.

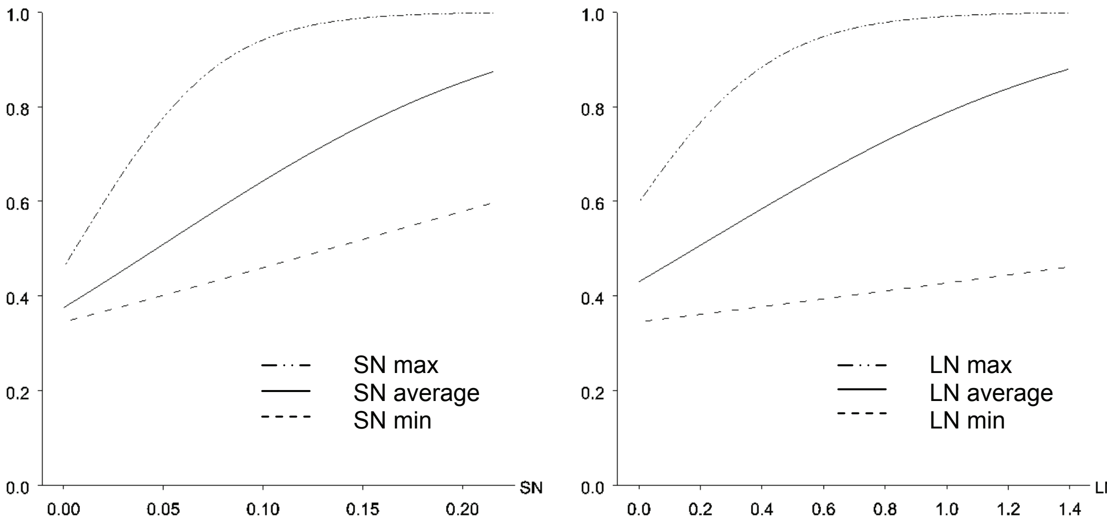
On a local scale, we compared the occurrence of two butterfly species, speckled wood and ringlet (A*phantopus hyperantus),* in isolated large networks, in combinations of large and small networks and in isolated small networks. On this scale, only the less mobile ringlet benefited from combining networks. Apparently, combination of networks is only beneficial if it happens on the correct spatial scale for the species under concern.

Model studies

We developed several artificial landscapes that all consist of a fixed percentage of woody habitat, but of a different proportion of large and small networks (patchy and linear habitat). We simulated population performance of several species differing in habitat preferences and spatial character traits. For this purpose we combined METPHOR, an individual-based (meta)population model (Verboom *et al.,* 2001), with SmallSteps (Baveco, 2002) a movement model. For each of the species types, we searched for the minimum spatial conditions for synergy in combined networks.

a) p(occurrence) speckled wood

b) p(occurrence) speckled wood



connectivity large networks connectivity small networks

Figure 1. Probability of occurrence of the butterfly species speckled wood versus spatial connectivity of large networks (LN) and small networks (SN). Increase in occurrence versus large networks is higher if connectivity of small networks is also higher (a). Increase in occurrence versus small networks is higher if connectivity of large networks is also higher (b) (Grashof *et al*., in prep).

References

Baveco, J.M (2002) The SmallSteps movement model. http://purl.oclc.org/NET/alterra/movement.

Grashof, C.J. *et al.* (in prep). Synergy between large and small networks on the higher sandy soils of the Netherlands.

Verboom, J. *et al.* (2001). Introducing the key patch approach for habitat networks with persistent populations: an example for marshland birds. *Biological Conservation* **100(1)**: 89-101.

Habitat availability and connectivity for a focal species (jaguar) in the Yungas region, Argentina

D. Somma[1], P. Perovic[2], R.H.G. Jongman[3], H. van Lier[3], A. Cerezo[4] , R.J.A. van Lammeren[3]

[1] National Parks Administration of Argentina, Av. Santa Fe 690, 1059, Capital Federal, Argentina.
e-mail: djsomma@yahoo.com.ar
[2] Instituto de Biología de la Altura, Universidad Nacional de Jujuy. Av. Bolivia 1711, 4600, San Salvador de Jujuy, Jujuy, Argentina.
[3] ALTERRA, Po Box 47, 6700 AA, Wageningen, The Netherlands.
[4] Facultad de Agronomía – Universidad de Buenos Aires, Av. San Martín 4453, 1417 Buenos Aires - Argentina.

Introduction

Our aim was to evaluate wildlife habitat availability and landscape connectivity in the Argentine Yungas at a regional scale for a selected feline taken as focal species: the jaguar (*Panthera onca*).

Jaguars have been proposed as landscape detective species in Brazil (Cullen, 2004). Landscape detectives are thus defined as organisms which can show how to plan and manage reserves and large interconnected eco-regions, because their requirements for survival reveal factors important to maintaining ecologically healthy conditions.
The central hypothesis is that by using jaguars as a landscape detective it is possible to identify and assess three important and independent features that characterize large carnivores and large scale conservation planning: (1) prey diversity and density, (2) large core areas and important habitat patches for biodiversity conservation, and (3) biological corridors and landscape connectivity. In our research we developed the items (2) and (3).

In particular, we wanted to establish a set of working hypotheses about the spatial distribution of high quality habitat for jaguars. We aim to identify areas of high conservation value, which of these are in potential conflict with human presence or uses, and possible habitat strips which can act linking corridors between core areas (e.g. Baritu and Calilegua National Parks, and Pintascayo Provincial Park). The jaguar is used as “primer” in the identification of key sites for biodiversity conservation across the Yungas region, an approach similar to the case of bears in northern Spain (Naves *et al.,* 2003).

Methods

A number of natural and human variables were considered, a statistical validation of the analysis and a regional model of habitat availability are presented (Austin, 2002). In this research, “habitat” is considered a species-specific concept (Garshelis, 2000).

Published and new data were combined for the analysis. The new data was obtained through fieldwork transects, meetings with park rangers, scientist, teachers, farmers, ranchers and special interviews to a singular and species-specific local group: the trackers (“*tigreros*”). A logistic regression analysis was carried out using presence data and a group of possible explanatory variables. This resulted in a habitat quality model for the jaguar. The problem of autocorrelation was resolved by the application of a scale dependent - random labeling methodology for point pattern analysis (Wiegand and Moloney, 2004). The performance of the jaguar habitat model was evaluated with ROC analysis.

Connectivity was managed as a species and landscape specific parameter. The jaguar was used as the focal species to perform the assessment of connectivity among habitat patches at regional scale. We applied percolation theory, graph theory and a range of analytical tools based on this conceptual framework. These tools were a landscape ecological metric: correlation length -C- and two derived indexes for patch evaluation applied to the analysis of individual patch relevance.

Results

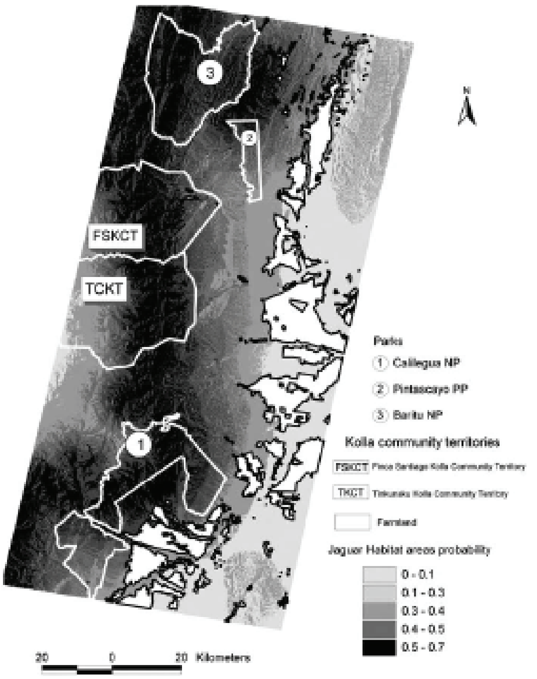


Figure 1. Jaguar habitat probability model.

The ROC analysis qualifies the model as reasonably good (AUC: 0.701). The connectivity analysis outlined different possible configurations of high quality habitat patches connecting the core areas. It would give options to the planner that could be managed as negotiation alternatives in a land use planning participatory process.

References

Austin, M.P. (2002) Spatial prediction of species distribution: an interface between ecological theory and statistical modeling. *Ecological Modeling* **157**: 101-118.

Cullen, L. (2004) Jaguar as Landscape detectives for the Atlantic Forest. Brazil. *6th International congress on wildlife management in Amazonas and Latin America*. September, 5th - 10th, 2004, Iquitos, Perú.

Garshelis, D.L. (2000) Delusions in habitat evaluation: measuring use, selection, and importance. L. Boitani & T. K. Fuller (eds.) Research techniques in animal ecology: controversies and consequences. Columbia University Press, New York, USA. pp. 111-164.

Naves, J., Wiegand, T., Revilla, E. and Delibes, M. (2003) Endangered species constrained by natural and human factors: the case of brown bears in Northern Spain. *Conservation Biology* **17**: 1276-1289.

Wiegand, T., and Moloney, K.A. (2004) Rings, circles, and null-models for point pattern analysis in ecology. *Oikos* **104**: 209-229.

Harvesting: a keystone process in cover type evolution at landscape level? Fourteen landscape histories in Quebec (Canada)

E. Alvarez[1], L. Bélanger[2], L. Archambault[3] and F. Raulier[2]

Wood and forest sciences department, Forestry and geomatic faculty, Laval University, G1K 7P4, Quebec, Canada.
e-mail: eric.alvarez.1@ulaval.ca
[2] Forestry and geomatic faculty, Laval University, Quebec, Canada.
[3] Natural Ressources Canada, Canadian Forest Service, Quebec, Canada.

Introduction

The natural range of variability (NRV) concept is a useful tool in forest management (Landres et al. 1999). However, despite a large consensus on the usefulness of this concept, many authors in recent years have noted its limits.

The first limit is expressed by the key question "Which period of time should we use?" Sprugel (1991) mentioned that taking the pre-colonial period may be misleading because of climate changes. An idea defended by Millar and Woolfenden (1999).

Second, this method is mostly valid in an "equilibrium" or "shifting-mosaic steady state" context such as a long fire-free period (Baker 1989; Spies and Turner 1999). In the presence of catastrophic fires, this equilibrium may no longer exist (Baker 1989, Shinneman and Baker 1997). As our study area, a temperate mixedwood forest in central Quebec (Canada), has a long history of major natural disturbances, we have to be cautious because we probably are in a non-equilibrium situation.

A useful complement to the NRV concept would be to keep the integrity of ecological processes. Marcucci (2000) talked about "keystone process". He defined it as "(…) those formatives processes that influence the trajectory of landscape change(…)".

The objective of the study is to validate if harvesting has been a keystone process at landscape level.

Methods

We monitored the evolution of forest cover for four periods of time (1946, 1957, 1976 and 1996) for fourteen landscapes that average 300 km^2. For each landscape, we also analyzed archival data to detail past natural disturbances and harvesting. Analysis was based on the combination of three approaches. 1) We evaluated if 1996 landscapes were within their natural range of variability. 2) We verified hypotheses on the evolution of forest cover following harvesting. 3) We grouped landscapes based on three cluster analyses.

Cover type appellations were standardized as appellations changed over the years. The area of each cover type was extracted from photo-interpretation databases. As we have not done photo-interpretation ourselves, we had to consider an error in the percent area of each cover type for each period of time considered. Unfortunately, we were unable to specify a level of error as very few studies have been done on the subject. (Naesset 1999). Also, natural disturbance areas were underestimated due to limitations of archival data.

Results

Natural disturbances have been so important that between the big fires of 1922/23 and 1996, only three landscapes have had much more harvesting than natural disturbances.

There were no cases for which all our hypotheses about the evolution of forest cover following harvesting matched. As expected however, maximum concordance occurred for two of the most harvested landscapes in the last forty years. The least respected hypothesis was about intolerant hardwoods stands. They decreased instead of increasing.

Hard(intolerant)-soft and jack pine stands were the most often outside the NRV.

In 1996, based on cluster analysis, up to 12 of the14 landscapes were in the same group despite very different disturbance histories.

Discussion

We could not conclude that harvesting has been, globally, a keystone process at landscape level for the period considered. Only jack pine stands responded fully to our criteria. For hard(intolerant)-soft stands, harvesting impacts were additive to what was already a natural tendency.

Based particularly on cluster analysis, it appeared that harvesting may have homogenized the landscapes. At landscape level, some studies confirmed the idea that the main effect of harvesting would be to modify the magnitude of the effects when compared to natural disturbances (Weir and Johnson 1998, Boncina *et al.* 2003).

Based on hierarchy theory, we hypothesized that harvesting is not a constraint but rather limits the displacement of landscapes inside their "constraint envelope" (O'Neill *et al.* 1989).

Management Implications

The main recommendation is to ensure that pure softwood stand (black spruce and jack pine) proportions reach historical levels.

References

Baker W L (1989) *Landscape ecology and Nature reserve design in the boundary Waters Canoe Area, Minnesota.* American Scientist **70(1)**: 23-35

Boncina A, Gaspersic F, Diacj J (2003) *Long-term changes in tree species composition in the Dinaric mountain forests of Slovenia.* The Forestry Chronicle **79(2**): 227-232

Landres P B, Morgan P, Swanson F J (1999) *Overview of the use of natural variability concepts in managing ecological systems.* Ecological Applications **9(4)**: 1179-1188

Marcucci D J (2000) *Landscape history as a planning tool.* Landscape and Urban Planning **49**: 67-81

Millar C I, Woolfenden W B (1999) *The role of climate change in interpreting historical variability.* Ecological Application **9(4)**: 1207-1216

Naesset E (1999) *Assessing the effect of erroneous placement of forest stand boundaries on the estimated area of individual stands.* Scandinavian Journal of Forest Research **14(2)**: 175-181

O'Neill R V, Johnson A R, King A W (1989) *A hierarchical framework for the analysis of scale.* Landscape ecology **3(3/4)**: 193-205

Shinneman D J, Baker W L (1997) *Nonequilibrium dynamics between catastrophic disturbances and old-growth forests in Ponderosa Pine Landscapes of the Black Hills.* Conservation biology **11(6):** 1276-1288

Spies T A, Turner M G (1999) Dynamic forest mosaïcs. In: Hunter Jr M L (ed.), *Maintaining biodiversity in forest ecosystems*, Cambridge University Press, Cambridge, pp 95-160

Sprugel D G (1991) *Disturbance, equilibrium, and environmental variability: What is "Natural" vegetation in a changing environment?* Biological conservation **58:** 1-18

Weir J M H, Johnson E A (1998) *Effects of escaped settlement fires and logging of forest composition in the mixedwood boreal forest.* Canadian Journal of Forest Research **28:** 459-467

At which spatiotemporal landscape scales does habitat amount explain the local abundance of species?

H. Paltto[1], A. Moilanen[2], B. Nordén[1]

[1] Department of Plant and Environmental Science, Göteborg University – Box 461, 405 30 Göteborg, Sweden.
e-mail: heidi.paltto@dpes.gu.se
[2] Metapopulation Research Group, Department of Biological and Environmental Sciences – PO Box 65, 00014 Helsinki, Finland

Background

Empirical studies show that different habitat specialist species and organism groups (taxa/guilds) respond differently to the amount of suitable habitat in the surrounding landscape (Paltto *et al*., 2006). Studies including (1) many study sites, (2) habitat availability within several spatial scales (e.g. formed as concentric rings around a focal patch) and (3) more than one time scale (historical maps also considered) are scarce, but point to the possibility that local species responses for a certain spatial scale change with changing temporal scale. Since species dispersal is a distance per time-process, the strongest effect of the amount of habitat in the surrounding landscape may be found at a scale corresponding to the dispersal capacity of a species. Using a metapopulation modeling approach we investigated how species with different life-history strategies respond to the amount of habitat in the current and historic landscape under a scenario of ongoing habitat fragmentation.

Methods

A grid-based stochastic patch-occupancy model simulating colonisations and extinctions of a species in a landscape was constructed. The model included a reduction of suitable habitat during simulations. We run the model for a number of hypothetical species with different dispersal and extinction characteristics (n=99 replicates). The species abundance in the focal habitat patch (25 grid cells) at a certain fragmentation degree (mean 2%, 5% and 20%) was related to the amount of habitat in the current and past landscape at various points in time (with 10 years interval) and at different spatial scales (circular areas around the focal patch within 0-1 km, 1-5 km and 5-20 km radii).

Results

A hypothetical species with slow dispersal and extinction rates was strongly related to the current amount of habitat at the smallest spatial scale (R=0.81; Figure 1a), while the relationship to the largest scale was weak and strongly delayed in time (R=0.27; 240 years). For another species (with higher dispersal rate but the same extinction rate) the intermediate spatial scale (R=0,40; Figure 1b) became relatively more important and slightly delayed in time (30-70 years) in comparison with the smallest scale. The relationship to the largest scale was weak and strongest for the current landscape (R=0,14). A third species (good dispersal ability and high extinction rate) was related to the smallest and intermediate spatial scales (R=0.32-0.41 during 130 years BP) and very weakly to the largest scale.

Analyses of species in less fragmented landscapes (mean 20 %) showed roughly the same pattern as mentioned in the paragraph above (mean 5 %), but with a slightly stronger relationship to the intermediate spatial scale, a weaker relationship to the largest scale and fewer time delays in species responses. Analyses of slow species in highly fragmented landscapes (mean 2 %) revealed clear time delays in their responses (Figure 1d; 100 years for the smallest, 50 years for the intermediate and 300 years for the largest scale).

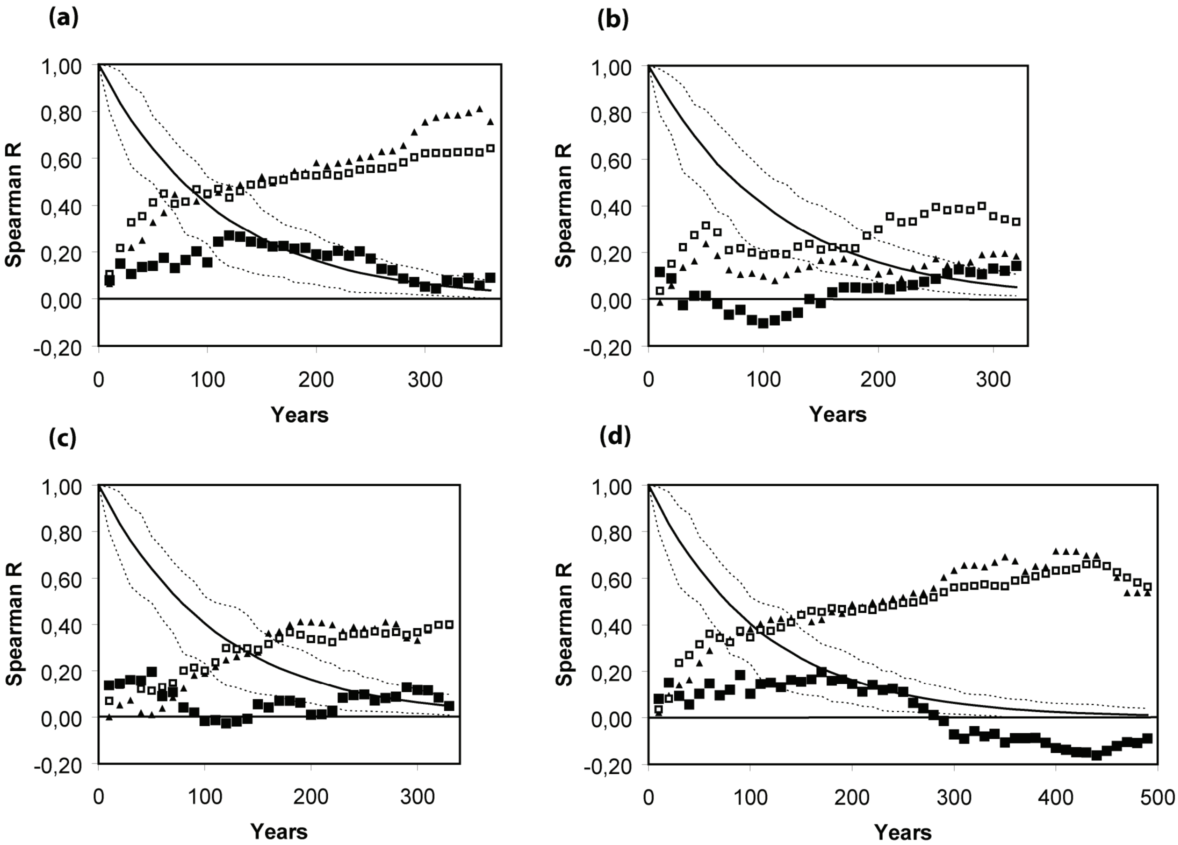


Figure 1. Spearman Rank Correlation coefficients for tests between habitat amount in the landscape (circle radius 0-1 km ▲, 1-5 km □, 5-20 km ■; n=99) and species abundance in a focal patch in the end of a run: (a) a species with slow dispersal and extinction rates, (b) a species with slow dispersal and high extinction rate, (c) a species with high dispersal and high extinction rate. (a, b, c: mean 5 % habitat in the end of the run), (d) same as (a) but in a more fragmented landscape (mean 2 % habitat). The lines show the habitat amount as proportion of the landscape: maximum, mean and minimum.

Conclusions and implications

Many empirical studies have explored the relationship between species occurrences/ abundances and habitat at landscape scale. Most of these studies include only a few spatiotemporal scales and thus there is a risk – if wrong scales are studied – that an effect of landscape connectivity is not detected. Our study shows that the relationship between the local abundance of a species and the landscape depends on the scales included, and that the response is dependent on the species dynamics. For the future it is of outmost importance to conduct empirical studies at multi-spatiotemporal scales to complement our results. It is also important that potential effects of scales not included in current projects are discussed; otherwise the conclusions may be misleading.

References

Paltto, H.; Nordén, B.; Götmark, F. & Franc, N. (2006) At which spatial and temporal scales does landscape context affect local density of Red Data Book and Indicator species? *Biological Conservation* **133**: 442-454.

Modelling the effects of elevation and topographical-based behaviour on inter-patch dispersal

J. Alderman[1], S.A. Hinsley [2]

[1] Landscape and Biodiversity Research Group, School of Applied Sciences, University of Northampton, Park Campus, Northampton, NN2 7AL, UK. email: jolyon.alderman@btinternet.com
[2] Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire, PE28 2LS, UK.

Introduction

One of the effects of fragmentation is to increase inter-patch dispersal distance, increasing the risk of predation en-route. Perceptual range (the ability to detect habitat patches at a distance) is suggested as one characteristic that would be advantageous to a dispersing individual by providing a greater choice of patches, resulting in more direct dispersal paths. Most real landscapes have topographical elements, such as hills, valleys and urban developments, which can all act to modify a species' perceptual range and directly influence movement behaviour. However, the majority of individual-based spatially explicit population models (SEPM) employ two-dimensional landscapes, which fail to model the effects of topography. In two dimensions, all habitat patches within a species' perceptual range are generally detectable, but topographical features may substantially alter 'detectability', with the associated likelihood of erroneous and misleading predictions.

Using an individual-based Spatially Explicit Population Model (SEPM), the aim of this study was to explore the effects of elevation and topography on inter-patch dispersal flow paths. Previous work showed that spatial configuration of the landscape influenced (modelled) flow paths (Alderman *et al.* 2005), thus it was thought likely that elevation would also affect dispersal.

Methods

This study was based on an intensively farmed 40,000 ha (20 × 20 km) landscape in eastern England, centred on Monks Wood (52°24'N, 0°14'W) in Cambridgeshire. Approximately 4% (1,660 ha) of the area consisted of fragmented woodland. Ranging in elevation from 0-70 m above sea level (ASL), several valleys run largely north-west to south-east, with Monks Wood itself lying on a shallow north-facing slope. The nuthatch (*Sitta europaea*) was used as a test species. Resident in the UK, the nuthatch is a small (c. 22-26 g) cavity-nesting, woodland passerine, which has been shown to be sensitive to forest fragmentation. Dispersal from the natal patch is common in fragmented habitat (Enoksson *et al.* 1995).

The model, called PatchMapper (Alderman *et al.* 2005), combines an individual-based nuthatch population simulator with a grid-based representation of the landscape. Perceptual range mechanisms were integrated into the inter-patch dispersal rules, allowing the disperser to move directly to the nearest wood within the specified range and field-of-view.

To meet the aims of this study, three tests were devised. As a reference, the first test modelled dispersal in a two-dimensional landscape, with no topographical data. To gauge the effects of elevation on dispersal, the second test incorporated topography together with a topographical-based behavioural response in the form of a valley-seeking algorithm. The third test added an urban avoidance element to the dispersal rules of the second test. The overall consequences of dispersal under each test were measured by recording their respective effects on dispersal paths through a landscape of fragmented habitat patches and an urban development, by recording population size in Monks Wood (located in the centre of the landscape). All tests utilised 5,000 yearly cycles, with an immigration rate of 15 individual birds per cycle, from each of the cardinal directions in turn. The tests were repeated for four (modelled) perceptual ranges of 0, 0.2, 2 and 5 km.

Results and Discussion

Compared to the two dimensional version of the landscape, the inclusion of elevation and topographical-based behaviour resulted in predicted population sizes that were strongly dependant on landscape topography at lower perceptual ranges. This dependence diminished as perceptual range increased, indicating that the scale at which an organism interacts with its landscape is important. The three modelling scenarios gave significantly different results, suggesting the existence of species and landscape dependant optimal perceptual ranges. Thus, the perceptual behaviour of the same species may differ in different landscapes. The urban development acted in a similar manner to a rock in a stream. Dispersal flow densities increased ‘upstream’, with the flow being deflected to either side of the development, meeting up again some distance ‘downstream’. Flow density was much reduced in an area immediately behind the development.

During dispersal, the areal extent of the viewable landscape is continually updated. Thus, a disperser can continually revise its movement decisions as previously unseen topography comes into view. Visually detectable topography will also have a large influence on initial choice of dispersal direction. It is likely, therefore, that the detectable topographical features and other landscape elements of a landscape will all play some part in determining inter-patch dispersal paths. Also, when presented with a choice of topographical elements, a disperser may, for example, select the path of least energy consumption, such as a reluctance to ‘hill-climb’ demonstrated by some species. Alternatively, a disperser may take the path of least perceived risk, such as utilising the cover afforded by a hedgerow network and the avoidance of unfamiliar habitat such as urban areas.

Conclusions

At the higher perceptual ranges, the traditional two-dimensional modelling method consistently under-estimated population sizes, compared with the three-dimensional approach. There were also significant differences between the three sets of inter-patch dispersal paths. These findings suggest that using population predictions based on two-dimensional landscapes to aid landscape management planning decisions may be problematic. One example of this may be the construction of a wind farm. Such a development may, depending on its location, deflect dispersal flow towards a particular patch and increase its population or shield it from dispersal, and reduce the population. Thus, it is recommended that both elevation and topographical-based behaviour, commensurate with the studied species, be applied to the movement rule-base of dispersal simulation models.

References

Alderman, J; McCollin, D; Hinsley, S.A; Bellamy, P; Picton, P. & Crockett, R. (2005) Modelling the effects of dispersal and landscape configuration on population distribution and viability in fragmented habitat. *Landscape Ecology* **20:** 857-870.

Enoksson, B; Angelstam, P. & Larsson, K. (1995) Deciduous forest and resident birds: the problem of fragmentation in a coniferous forest landscape. *Landscape Ecology* **10:** 267-275.

Importance of riparian corridors for native fauna – small mammals in forest patches, matrix habitats and linear structures in an Atlantic forest fragmented landscape

L. Naxara [1], R. Pardini [2]

[1] Departamento de Ecologia and [2] Departamento de Zoologia, Instituto de Biociências, Universidade de São Paulo, Rua do Matão – travessa 14, 101, São Paulo, SP, Brazil.
e-mail: launax@yahoo.com.br

Introduction and Methods

Landscape connectivity, defined as the amount of flow of organisms or genes in a landscape, is influenced by the spatial configuration of remnants, matrix permeability and the presence of stepping stones and corridors. Although the maintenance and restoration of riparian corridors have frequently been the focus of conservation strategies and environmental legislation in the tropics, and in the Atlantic forest in particular, studies on the importance of these linear structures to native species are rare. Studies performed in other regions of the world point not only to positive but also to negative ecological effects of corridors, which can potentially be stronger in tropical forests given the clear edge-induced habitat changes observed in this type of forest (Laurance *et al*., 2002). Here, we aim to evaluate the importance of riparian corridors to endemic and invasive small mammals in an Atlantic forest fragmented landscape.

Four similar systems were selected in a fragmented landscape in Tapiraí and Piedade, São Paulo State, Brazil. Each of those encompasses two forest patches (20-36 ha) connected by one riparian corridor (420-613 m in length and 50-90 m in width) and surrounded by open areas of agriculture or pasture. In each system, we set four 50-m long and 20-m wide grids of Sherman and pitfall traps, a 100 m from each other: one in the interior of the forest patch, one at the edge of the forest patch, one in the corridor and one in the open matrix. We carried out a 6-day sampling session every two months, totaling five sessions and 30 sampling days in each of the16 grids in 2006. We compared small mammal richness and abundance among habitat types using Repeated Measures ANOVA and Tukey test. When necessary, data was ranked-transformed to attain homocedasticity.

Results and Discussion

We captured 555 individuals of 16 small mammal species, seven endemic to the Atlantic forest and nine also found in open biomes. While the two most abundant species - *Akodon montensis* and *Oligoryzomys nigripes*, which are not restricted to the Atlantic forest - were captured in all sampled habitats, nine species - seven of which endemic to the Atlantic forest - were captured only in forested habitats, three non-endemic species only in the matrix and two non-endemic species in the matrix, corridors and edges. Although richness did not vary among habitat types ($F= 0.163$, $P= 0.918$), total abundance showed a significant variation ($F= 4.000$, $P= 0.034$), decreasing from the matrix through corridors, edges and interiors (Figure 1). Nine species had more than 20 individuals captured and were analyzed individually. The abundance of the two non-endemic, most abundant and widespread species, *A. montensis* ($F= 4.107$, $P= 0.032$) and *O. nigripes* ($F= 7.278$, $P= 0.004$), varied among habitats: the abundance of *O. nigripes* was lower in the matrix and interiors compared to corridors and edges, and *A. montesis* was less abundant in interiors compared to the other habitats (Figure 1). Whereas the abundance of the most common endemic species - *Brucepattersonius soricinus*, which was not present in the matrix - varied significantly among habitat types ($F= 19.903$, $P< 0.001$), being more abundant in corridors, followed by interiors and edges, the abundance of the second most abundant endemic species - *Marmosops incanus*, which is also absent from the matrix - was not significantly different among forested habitats ($F= 2.464$, $P= 0.112$) (Figure 1). The two most abundant species in the matrix, *Necromys lasiurus* and *Calomys tener*, are savanna species and were exclusively captured in this habitat. However, the other non-endemic species, *Oligoryzomys flavescens*, although absent from interiors, varied significantly in abundance among habitats (F= 4.150, P= 0.031), being more abundant in the matrix and corridors compared to edges (Figure 1).

Results point to a strong segregation in small mammal distribution between open areas and forest remnants - including interiors and edges of patches and corridors, with only two generalist species not restricted to the Atlantic forest being able to occupy all habitats types. Open areas are dominated by invasive species from savanna biomes, which can attain extremely high density increasing total small mammal abundance in those areas, whereas riparian corridors and forest patches harbor endemic species. Corridors represent an extension of forest patches for endemic species, since the abundance of none of them declined from interiors or edges of patches to corridors, indicating the potential of corridors for mitigating fragmentation effects for native small mammals. On the other hand, corridors may function as a barrier to the expansion of invasive species, since most of those did not occupy corridors. Our results indicate that riparian corridors are important not only for increasing connectivity by providing high quality habitat for native species, as already observed in a more forested landscape in Amazonia (Lima & Gascon 1999), but also for preventing the expansion of invasive species in highly fragmented landscapes.

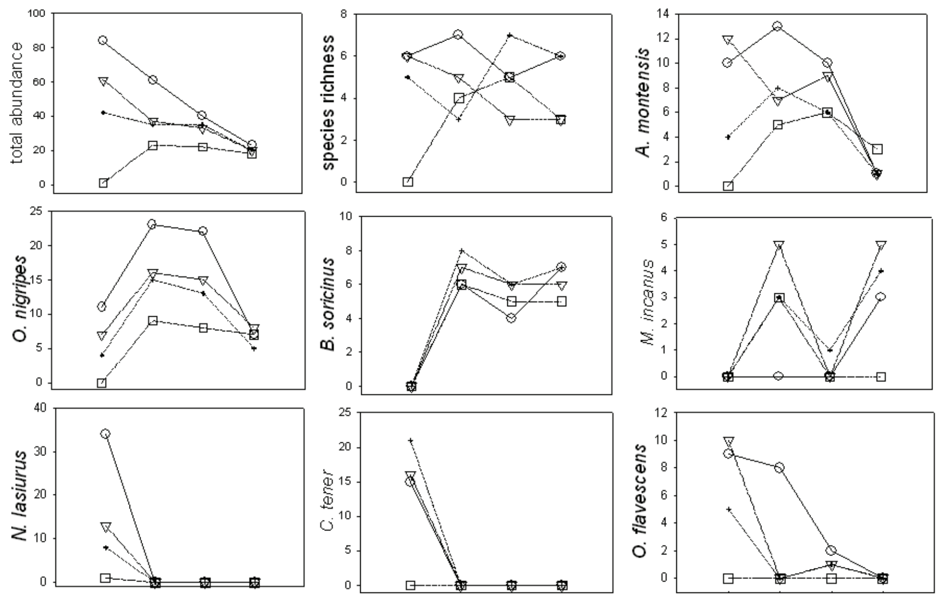


Figure 1. Small mammal richness and abundance in open matrix (M), riparian corridors (C) and edge (E) and interior (I) of forest patches in four systems (different symbols) in a fragmented Atlantic forest landscape in Brazil.

Acknowledgements

To FAPESP (05/56555-4, 05/57307-4), for financial support.

References

Laurance, W. F; Lovejoy, T.E; Vasconcelos, H L; Bruna, E. M; Didham, E. K; Stouffer, P. C; Gascon, C; Bierregaard, R. O; Laurance, S. G & Sampaio, E. (2002) Ecosystem decay of Amazonian forest fragments: A 22-year investigation. *Conservation Biology* **16**: 605-618.

Lima, M.G. & Gascon, C. (1999) The conservation value of linear forest remnants in Central Amazonia. *Biological Conservation*, **91**: 241-247.

Ecological Infrastructure: The Concept, Development and Application

H. L. Liu[1 2], D. H. Li[1] and X.L.Han[1]

[1]Graduate School of Landscape Architecture, Peking University, Beijing, China 100871e-mail: liuhlong@mail.tsinghua.edu.cn.

[2]Department of Landscape Architecture, Tsinghua University, Beijing, China 100084.

The concept of ecological infrastructure originally emerged in the 1980s, and several theories and ideas facilitated its later development. Basing on available literatures, a systematic review of five aspects can be made.

Ecological infrastructure in Conservation Biology

Mander (1988) and Selm (1988) have laid the foundation of ecological infrastructure concept simultaneously. Obviously, since late 1960s when Landscape Ecology and Island Geography theories grew up, the recognition of ecological corridors and other key landscape elements in bio-diversity conservation boosted the formation of this idea. Actually, considerable similar ideas (Ahern, 1995), such as environmental corridors (Lewis, 1964), Habitat Networks (Noss & Harris, 1986), landscape linkages (Harris & Gallagher, 1989), Dutch Ecological Main Infrastructure (Bohemen, 2002), National Ecological Network of Netherlands (Ahern, 1995) and EECONET (Jongman, 1995; Bennett, 1994) etc, have indicated that the nature conservation is changing from specie-centered and site protection approaches to ecosystem-oriented ones focusing on the integral conservation infrastructures (Jongman, 1995).

Ecological infrastructure in ecosystem service study

As Constanza mentioned *the minimum level of ecosystem infrastructure* and *a certain critical ecosystem structure* (Constanza *et al*. 1997, from Fromm, 1999), it is obvious that the original intention of eco-economist's studies is to explore the value of ecosystem services provided by the earth's ecological infrastructure (World Resources Report, 1998-1999). Accordingly, it is an important progress to combine ecosystem service with basic ecological structure (Yu & Li, 2002, 2003). Ecological infrastructure serves the bridge connecting ecosystem service with landscape planning, so people can take operable measures to safeguard and conserve the sustainability both of nature and people.

Ecological man-made infrastructure

Flink (1997) has classified infrastructure into three types: man-made physical, natural and social ones and man-made physical infrastructures have caused enormous impacts to natural system and ecological processes. According to Williamson (2003), infrastructure reflects the social priorities of diverse cultures, so the solution for today is green/ecological infrastructure. Scientists and engineers try to solve problems including fragmented habitats, constrained floodplains and impermeable surface by making compensation and restoration of ecosystem service and enhancing the landscape continuity (Cuerus *et al*. 1993, from Seiler & Eriksson, 1995; Bohemen, 1998). A number of cities in North America and Europe are active to implement such kind of programs (Benedict & McMahon, 2002)).

Ecological infrastructure and open space planning

Parks and green spaces have served as fundamental infrastructure to solve urban problems such as congestion and filth. Based on Randolph (2004), concepts such as Park, Park System, Greenbelt, Green Heart, Parkway, Open space and Greenway, evolve gradually and their objectives varied in different stages. Ecological infrastructure, being continuous green space network, is increasingly recognized as a new strategy of open space planning and land conservationSchneekloth, 2003; Randolph, 2004; Yu & Li, 2001, 2002and has been advocated in *1999 Report of the American President's Council on Sustainable Development* as *nation's natural life support system etc* (Williamson, 2003).

Ecological infrastructure and the planning methodology reformation

Ecological infrastructure concept has driven the reformation of planning methodology. Honachefsky (1999) stressed on the value of *making preservation of the ecological* *infrastructure the priority of the municipal master plan* and Benedict *et al*. (2002) advanced *a framework for smart conservation and smart growth* that indicates land conservation should be concert with rather than isolated or opposite to development. New ideas, such as *Smart Growth and Regional City* etc, partially hold such points (Benedict *et al*. 2002).Yu and Li (2001, 2002) have explored comprehensive urban ecological infrastructure strategy and the Negative Planning approach to guarantee urban sustainability in China.

To sum up, ecological (green) infrastructure is the critical natural system on which the sustainability is based and from which residents, not only the wildlife but also the people, can continuously enjoy the benefits of ecosystem services.

References

Mander, U. & Jagonaegi, J. et al. (1988) Network of compensative areas as an ecological infrastructure of territories. Connectivity in Landscape Ecology, *Proceedings of the 2nd International Seminar of the International Association for Landscape Ecology*, Ferdinand Schoningh. Paderborn, 35-38.

Selm, A, J. V. (1988) Ecological infrastructure: a conceptual framework for designing habitat networks. In Schrieiber. K. -F. (ed), Connectivity in Landscape Ecology, *Proceedings of the 2nd International Seminar of the International Association for Landscape Eclogy*. Ferdinand Schoningh. Paderborn, 63-66.

Ahern, J. (1995) Greenways as a planning strategy. *Landscape and Urban Planning*, **33**□131-155.

Yu, K.J. (1996) Security patterns and surface model in landscape planning. *Landscape and Urban Planning*, **36 (5):** 1-17.

Jongman, R.H.G. (1995) Nature conservation planning in Europe: developing ecological networks. *Landscape and urban planning*, **32**:169-183.

Jongman, R.H.G., & Mart Külvik, Ib (1995) Kristiansen, European ecological networks and greenways, *Landscape and Urban Planning* **68** :305–319.

Benedict, M., & McMahon, E. (2002) Green Infrastructure: Smart Conservation for the 21st Century. *The Conservation Fund. Washington, DC: Sprawl Watch Clearinghouse*. Retrieved June 13, 2003.

Flink, C.A. (1997) *Greenway: Serving Infrastructure Needs in the 21st century*. Paper Greenways Incorporated, North Carolina.

Fromm, O. (2000) Ecological Structure and Functions of Biodiversity as Elements of Its Total Economic Value, *Environmental and Resource Economic*s, **16**: 303-328.

Yu, K.J., Li, D.H. & Chao, L.M. (2001) Ten landscape Strategies to Build Urban Ecological Infrastructure, *Planner,* **6**: 9-17.

Yu, K.J. & Li, D.H. (2002) On Negative-planning Concept and Ecological Infrastructure, *Proceedings of Green City in Hangzhou*, Beijing: China Fine Art. School Press.

Impacts of landscape fragmentation on breeding habitats of Oriental White Stork in the Sangjiang Plain, China

Liu HongYu[1], Li Zhaofu[2]

[1] College of Geography, Nanjing Normal University.122, Ninghai Road, Nanjing, 10097,China.
e-mail: liuhongyu@njnu.edu.cn
[2] College of Resources and Environmental Sciences, Nanjing Agricultural University. Weigang Road, Nanjing 210095, China.

Introduction

Since the fragmentation of natural habitats is one of the most serious problems for many species, it is highly interesting to study the impacts of landscape fragmentation on habitats of endangered species (Farina, 1998). The Oriental White Stork (Ciconia boyciana), as a representative wetland waterfowl in the Sanjiang Plain, China, has sharply declined in numbers over the last decades apparently due to forest harvesting and fragmentation of natural wetland landscapes (Li Xiaomim, 2002; Liu Hongyu, 2005). Conservation measures have led to the establishment of a wetland reserve network to assure the maintenance of the Oriental White Stork at a regional scale. However, little is known about the effects of landscape structure and fragmentation of landscape on the habitats and the distribution of Oriental White Stork.

Results

Distribution of breeding habitat of Oriental White Stork

Six breeding habitat variables were tested by field surveys conducted in spring 2004 and 2005 before they were used to establish a HSI model for evaluating the breeding habitats of Oriental White Stork and their dynamic distribution over the past decades in the study area. Distributions of the suitable breeding habitats were identified by integrating the HSI model into GIS environments. Results show that the breeding habitats were originally distributed in almost all of the area of the Sanjiang Plain in 1954, but habitats in the west-southern part have been lost after the first large-scale reclamation when large area of wet meadows and marshes were lost. The main suitable distribution area was located in the Northeast part from 1966 to 1983. But, the remaining habitats were only distributed in the northern part along Heilongjiang River and eastern area along the Wusuli River from 1993 to 2005. Our results also showed that the landscapes were in matrix states (wetland total area > 50% and connectivity > 50) in periods of 1954~1976. This result suggested that the historical periods of wetland changes could be divided into the matrix state (1954~1976) and fragmented state (1983~2005) in a landscape scale.

Patch characteristics and dynamics

The sharply declined trend in areas for suitable breeding habitats of storks is clearly shown in Table1. The total habitat area decreased 81.9% by 2005 with 73.6% of wetlands being lost in the study area. The main reason for the change may be the significant variation of patch characteristics and their sizes in landscapes. Our results show that the maximum patch size of wetlands accounted for 86.3%~70.9% of the total wetland area in 1954~1983 and more than 15% of patches of wetlands were occupied. But only 9%~1.5% of wetland patches were occupied after the wetland was fragmented in the period between 1983~2005. This phenomenon indicates that larger patches have more positive effects on habitat quality and patch characteristics have greater importance in maintaining higher quality habitats for Oriental White Storks in the study area. Table 1 shows that larger patches have higher diversity than small patches and suggests that habitat heterogeneity within a larger patch of wetland could therefore provide more suitable and safety reproduction area for Oriental White Storks.

Effects of connectivity of wetlands on habitats

Landscape connectivity had consistent positive effects on breeding habitats (Table.1). Habitat connectivity is more than 50 in state of landscape matrix of wetlands between periods of 1954~1976 which showing more than half of wetlands could be occupied for breeding habitats by storks. But habitat connectivity had seriously declined when the landscape matrix changed from wetland into farmland after 1983. Furthermore only 1.4% of wetland patches would be occupied in 2005. This suggests that isolation by distance between patches was also a significant factor affecting quality of breeding habitats for oriental white storks, but the effect of distance was accentuated by fragmentation of the landscape. Isolated patches may be absolute barriers for storks because the maximum distance from a nesting patch to a feeding area is usually less than 2km or 3km in the study area.

Table 1. Characteristics of habitat patches in historical periods in the Sanjiang Plain,China

Habitat/ Wetland	Area (%)	Mean patch size (km^2)	Diversity of Max. patch (H)	Patch number	Patch connectivity
1954	40.8/71.1	178.6/67.7	3.63/3.63	104/478	69/88
1966	26.5/55.0	65.5/36.4	3.12/3.12	184/688	62/71
1976	23.8/50.7	70.9/22.7	2.98/2.98	153/1016	50/56
1983	19.4/37.4	61.2/11.5	1.56/1.66	144/1480	27/19
1993	14.8/22.3	27.0/4.4	0.95/1.48	249/2321	23/24
2005	7.4/18.8	21.4/0.76	0.86/1.36	157/11272	19/15

Discussion

Data on patch size and distance between patches is generally easy to obtain, and there is no doubt that these variables are often important to explain the distribution of a species. However, for studies of distribution and persistence of little-known species in patchy habitats, it is prudent to evaluate both patch characteristics and landscape context of habitat patches whenever possible. Efforts should be made to evaluate relevant patch characteristics and factors that determine connectivity for such species.

Acknowledgements
This work was carried out with financial assistance provided by National Natural Science Foundation of China (40471003).

References
Imo Farina.(1998) Principles and methods in landscape ecology. Chapman & Hall Ltd., pp.58~68.

Hanski I. & O. Ovaskainen. (2000) The metapopulation capacity of a fragmented landscape. Nature, 404:755-758.

Li Xiaomim. (2002) Wild animal resources and their changes. Liu Xingtu & Ma Xuehui. The Natural Environmental changes and their conservation in the Sanjiang Plain. Science Press, pp232-234.

Liu Hongyu; Lu Xianguo; Zhang Shikui et.al.(2005) Fragmentation process of wetland landscape in watersheds of the Sanjiang Plain. Chinese Journal of Applied Ecology, 16(2): 289~295.

A graph-based methodology for integrating habitat connectivity in landscape conservation planning: application to the capercaillie in Catalonia (NE Spain)

L. Pascual-Hortal and S. Saura

Forest Landscapes and Biodiversity Research Group. Department of Agroforestry Engineering. Higher Technical School of Agrarian Engineering. University of Lleida. Av. Rovira Roure, 191. 25198 Lleida. Spain.
e-mail: lpascual@eagrof.udl.es

Introduction

Large-scale habitat loss and fragmentation are critically hindering the dispersal and survival of many species. The integration of landscape connectivity criteria in conservation planning applications is therefore a need for preserving the biodiversity and the ecological functions of natural ecosystems. Nevertheless, there is a lack of operative methodologies to effectively tackle this problem.

Connectivity analysis through habitat availability indices and graph structures

We propose a practical and quantitative methodology for landscape connectivity analyses (figure 1), based on graph structures and algorithms, GIS operations and new habitat availability indices (integral index of connectivity, probability of connectivity) that overcomes several computational and decisional limitations of other existing approaches. The new developed indices present improved properties in the sense of being both sensitive to different types of negative changes that can affect the landscape mosaic and effective detecting which of those changes are more critical for its conservation from a spatial analysis point of view (Pascual-Hortal and Saura, 2006a, 2006c). The habitat availability concept considers a habitat patch itself as a space where connectivity exists, integrating habitat abundance and connectivity between patches in a single measure; we suggest that the connectivity problem should be considered within the wider concept of habitat availability in order to be useful for conservation planning (Pascual-Hortal and Saura, 2006b). The application of graph structures and algorithms is a powerful and effective way of overcoming computational limitations that appear when dealing with large data sets and performing complex analysis regarding connectivity (Urban and Keitt, 2001).

We developed a new version of the Conefor Sensinode software (version 2.2) as an analysis support tool for identifying and ranking by importance the habitat patches that most contribute to the maintenance of landscape connectivity. This software has been developed by modifying, reprogramming and including new indices and features in the Sensinode 1.0 software (LandGraphs package) developed by Dean L. Urban (Duke University). Although being developed under a complex theoretical and mathematical basis, Conefor Sensinode 2.2 is easy to use and interpret by users (not knowledge on graph-theory required). A free copy of this software can be obtained by contacting the authors.

Conservation planning application to the capercaillie habitat in Catalonia

For demonstrative purposes, we apply this methodology to the analysis of the endangered capercaillie (*Tetrao urogallus)* habitat in Catalonia (NE Spain). The habitat distribution data was obtained from the *Catalan Breeding Bird Atlas* (Estrada *et al.*, 2004), which provides the probability of occurrence of this bird for each 1x1 km UTM square covering Catalonia. By applying the new-developed index probability of connectivity (PC), we determine the connected subregions existing within the landscape and the key habitat areas for the connectivity of the habitat mosaic for this species. Furthermore, on the basis of these results, we identify the public forests holding larger amount of high-priority sites for capercaillie connectivity and evaluate the effectiveness of different protected areas networks (e.g. Natura 2000) in this sense. We conclude providing specific recommendations for the management of capercaillie habitat in these key locations and highlighting the potential and practical interest of this methodology for successfully integrating connectivity in landscape conservation planning applications.

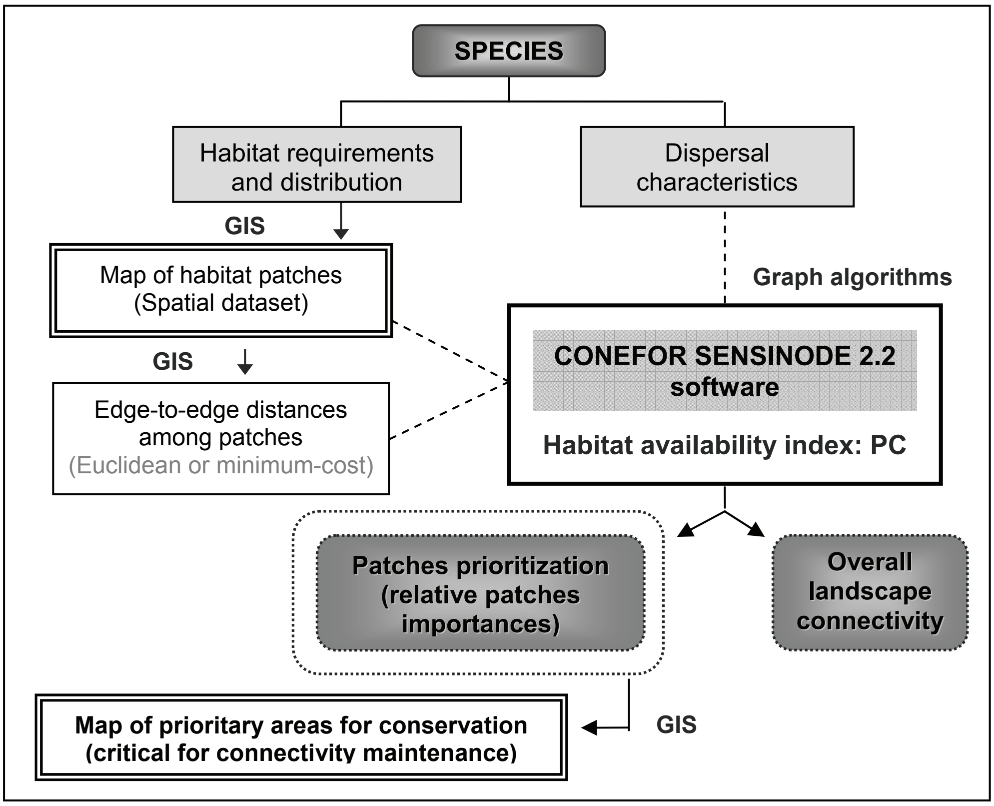


Figure 1. Diagram of the methodology for the analysis of landscape connectivity and the Conefor Sensinode 2.2 software in which it has been implemented.

References

Estrada, J.; Pedrocchi, V.; Brotons, L & Herrando, S. (2004) (Eds). *Atles dels ocells nidificants de Catalunya 1999-2002*. Lynx Edicions, Barcelona, Spain.

Pascual-Hortal, L. & Saura, S. (2006a) Comparison and development of new graph-based landscape connectivity indices: towards the prioritization of habitat patches and corridors for conservation. *Landscape Ecology* **21:** 959-967.

Pascual-Hortal, L. & Saura, S. (2006b) Integrating landscape connectivity in broad-scale forest planning through a new graph-based habitat availability methodology: application to capercaillie (*Tetrao urogallus*) in Catalonia (NE Spain). *European Journal of Forest Research* DOI 10.1007/s10342-006-0165-z.

Pascual-Hortal, L. & Saura, S. (2006c) Integrating landscape connectivity in broad-scale forest planning: a methodology based on graph structures and habitat availability indices. R. Lafortezza & G. Sanesi (Eds). *Patterns and processes in forest landscapes: consequences of human management. Proceedings of the IUFRO Landscape Ecology Conference*. Academia Italiana di Scienzi Forestali.Locorotondo, Bari, Italy, pp. 111-116.

Urban, D. & Keitt, T.H. (2001) Landscape connectivity: a graph-theoretic perspective. *Ecology* **82:** 1205-1218.

Refining the fragmentation paradigm: the over-riding influence of land-use history on present day ecosystems in fragmented agricultural landscapes

PG Spooner, ID Lunt

School of Environmental Sciences, Charles Sturt University, PO Box 789 Albury, NSW 2640, Australia.
e-mail: pspooner@csu.edu.au

Throughout the world, the development of agriculture has resulted in the rapid transformation of continuous ecosystems to landscapes dominated by crops and pastures, within which small remnants of the original vegetation are retained (e.g. Hobbs & Saunders, 1994; Yates & Hobbs, 1997a; de Blois *et al.,* 2001, 2002). The analogy between remnant patches in agricultural landscapes and islands in seascapes has enabled island biogeography theory (MacArthur & Wilson, 1967) to be extended to agricultural landscapes worldwide (Burgess & Sharpe, 1981; Gilpin & Soulé, 1986; Hanski & Simberloff, 1997). However, a recent review of fragmentation experiments (Debinski & Holt, 2000) revealed that most fragmentation studies exhibited species richness patterns contrary to predictions based upon island biogeography theory. Levenson (1981), for example, showed that species-area relationships were incapable of predicting plant species abundances. The contradictory nature of many studies has led to ongoing questions about the utility of the fragmentation paradigm (Simberloff & Abele, 1982; Gilpin & Soulé, 1986; Usher, 1987; Robinson *et al*., 1992; Hanski & Simberloff, 1997; Davies *et al*., 2001; Watson, 2002; Hobbs & Yates, 2003; Lindborg & Eriksson, 2004).

Landscape ecology considers spatial and temporal interactions across the landscape and the influences of spatial patterns on biotic and abiotic processes (Levin, 1992; Wiens, 1997; Baker, 1999; Turner *et al*., 2001). The discipline emerged from attempts to develop an all-encompassing fragmentation paradigm (Turner, 1989; Naveh & Lieberman, 1990; Wiens, 1997; Naveh, 1998). Despite general acceptance by plant and animal ecologists, landscape ecology has often been criticised for: (1) concentrating mainly on spatial patterns and ignoring temporal changes (Hobbs, 1999; Turner *et al*., 2001), and (2) tending to exclude people from the landscape (Hammett, 1992; Kirkpatrick, 1999). Recent studies have placed greater emphasis on changes in functional aspects of remnant ecosystems in fragmented landscapes (e.g. Saunders *et al*., 1991; Hobbs *et al*., 1993; Kearns *et al*., 1998), and have highlighted that some landscapes are better described as variegated rather than fragmented, since the landscape matrix is not necessarily hostile to all species (McIntyre & Barrett, 1992; McIntyre & Hobbs, 1999). However many studies are still conceptually based on traditional patch area–isolation concepts (Wilcove *et al*., 1986; Laurance & Bierregaard, 1997).

The apparent contradictory nature of many fragmentation studies may simply reflect the short time frame of observations, which often cannot encompass the many indirect feedbacks that occur in anthropogenic disturbed landscapes (Debinski & Holt, 2000). Agricultural landscapes are characterised by dramatic changes on varying timescales. Some short term changes are predictable in periodicity (such as annual cultivation of crops) and even type (i.e. change in crops), but due to hysteresis (lag effects), longer term changes in fragments are poorly understood (MacDonald & Smith, 1990). For example, many tree species may live for centuries, and since adult plants are often less sensitive to changes in environmental conditions than juvenile stages, current patterns may simply represent a slow process of gradual extinction (Adamson & Fox, 1982; Hobbs, 1987; Bennett, 1993; Foster, 2000; Saunders *et al*., 2003). An alternate hypothesis for interpreting the contradictory nature of many fragmentation studies is the over-riding imprint of spatially variable, historical anthropogenic disturbances, which selectively advantage some taxa and disadvantage others (Wilcove *et al*., 1986). Unfortunately our ability to detect the effects of short and long term processes may be clouded by what Dovers (2000) describes as our ‘amnesia’, or ignorance of past human events and their residual effect on landscapes.

'Historical ecology' has been cited as a new paradigm in which ecologists view ecosystems as *historically* and spatially influenced non-equilibrium systems that are complex and open to human inputs (Hammett, 1992; Balée, 1998; Swetnam *et al*., 1999; Egan & Howell, 2001). This framework recognises that: (1) historical events play a major role in ecology, as changes in abiotic conditions or species composition that happened in the past can have large and often irreversible effects on the structure and dynamics of present day ecosystems (de Blois *et al*., 2001, 2002), and (2) remnant ecosystems may exist in various non-equilibrium states due to a complex history of anthropogenic disturbance regimes (Naveh, 1998; Pyne, 1998; Motzkin *et al*., 1999; Lugo & Gucinski, 2000; de Blois *et al*., 2002). Historical ecology shares a similar approach to the 'environmental history' discipline, since both are interdisciplinary, however the latter tends to focus on the development of a narrative driven 'story' (Bowman, 2001; Griffiths, 2002), whilst historical ecology is more akin to traditional biogeography in its attempts to quantify human relationships with the landscape.

Building on disturbance ecology, the historical ecology framework recognises that landscape elements may have evolved with human inputs to such an extent that abandonment of human interference may lead to impoverishment of structural and biological diversity (Solon, 1995; Naveh, 1998; Kirkpatrick, 1999; Ross *et al*., 2002; Spooner *et al*., 2004a, b). This approach highlights that not all human activity leads to degradation, and that humans are an integral component of landscape dynamics (Gragson, 1998; Naveh, 2000; Peterson, 2000). Agricultural landscapes contain remnant ecosystems that have evolved from different historical management regimes, economies and political policies (Ihse, 1995). By detailing the history of human activity and resulting changes in vegetation structure, composition and pattern, we can examine biotic responses to novel anthropogenic disturbance processes and devise appropriate conservation strategies (Reed, 1990; Foster *et al*., 1998; Naveh, 1998; Swetham *et al*., 1999; Bowman, 2001; Miller & Hobbs, 2002; Ross *et al*., 2002; Foster *et al*., 2003).

The aim of this paper is to enhance current attempts to understand patterns of biodiversity in fragmented agricultural landscapes, by using an historical ecology perspective to highlight *the over-riding influence of land-use history in creating past*, *current and future patterns of biodiversity across a range of spatial scales*. We present a series of conceptual postulates to enhance our understanding of biodiversity patterns in ways that cannot be met by existing frameworks. We then illustrate each of these postulates with examples, largely drawn from fragmented woodlands in south-eastern Australia. We summarise the key implications of these postulates, and conclude by discussing the potential advantages of using this approach to guide the development of future studies of biodiversity patterns in other agricultural landscapes.

3.9 Posters

Seed rain in rainforest fragments: relating seed and fragment features

F.M. Jesus[1], P.R. Pivello[1], S.T. Meirelles[1], J.P.Metzger[1]

[1] University of São Paulo, Institute of Biosciences, Department of Ecology, Rua do Matão, Travessa 14, Cidade Universitária Armando de Salles Oliveira, São Paulo, SP, Brazil 05508-900
e-mail: flaviamj@ib.usp.br

Introduction

Seed dispersal is one of the most important processes for forest dynamics (van der Pijl 1982). The arrival of diaspores in forest fragments through seed rain is a key-process to direct gene flow, recruitment rates, species turnover, and therefore, the community composition and structure (Venable & Brown 1993). Besides this, the current composition of plant communities allows for predictions on the community course, as its development or recovery. However, in fragmented landscapes the spatial arrangement of remaining forest patches may affect the seed flux according to habitat connectivity and patch size. Therefore, our objectives were to investigate the influence of patch size and habitat connectivity on seed rain composition, and to compare tree species composition and seed rain within patches.

Methods

We analyzed nine Atlantic rainforest fragments surrounded by an agricultural matrix (São Paulo, Brazil) being three small and isolated, three small and connected to three large fragments. Seeds were collected during 12 months through 108 nylon seed traps (0.5 m^2) arranged as triplets in the centre of each forest patch. Seeds were classified according to dispersal mode (autochoric, anemochoric, zoochoric), species life form (tree, shrub, vine, epiphyte), and functional group (early successional, late successional). Tree species in the fragments were estimated inside 10 m^2 plots around seed traps. The independence of seed rain composition upon fragment features was tested by G-test (Yates correction, Zar 1996); species similarity between the arboreal community and seed rain was verified with Jaccard indices (Magurran 1988).

Results

We registered 20,142 seeds belonging to 115 species. The small-isolated patches accounted for more than 50% of total seeds, the highest amount of anemochoric and early-successional seeds. They also showed a high amount of epiphyte seeds, but a low amount of liane seeds (Table 1). Large patches accounted for 17.6% of total seeds and the highest amount of arboreal, zoochoric, autochoric, and late-successional seeds (Table 1). The small-connected patches accounted for 32% of total seeds, and the highest amount of shrub seeds (Table 1), being all other parameters intermediate between the values of large and small patches. The small-isolated patches showed the lowest diversity, while the large ones showed the highest equability (Table 2). Tree species similarity between seed rain and the corresponding fragment was very low, gradually increasing from the small-connected to large and to small-isolated (Fig.1).

Discussion

The results suggest that fragment size and connectivity affect seed rain composition. The small-isolated patches seem to receive more wind-dependent seeds of initial successional trees, mostly coming from nearby. Animals use more intensely the large patches, dispersing later-successional seeds. A high influence of external factors such as wind in the small patches may explain the very low similarity between seed rain and the arboreal community. Small fragments, however, do contribute with the seed flow in the landscape.

Table 1. Values of G (G-test with Yates correction) and p (probability at 0.95) resulting from comparison between the studied patches (SI= small-isolated patch; SC= small-connected patch; L= large patch)

	SI x SC	SI x L	SC x L
anemochoric	$G_{(0,05;gl=1)}$=596,64;p<0,00	$G_{(0,05;gl=1)}$=860,87;p<0,00	$G_{(0,05;gl=1)}$=68,48;p<0,00
authocoric	$G_{(0,05;gl=1)}$=53,55; p<0,00	$G_{(0,05;gl=1)}$=4,79; p<0,02	$G_{(0,05;gl=1)}$=33,29; p<0,00
zoochoric	$G_{(0,05;gl=1)}$=558,76; p<0,00	$G_{(0,05;gl=1)}$=797,9; p<0,00	$G_{(0,05;gl=1)}$=61,89; p<0,00
epiphyte	$G_{(0,05;gl=1)}$=212,17;p<0,00	$G_{(0,05;gl=1)}$=87,82;p<0,00	$G_{(0,05;gl=1)}$=1,35; p<0,24
shrub	$G_{(0,05;gl=1)}$=682,17;p<0,00	$G_{(0,05;gl=1)}$=317,59; p<0,00	$G_{(0,05;gl=1)}$=15,17;p<0,00
arboreal	$G_{(0,05;gl=1)}$=976,71; p<0,00	$G_{(0,05;gl=1)}$=459,73; p<0,00	$G_{(0,05;gl=1)}$=6,39; p<0,00
vine	$G_{(0,05;gl=1)}$=780,33; p<0,00	$G_{(0,05;gl=1)}$=15,17; p<0,00	$G_{(0,05;gl=1)}$=0,04; p<0,83
early-successional	$G_{(0,05;gl=1)}$=4873,73;p<0,00	$G_{(0,05;gl=1)}$=73,04;p<0,00	$G_{(0,05;gl=1)}$=1973,72; p<0,00
late-successional	$G_{(0,05;gl=1)}$=6,11; p<0,01	$G_{(0,05;gl=1)}$=31,86; p<0,00	$G_{(0,05;gl=1)}$=11,09; p<0,00

Table 2. Tree species richness and diversity indices in nine rainforest patches (São Paulo State, Brazil) according to seed rain composition (n= number of seeds; S= species richness; H'= Shannon´s diversity index; J= Pielou's eqüability index; SI= small-isolated patch; SC= small-connected patch; L= large patch)

	Patch identification								
	CM (SI)	TE (SI)	DI (SI)	LU (SC)	MA (SC)	AL (SC)	TA (L)	PE (L)	PD (L)
n	1209	3456	5499	2059	1671	2702	1432	667	1447
S	33	47	32	53	35	39	27	39	38
H'	0,803	0,768	0,335	0,963	0,694	0,652	0,575	0,946	0,868
J	0,529	0,459	0,223	0,559	0,450	0,410	0,402	0,595	0,550

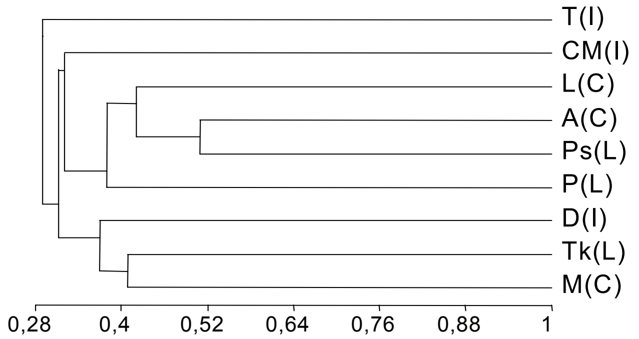


Figure 1. Dendrogram resulting from a MVAR (minimum variance criterion) cluster analysis (Jaccard's coefficient), and seed rain data of the analyzed patches.

References

Magurran, A. E. 1988. *Ecological diversity and its measurement*. Princeton University Press, Princeton, New Jersey.
Van der Pijl, A. 1982. *Principles of dispersal in higher plants*. 2nd edition. Springer-Verlag, Berlin.
Venable, D.L. & Brown, J.S. 1993. The population-dynamic functions of seed dispersal. *Vegetatio,* 107/108: 31-55.
Zar, J. H. 1996. Biostatistical analysis. 3. ed. Nova Jersey, Prentice Hall.

Agro-environmental structures in the countryside. Their role in local bird movements within the Sile River Natural Park

D. Tocchetto, M. Borin

University of Padova, Department of Environmental Agronomy and Crop Production, Agripolis, 35020 Legnaro (PD), Italy.
e-mail: davide.tocchetto@unipd.it

Introduction

Within the framework of the National Research Programme “Ecological networks and agriculture” begun in 2004, a pilot area was established in the Sile River Natural Park, in Veneto Region, N-E Italy. Due to its geographical position, the Park is an important area for biodiversity conservation. The habitats host a wide diversity of species of both flora and fauna, many of which are rare and protected.

Methods

The research focused on assessing the presence and multiple roles of ecological network structures in a farming area inside the Park. Three adjacent zones were identified, each differing in shape, hydrology, history, farming activities, agro-environmental structures and other aspects. At a local scale each landscape element, i.e. fields, hedgerows, ditches, field roads, woods, etc., is part of and has a function in an ecological network system (as core areas, corridors, stepping stones, buffer zones). To evaluate the functions related to animal life, bird movement surveys were conducted in 2006. It is well known that landscape structures have direct influences on bird populations. Small woods, isolated trees, hedges, farm fields, etc., allow and encourage the movement of birds.

Four observation sites were chosen in the study area, each differing in land use, farm management and neighbouring hedgerow structure and length. The bird surveys consisted of 30 minutes of direct watching in the observation site. During the survey period the following flight movements were noted: i) high above the site, ii) from hedgerow to field, iii) between two or more hedgerows, iv) from plant to plant (within the hedgerow), v) leaving the site, vi) flying into the field, vii) flying into the hedgerow. Four surveys were conducted from June to September 2006.

Results and conclusions

The observations show high mobility where there are many hedgerows and the land use is varied. More than two thousand movements were counted during the surveys.

All the movement categories considered occurred in sites 1, 2 and 3, with an average of 2.8, 2.0 and 1.9 counts per 30 minutes, respectively. Due to the agro-environmental features many movements were noted from the hedgerows to fields, between hedges, and flights from outside into the hedges or fields. Site 4, located in a large maize-growing area, totalled 0.9 counts per 30 minutes. There are no elements in this site (such us wheat grain, berries, etc.) to attract birds and more than 84% of the movements were “flying high above the site”.

The results show that the agro-environmental elements had a strong influence on the birds daily activities and movement within the study area and in the nearby zones. These movements depend both on the season and the specific features of the countryside.

Applying the bidirectional cost-distance theory to the connectivity analysis of forest bird species richness in a fragmented landscape in the Andean mountains

J. Aubad[1]. C. Martinez[1]. H. Gulinck[2]. M. A. Rodriguez[1].

[1] Departamento de Ecología, Universidad de Alcalá, 28871 Alcalá de Henares Madrid, Spain; e-mail: jorgeaubad@yahoo.es
[2] Department of Land Management and Economics. Katholieke Universiteit Leuven. Belgium.

Forest fragmentation is one of the major ecological problems worldwide and specially in areas with extraordinary species richness and endemicity. Among others, the connectivity concept was introduced as a tool in the search for solutions, not only theoretical but also practical, for fragmentation impacts and biological richness loss.

The study landscape is located in the Central Andean Mountains of Colombia and is currently under evaluation by the State environmental office for conversion into a regional conservation area.

The selection of the variables was in accordance with a previous model based on Generalized Linear Models (GLZ). To apply this model we registered bird species of the natural forest patches. We also recorded all landcover types that surround forest patches to compare bird species richness similarity. This method allows the quantification of each landcover polygon of the landscape in the resistance map.

We used two maps for the cost distance analyses; a forest sources map and the resistance map for the input model. The output image of the cost distance analysis is a cost map with values that surround the specific sources, where the value of each cell represents the distance to the source and the displacement effort. We compared the scenarios of 2001 and 2021, a hypothetical landcover map that includes changes if current conservation concerns persists. Using the bidirectional cost distance (BCD) algorithm we generated multiple values and topological structures as a support basis for the design of ecological habitat-corridors in this landscape.

The bidirectional cost distance model (BCDM) assumes the simple addition of the cost surface calculated from a point A to the cost surface from another point B. Therefore BCDM is the sum of a cost-map from one source to another, plus a cost-map from the other to the first source, where the result is a continuous raster map with a main route created by the low cost values (BCD Route)

Conclusions

BCD models allow the quantification of changes in connectivity surfaces. These models estimate the effects of the current conservations strategies on future bird species richness of Andean mountain forests. BCD models show consistent results that facilitate decision making at this landscape level and the design of natural forest conservation areas.

Direct and indirect effects of habitat heterogeneity on flower-visiting insects and associated species interactions

T. Diekötter[1,2], K.J. Haynes[1], D. Mazeffa[1], T.O. Crist[1]

[1] Department of Zoology, Miami University, Oxford, Ohio 45056, USA. e-mail: tim.diekoetter@uni-giessen.de
[2] Justus-Liebig-University, IFZ - Department of Animal Ecology, Heinrich-Buff-Ring 26-32, D-35392 Giessen, Germany

The direct effects of landscape structure on individual species or functional groups may be transferred indirectly through webs of interacting species. To date, however, most studies on the effects of habitat size and spatial arrangement have focused primarily on responses of population size or diversity. In a factorial field experiment, we explored the direct and indirect effects of habitat area, habitat fragmentation, and matrix composition on a community of flower-visiting insects in a red clover (*Trifolium pratense*) agroecosystem. Field surveys revealed matrix-dependent changes in the visitation rates of pollinators in clover patches. The number of pollinator visits per clover inflorescence was greater in clover patches embedded within a bare-ground matrix than in patches within a matrix composed of orchard grass (*Dactylis glomerata*). This effect of the matrix on visitation rates was attributed to larger numbers of pollinators and visits per individual pollinator in patches surrounded by bare ground. Structural equation modeling indicated that these changes in pollinator visitation propagated across a tri-trophic system of clover seeds, seed predators, and their wasp parasitoids: higher visitation rates very likely increased seed set, which in turn seemed to have resulted in higher abundances of seed predators and their parasitoids. Our results strongly suggest that interactions among species can be influenced not only by internal patch characteristics but also by landscape context. The very likely pollinator-mediated matrix effect on seed-seed predator-parasitoid interactions observed in this study emphasizes the importance of considering direct and indirect interactions in studies on community structure and ecosystem functioning. Our findings also suggest that habitat spatial structure and matrix effects may have important influences on ecosystem services such as pollination.

Habitat Networks in England

R.D.J. Catchpole

Natural England, Science and Evidence Team, Bull Ring House, Northgate, Wakefield, West Yorkshire, WF1 3BJ.
e-mail: roger.catchpole@naturalengland.org.uk

Introduction

Over the last 65 years there has been an extensive fragmentation and loss of semi-natural habitat beyond protected areas in the UK. The documentation of these changes, in a series of studies, has been described by one author as a “grim litany of outrage and complaint” (Adams, 2003 p.5). What has been largely ignored, however, is how the pattern of land use intensification has affected the functional isolation of this remaining habitat. While it has been possible to define patch locations, no evaluation of patch context has been undertaken, in spite of the recognised importance of this factor on site integrity (Riffell *et al.* 2003, Ricketts, 2001, Goodwin & Fahrig, 2002). In response to this need, areas where the functional connectivity of terrestrial habitats might still remain were defined so that conservation action could be targeted and wider networks of habitat maintained.

Methods

Functional connectivity was evaluated by ‘least-cost’ methods which used expert judgements to define relative movement cost estimates for a ‘generic focal species’ associated with four broad habitat types. The habitats consisted of deciduous woodlands, heathlands, grasslands and mires, fens and bogs. They were derived from modified national habitat inventories that were first published in 2004 (English Nature). The matrix was derived from remotely sensed (Landsat Thematic Mapper) land cover data (Land Cover Map 2000, ITE 2000).

Results

For each broad habitat, three nested GIS layers were produced across the whole of England to indicate potential movement envelopes at each dispersal interval. The degree of overlap between different network types, number of patches within networks and their extent varied widely. In more intensively managed landscapes, single patches with small movement envelopes were typical. At a strategic level, it was possible to identify more extensive areas of landscape where habitat networks might be maintained.

Conclusions

While further work clearly needs to be undertaken to test this generalisation, the approach offers a pragmatic solution to the question of where land use managers might seek to maintain and enhance functional connectivity. It is envisaged that any action that seeks to increase functional connectivity will be the exception rather than the rule.

References

Adams, W.M. (2003). *Future Nature: a Vision for Conservation*. Earthscan, London.

Riffell, S.K., Keas, B.E., Burton, T.M. (2003). Birds in North American Great Lakes coastal wet communities: is landscape context important? *Landscape Ecology* **18:** 95-111.

Ricketts, T.H. (2001). The matrix matters: effective isolation in fragmented landscapes. *American Naturalist* **158:** 87-99.

Goodwin, B.J. & Fahrig, L. (2002). Effect of landscape structure on the movement behaviour of a specialised goldenrod beetle, *Trirhabda borealis*. Canadian *Journal of Zoology* **80:** 24-35.

English Nature (2004). *National UKBAP priority habitat inventories*. English Nature, Peterborough.

ITE (2000). Land Cover 2000, Institute of Terrestrial Ecology, United Kingdom.

Prioritizing forest restoration based on late-seral habitat connectivity

W.H. Richards

Seattle Public Utilities - 19901 Cedar Falls Rd SE, North Bend, Washington, United States.
e-mail: bill.richards@seattle.gov

Introduction

The cost of implementing forest restoration projects, in terms of both time and money, in all areas that would likely benefit usually outstrips the resources available for such projects. When the goal of restoration is based on habitat, the question arises of how to prioritize restoration based on the connectivity of that habitat (Richards *et al.*, 2002). This study addresses prioritizing late-seral forest restoration on a watershed scale in Washington State, USA.

<u>Steps of Analysis</u>

Step 1.
Target forest characteristics that would likely benefit ecologically from restoration.
Step 2.
Spatially locate forest stands with targeted forest characteristics.
Step 3.
Create “base landscape” by simulating forest growth over the planning period.
Step 4.
Create “alternative landscape(s)” based on potential effects of restoration.
Step 5.
Simulate dispersal of late-seral forest dependent wildlife species in both landscapes. The PATCH model (Schumaker, 1998) simulates wildlife dispersal based on:

1) the distribution of habitats on a landscape (see Step 4),
2) the affinity of wildlife species for habitats,
3) home range size (smaller home ranges mean bigger potential populations),
4) mortality during dispersal (increased mortality with increased distance), and
5) dispersal turning probabilities (increased probability when in proximity to habitat).

Step 6.
Compare spatially explicit dispersal activity (see Step 5) between landscape alternatives to identify areas that most benefit habitat connectivity.

References

Richards, W.H., D.O. Wallin, and N.H. Schumaker. 2002. An analysis of late-seral forest connectivity in western Oregon, U.S.A. Conservation Biology 16(5):1409-1421.

Schumaker, N.H. 1998. A user’s guide to the PATCH model. EPA/600/R-98/135. Environmental Research Laboratory, U.S. Environemental Protection Agency, Corvallis, OR. Available from: http://www.epa.gov/wed/pages/models/patch/patchmain.htm.

Developing ecological networks – a functional approach

M.C. Fessey, N. Bailey

Spatial Ecology and Land Use, Oxford Brookes University, Oxford, UK.
E-mail: nbailey@brookes.ac.uk

Introduction

This study applies and builds upon recently developed techniques for identifying optimum areas for habitat creation so as to reduce the fragmentation of important habitat in the landscape. The chosen study area is the Milton Keynes and South Midlands (MKSM) sub-region in the East Midlands of England. The MKSM was identified by the UK Government Sustainable Communities Plan in 2003 as one of 4 major growth areas in the South East of England. The planned house building in the MKSM could lead to funding being made available for habitat creation that serves the multifunctional purposes of green infrastructure.

Methodology

A GIS is developed to model the functional connectivity of existing patches of woodland, wetland and grassland habitat. Functional connectivity is determined not just by the distance between habitat patches, but also by the permeability to species movement of the intervening landscape matrix (this can be thought of as a resistance surface). A range of Generic Focal Species (GFS) are developed and used as a surrogate for species specific behavioural information that this type of model would normally demand. A major challenge is finding large scale data-sets that can reflect, relatively accurately, the real life heterogeneity in the resistance surface. This study makes use of Land Cover Map 2000 as a base for the development of the resistance surface as well as using qualitative descriptions from a national landscape characterisation study.

At this point the model is useful in that it can identify where newly created habitat patches could benefit ecologically by being functionally connected to another (currently isolated) habitat patch or existing ecological network. This study is novel in that it then develops the model further to identify where habitat creation might link existing isolated habitat patches, or existing functionally connected networks, so as to create large scale ecological networks.

A multiscale framework for analysis of species and population distribution and persistence in heterogeneous landscapes

M. L. Lorini[1234], V.G. Persson[123] , I. Garay[13] and J. Xavier-da-Silva[23]

[1] Laboratório de Gestão da Biodiversidade, Instituto de Biologia, Universidade Federal do Rio de Janeiro (UFRJ), CCS, Bloco A, Sala 100, Ilha do Fundão, Rio de Janeiro (RJ), Brasil, e-mail: marialucia.lorini@gmail.com
[2] Laboratório de Geoprocessamento, IGEO, UFRJ. [3] Programa de Pós-Graduação em Geografia, IGEO, UFRJ. [4] CAPES/ PETROBRAS.

Developing and maintaining sustainable landscapes became a major challenge in the XXI century. However, to face this challenge we must deal with interactive complex systems (abiotics, biotics, cultural and socioeconomics) that reflect spatial and temporal heterogeneities in multiple scales (Wu *et al.*, 2006). From a theoretical and conceptual point of view, the task of facing landscape complexity may be benefited by approaches as Hierarchical Patch Dynamics (Wu, 1999) or Cognitive Landscape and Eco-field (Farina and Belgrano, 2006). Implemented in a GIS. In this conception, we developed a methodological multiscale framework to analyze pattern and process of distribution and persistence of species, populations and habitats in heterogeneous landscapes. Our study-case represents one of the 25 most endangered primates in the world, the Black-faced Lion Tamarin (*Leontopithecus caissara* Lorini and Persson, 1990), which inhabits the Brazilian Atlantic Forest, one of the 25 global biodiversity hotspots. The integrative and spatial basis of the framework design combine multiple tools from RS and GIS; Machine-learning; Ecological Niche Modelling; and Population Viability Analysis. A hierarchical multiple-scale modeling and scaling strategy followed the “scaling ladder” approach (Wu, 1999; Burnett and Blaschke, 2003) in order to assess the distribution and persistence of *L. caissara* from the global to local scales. A spatially nested hierarchical system with distinctive scaling domains or levels of organization was constructed using top-down (partitioning) and bottom-up (aggregation) schemes, resulting in a three level architecture (tab. 1).

Table 1. Hierarchical multiscale architecture.

hierarchical level	*organization level*	*spatial extension*	*spatial grain*
+1	distribution	continental/biome/ecoregion	500m -1km
0	metapopulation	regional landscape	30 - 90m
-1	Population	local landscape	1 - 30m

This architecture is the framework for making observations and developing models at focal levels, and then for extrapolating information across the domains of scale hierarchically. We suggest that scaling ladder approaches may contribute to address questions like “how the dynamic of abiotic, biotic and anthropic factors relate to landscapes’ spatial and temporal heterogeneity”; “how this affects the dynamics of biodiversity distribution at local, regional and global scales” or “how the dynamics of natural and human disturbances reflect on the evolution of biodiversity geographic limits and landscapes’ transformation” and “which are the implications for processes as species fragmentation, differentiation, extinction and invasion”.

References

Burnett, C. & Blaschke, T. (2003). A multi-scale segmentation/object relationship modelling methodology for landsacpe analysis. *Ecological Modelling* **168**: 233-249.

Farina, A. & Belgrano, A. (2006). The eco-field hypothesis: toward a cognitive landscape. *Landscape Ecology* **21(1)**: 5-17

Wu, J. (1999). Hierarchy and scalling: extrapolating information along a scaling ladder. *Can. J. R.. Sensing* **25 (4)**: 367-380.

Wu, J.; Jones, B.; Li, H. & Loucks, O.L. (Eds). (2006). *Scaling and uncertainty analysis in Ecology*. Springer, Dordrecht, The Netherlands.

Multiple-scale analysis of species filtering processes and their determinants.

L. Blank, Y. Carmel

Division of Environmental, Water and Agricultural Engineering, Faculty of Civil and Environmental Engineering, Technion – Israel Institute of Technology, Haifa 32000, Israel.
e-mail: liorb@tx.technion.ac.il

Understanding the factors regulating the diversity of ecological communities is one of the greatest challenges of community ecology. The processes generating the observed patterns of species diversity can be conceptualized as 'filters' that determine the derivation of local-scale species assemblages from the species pools of larger scales (Hillebrand, 2002, Lawton, 1999, Zobel, 1997). These filters, represented by climatic conditions, disturbance regime and biotic interactions, result in specific local assemblages that are non-random subsets of the regional species pool (Schmid *et al.*, 2002). Furthermore, these filters operate along a range of scales resulting in different species composition at different spatial scales. This 'filtering' concept has been used as a conceptual framework of ecological communities (Keddy, 1992), yet empirical applications of this concept in natural communities have usually been limited to only two scales: a 'local community' and a 'regional species pool'. The distinction between these two scales is usually arbitrary. Moreover, the identity and relative importance of the 'filters' responsible for the observed relationships were often left unknown.

In order to advance our understanding of the regional-local relationship of biodiversity we developed a nested, hierarchical sampling design which enables us to analyze patterns of biodiversity at spatial scales ranging from a few meters to thousands of square meters (Noda, 2004). The sampled biodiversity that represent producers, herbivores, detritivores and carnivores are analyzed with respect to three potential filters: soil, topography, and woody vegetation spatial pattern.

Our preliminary results indicate that there is no apparent impact of woody vegetation spatial pattern on woody species in the local-scales (1 m^2-100 m^2). However, at meso-scales (10^3 m^2-10^6 m^2) woody vegetation exert high impact on woody species.

We believe that such a spatially hierarchical, multi-factor analysis of species diversity and filtering will contribute significantly to understanding of the role of scale in determining the organization of ecological communities.

References

EN.REFLIST

Influence of inter-habitat gap size on the dispersal pattern of *Xiphorhynchus fuscus* (Aves, Passeriformes, Dendrocolaptidae) in the Brazilian fragmented Atlantic forest.

D. Boscolo, C.Candia-Gallardo, M. Awade and J.P. Metzger.

Departamento de Ecologia, Instituto de Biociências, Universidade de São Paulo - USP, Rua do Matão, trav. 14, nº 321, Cid. Universitaria, São Paulo, Brazil, zip: 05508-900
e-mail: danilob@ib.usp.br

Introduction

In fragmented landscapes, habitat patches are usually isolated from each other by a matrix environment unsuitable for several species (Wiens 1995). This may lead to severe isolation and reduced habitat connectivity, hindering the movement of individuals between patches and incurring in ineffective dispersion, high extinction risk and low species persistence time (Lindenmayer *et al*. 1999). These processes are generally linked to the skill of dispersing individuals to overcome the matrix and reach nearby patches (Brooker & Brooker 2001). However, this ability is not known for several species living in fragmented habitats. Our objective was to collect information on how inter-habitat gaps may impede the flux of *Xiphorhynchus fuscus*, a bird species found in fragmented Brazilian Atlantic forest.

Methods

Twelve individual birds were captured inside six forest fragments using mist nets. After tagging them with micro radio transmitters, the birds were translocated to varying distances (50 to 260 m) across the landscape divided into two paired treatments: translocation inside the capture patch and to a nearby fragment isolated by open fields. Birds were followed by telemetry for three consecutive days or until they returned to their origin patch (displacement across the matrix) or to the vicinity of the capture point (displacement within the forest).

Results and Discussion

The mean return time of birds displaced across the matrix was significantly higher than of those inside the forest ($F=11.02$, $p<0.01$). Birds were able to cross at once habitat gaps of up to 150 m. Larger distances across the matrix incurred in longer return time ($p=0.04$) being overcome only with the use of isolated trees. This species can disperse through fragmented habitat, but this ability is limited by increasing inter-patch distances. The implementation of small steeping stones in the open matrix may improve landscape connectivity for this species, enabling the individuals to reach more isolated patches.

References

Brooker, M. & Brooker, L. (2001) Breeding biology, reproductive success and survival of blue-breasted fairy-wrens in fragmented habitat in the western Australian wheatbelt. *Wildlife Research* **28:** 205-214.

Lindenmayer, D.B; McCarthy, M.A. & Pope, M.L. (1999) Arboreal marsupial incidence in eucalypt patches in south-eastern Australia: a test of Hanski's incidence function metapopulation for pacth occupancy. *Oikos* **84:** 99-109.

Wiens, J.A. (1995) Habitat fragmentation: island vs landscape perspectives on bird conservation. *Ibis* **137:** 97-104.

The role of connectivity on species-area relationship: evidences from birds in the Atlantic Rainforest

E. Hasui, M. C. Ribeiro, A. C. Martensen, R. G. Pimentel, J. P. Metzger

Landscape Ecology and Conservation Laboratory – LEPAC, Bioscience Institute, University of São Paulo, Rua do Matão - travessa 14 nº 321 CEP 05508-900,
São Paulo, Brazil.
e-mail: ericahasui@yahoo.com

The Species-Area Relationship (SAR), $S = c\ A^z$, has stimulated the interest of naturalists since the early 1900's and remained central in our understanding of biodiversity patterns. Despite the generalities of the SAR predictions under different landscape configurations, these predictions remain vague. A review of empirical studies had suggested huge variations and frequent underestimations of richness in the remaining patches. The species loss function, based on SAR, uses solely the proportion of habitat lost to estimate the proportion of species expected to become extinct without considering any configuration aspect where the habitat was removed. Here, we hypothesized that the slope (expressed by the "z" value) of SAR can be modulated by connectivity following different possibilities: (A) Higher influence of connectivity for intermediate size patches; (B) From Lomolino (2000) hypotheses of sigmoidal species-area relationships, it was predicted that "small patches effect" may correspond to a range o patch size where the influence of connectivity is especially higher; (C) Linear models may be pointed out as the best models, showing a constant rise in the species-area relationship and also connectivity influence along the entire gradient of patch size; (D) Effects of connectivity depending of the size of the fragment. We used data from previous studies of bird species richness obtained with similar survey methods (point counts) in 73 fragments (median 39.4 ha; range 3.42 – 339.34 ha) localized in the Southeast Atlantic Rainforest of Brazil. The connectivity of each fragment was calculated using proximity indices as well as indices based on graph theory. The relationship between species richness estimation (fixed by number of individual sampled among fragments) and fragment sizes were evaluated with regression models applying the best fit using linear, logarithmic, power, piece-wise and exponential models. Results pointed out the regression model using multiple linear regression as the best model ($r^2_{\text{adj.}} = 0.24$, $p = 0.00003$), and there was no evidence of asymptote in the small patches. Preliminary connectivity analysis, considering distances as 60 m best explain influence on species-area relationship. There was evidence to support the effect of connectivity depends of the size of the fragment.

References

Lomolino, M. V. (2000). Ecology's most general, yet protean pattern: the species-area relationship. *Journal of Biogeography* 27 (1): 17-26.

Lomolino, M. V. (2001). The species-area relationship: new challenges for an old pattern. *Progress in Physical Geography*, 25 (1): 1-21.

Species richness and frequency of large and medium mammals related to landscape parameters in an agro-forested region (São Paulo State, Brazil)

G. Ciocheti, L.R. Tambosi, M.C. Lyra-Jorge, M.C. Ribeiro, V.R. Pivello

LEPaC–Laboratório de Ecologia da Paisagem e Conservação, Departamento de Ecologia, Universidade de São Paulo, Rua do Matão, trav. 14, Cidade Universitária, CEP: 05508-900, São Paulo, SP-Brasil.
e-mail: giordano@ib.usp.br

Introduction

Habitat loss has been changing the structure of landscapes, isolating populations, and leading to reduced resources for fauna. To implement actions towards the protection of native fauna species it is fundamental to understand how such structural changes in the landscape affect their behavior. Having as a prime goal the conservation of large and medium mammals in a fragmented landscape, our objective in this study was to relate the activity patterns of such mammals with the present landscape structure.

Material and Methods

In a 50,000 ha area (47°45'W-21°38'S; São Paulo State, Brazil) composed of remaining forest and savanna patches surrounded by sugarcane and eucalyptus plantations, we selected seven patches – being two of woodland savanna, two of typical savanna, two of semideciduous forest, and one of eucalyptus monoculture – to install 20 camera traps (the number of camera traps was proportional to patch area) which were monthly checked, during 12 months. Species richness and frequency of large and medium mammals were then recorded.

We generated a land use map (scale 1:15,000) and calculated some landscape structural indices for the study region (patch size, patch shape, edge contrast; landscape connectivity and proximity) using the Fragstats program.

Results

Table 1. Spearman correlation coefficients between the mammal species frequency and richness and the landscape metrics tested. (PasP = perimeter of pasturelands adjacent to the focal patch; PasA = total area of pasture adjacent to the focal patch; EucA = total area of eucalyptus plantation adjacent to the focal patch; Area = total area of the focal patch; PARA = relationship between the focal patch perimeter and area; Prox [proximity index] = sum of patch area divided by the nearest edge-to-edge distance squared between the focal patch and all patches of the same type whose edges are within a specified distance of the focal patch; ENN = euclidian distance between the focal patch and other patches of the same type.)

	Chrysocyon brachyurus	*Puma concolor*	*Leopardus pardalis*	*Didelphis albiventris*	*Mazama guazoubira*	*Myrmecophaga tridactyla*	*Pecari tajacu*	*Species Richness*
EucA	NS	NS	NS	NS	NS	NS	NS	**0.87623**
PasP	**0.7641**	NS	NS	NS	NS	NS	NS	NS
PasA	**0.809**	NS	NS	NS	NS	NS	NS	NS
Area	**0.8469**	NS	NS	NS	NS	NS	NS	**0.770934**
PARA	**-0.8289**	NS	NS	NS	NS	NS	NS	**-0.899423**
Prox	NS	NS	**0.775**	NS	**0.810**	NS	NS	NS
ENN	NS	NS	NS	NS	NS	NS	**0.8568**	NS

Discussion

Although this study did not count on replicates and the results cannot be generalized, it indicates that structural changes in the landscape may affect the behavior of large/medium mammals.

The importance of patch size, connectivity and annual variation to understanding the effects of fragmentation on leaf litter frogs in the Atlantic Rainforest.

M. Dixo, J.P. Metzger

Laboratório de Ecologia da Paisagem e Conservação da Natureza. Depto. de Ecologia, IB-USP.
e-mail: mariannadixo@yahoo.com.br

Introduction

Connectivity and fragment size are major parameters of the landscape structure to maintain species in fragmented landscapes (Fahrig, 2003). Few studies have focused on amphibians and reptiles (McGarigal and Cushman, 2002). In the present study, we investigated the effects of fragment size and corridor presence over two years on total abundance, alpha diversity, beta diversity, evenness, and abundance of frog species in the Atlantic Rainforest, one of the most diverse and threatened biomes in the world.

Methods

Leaf litter frog community of the Atlantic Plateau of São Paulo (Brazil) was sampled using pitfall traps in 20 forest fragments and six sites within a continuous area, the Morro Grande Reserve. Fragment size varied between 2 to 276 ha and conditions of connectivity varied depending on the presence or absence of corridors.

Results and discussion

The community of frogs responded negatively to forest fragmentation. Fragments had fewer species than the continuous forest and they were not as evenly distributed. Furthermore, small isolated fragments were more instable and hyper-dynamic than larger fragments and control areas. Although the fragmented landscape preserved a large number of species, forested landscapes help conserving the anuran community more intact, richer and stable. Contrary to expectations, the presence of corridors was not associated with greater richness and/or abundance of frogs in the connected fragments, but beta diversity was greater in isolated fragments, indicating that the presence of corridors makes the connected fragments more homogenous. This result reinforces the thesis that small vertebrates are able to utilize even narrow corridors, (Lima and Gascon, 1999).

Conclusion

This study highlights the importance of creating extensive public reserves, like Morro Grande Reserve. Furthermore, corridors connecting fragments may buffer temporal variations, providing greater stability to frog community. Additionally, our study demonstrated the importance of considering temporal variations to understand the response of frog community to fragmentation.

Acknowledgements

Support for this work was provide by FAPESP - (99/05123-4; 01/07916-3), Fundação O Boticário de Proteção à Natureza (0564-20022) and CNPq (690144/01-6).

References

Fahrig, L. (2003) Effects of habitat fragmentation on biodiversity. *Annual Reviews in Ecology, Evolution and Systematics* **34:** 487-515.

Lima, M.G, Gascon, C. (1999) The conservation value of linear forest remnant in central Amazonia. *Biological Conservation* **91:** 241-247.

McGarigal, K., Cushman, S.A. (2002) Comparative evaluation of experimental approaches to the study of habitat fragmentation effects. *Ecological Applications* **12:** 335-345.

Predicting badger (*Meles meles*) sett suitability across England and Wales

T.R. Etherington

Central Science Laboratory, Sand Hutton, York, YO41 1LZ, UK.
e-mail: t.etherington@csl.gov.uk

Introduction

The occurrence of bovine tuberculosis in cattle herds across England and Wales has been spreading at an exponential rate in recent years, and is now a serious economic problem. The badger (*Meles meles*) is suspected to be a major vector for spreading this disease amongst cattle herds. In order to conduct disease modelling to try and understand the problem, an estimate of badger distribution and abundance is required. Knowledge of sett suitability across the landscape would be an important component of any badger population estimate.

Modelling Approach

A large number of setts surveyed across southwest England were used as the basis of the sett suitability model. The landscape variables related to the sett data are known to influence sett location (Neal and Cheeseman, 1996) and were created at two scales. The first scale referred to conditions at the sett itself and included elevation, slope, cover and soil conditions. The second scale described conditions around the sett and included the amount of improved grassland. All data were referenced to 100×100m grid cells in line with the precision of the sett location data.

The Mahalanobis D^2 statistic (Jenness, 2003; Rotenberry *et al.*, 2006) was used to develop the sett suitability model as it avoids the need for absence data. This is advantageous as sett locations are not spatially independent of one another, therefore absence of a sett does not necessarily mean the area is unsuitable. The Mahalanobis D^2 statistic also allows for extrapolation, which was required as the sett suitability model developed was ultimately applied across England and Wales.

Conclusion

The approach used shows great promise for predicting the suitability of a landscape for sett locations, and that it is possible to achieve this at both a fine grain and over a large extent. However, the success of the extrapolation of the model outside of the southwest of England where all the sett data was collected remains untested.

References

Jenness, J. (2003) Mahalanobis distances extension for ArcView 3.x, Jenness Enterprises. Available at http://www.jennessent.com/arcview/mahalanobis.htm

Neal, E. & Cheeseman, C. (1996) *Badgers*. Poyser, London.

Rotenberry, J.T.; Preston, K.L. & Knick, S.T. (2006) GIS-Based Niche Modeling for Mapping Species' Habitat. *Ecology* **87:** 1458-1464.

Scale does matter!

N.C. Brouwers, A. Newton

Bournemouth University - School of Conservation Sciences, Talbot Campus, Fern Barrow, Poole, Dorset, BH12 5BB,
e-mail: nbrouwers@bournemouth.ac.uk

Introduction

Current woodland conservation policy stresses the importance to preserve, expand and re-connect habitat fragments on a landscape scale. However, Dolman and Fuller (2003) suggest that more studies are necessary on woodland specialists species to provide a firmer basis for current management strategies. To address this knowledge gap, research was undertaken on a specialist woodland invertebrate, the wood cricket (*Nemobius sylvestris*) on the Isle of Wight, UK. In 2005, a landscape scale survey and in 2006 a more detailed study within 3 separate woodland fragments was undertaken. The results of both studies were used to assess the relevance of a landscape scale approach for conservation effort of this species.

Method

In 2005, all mature broadleaf dominated woodland complexes, larger than 5 hectares, on the northern part of the island were surveyed. Wood cricket presence or absence was recorded together with several patch variables. In 2006, within the 3 selected woodlands, 1x1 meter grids were developed recording wood cricket presence and a series of habitat variables. For each, several distance measures were computed using ArcGIS (version 9.1).

Results

The distribution of the species on a landscape scale and within woodlands showed a similar patchy pattern. For the landscape scale, a significant positive relation was found for the probability of wood cricket being present and woodland (patch) area, and a negative relation with distance to the nearest neighbouring inhabited woodland. Within woodlands a significant positive relation was found for the probability of wood cricket being present and leaf litter volume, and negative relations with vegetation cover, vegetation height, South oriented canopy closure and nearest neighbour distance to an inhabited permanent woodland edge. On both scales nearest neighbour distance revealed the highest explanatory power for wood cricket presence.

Discussion

Results reveal the importance of different explanatory factors (related to wood cricket presence) when looking at different scales. Therefore, for wood cricket (and possibly others woodland specialist species), conservation effort within woodlands seems equally relevant besides the current landscape scale initiatives.

References

Dolman, P.M. & Fuller, R.J. (2003) The processes of species colonisation in wooded landscapes: a review of principles. J. Humphrey, A. Newton, J. Latham, H. Gray, K. Kirby, E. Poulsom & C. Quine (Eds). *The Restoration of Wooded Landscapes.* Forestry Commission, Edinburgh, 25-36.

Distribution of large terrestrial mammals in an Atlantic Forest fragmented landscape: Does mesopredators benefit from deforestation?

K.D. Espartosa[1] and R. Pardini[2]

[1]Departamento de Ecologia and [2]Departamento de Zoologia, Instituto de Biociências, Universidade de São Paulo, Rua do Matão, travessa 14, 101, CEP 05508-900, São Paulo, SP, Brazil.
e-mail: ka_espartosa@yahoo.com.br

Introduction and Methods

While large mammals require large areas, present low population densities, are frequently hunted and thus commonly suffer local extinctions, some generalist medium-sized mammals are common in anthropogenic landscapes and may lead to cascade effects, such as increasing bird nest predation. However, factors that influence mesopredator distribution are poorly known. Using a 10-day sampling with 3 camera traps in 24 forest patches in a 10,000-ha Atlantic Forest landscape (23°50'S; 47°20'W), we investigated if the distribution of mesopredators is influenced by the amount of forest at a local scale (800 m circumference) using logistic and linear regressions. We expect that mesopredators are favored by deforestation and human activities, being present in sites with low amount of forest.

Results and Discussion

Four mesopredators were the most common species registered, representing 91% of the 330 total records. The common opossum, *Didelphis aurita*, was the most widespread specie present in 17 sites, followed by the nine-banded armadillo, *Dasypus novemcinctus*, registered in 13, the domestic dog, *Canis familiaris*, in 12, and the crab-eating fox, *Cerdocyon thous*, in 7. The variation from 10 to 70% of forest surrounding sites did not influence the opossum, armadillo and fox occurrence or abundance. However, both domestic dog occurrence (-2LL= 28.388; P= 0.027) and abundance (R^2= 0.172; P=.0.024) was negatively affected by the amount of forest (Figure 1). The presence of this exotic species inside remnants may lead to negative consequences, not only through the transmission of diseases, but also through predation (Butler *et al.*, 2004). Our results corroborate that mesopredators benefit from altered landscapes and that deforestation and the consequent increase in human activities favor the arrival and proliferation of at least one exotic mesopredator, which probably increase predation rates and alters the structure of small vertebrate assemblages in small isolated remnants.

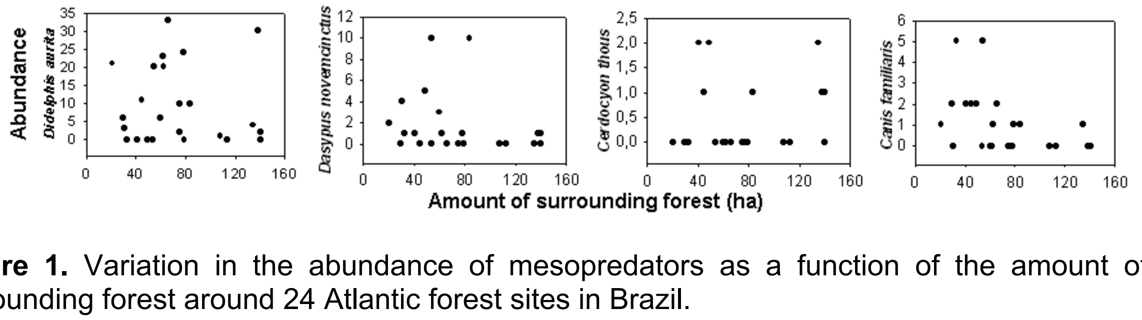


Figure 1. Variation in the abundance of mesopredators as a function of the amount of surrounding forest around 24 Atlantic forest sites in Brazil.

References

Butler, J.R.A.; du Toit, J.T. & Bingham, J. (2004) Free-ranging domestic dogs (*Canis familiaris*) as predators and prey in rural Zimbabwe: threats of competition and disease to large wild carnivores. *Biological Conservation* **115:** 369–378.

Effects of landscape composition and physical characteristics of the land on the biological control of aphids

[1,2] N. Roullé, [1] E. Lucas, [2] G. Domon, [2] J. Ruiz

[1] Biological Sciences Department, University of Quebec in Montreal, Montreal, Quebec, H3C 3P8, Canada.
e-mail: nathalieroulle@yahoo.com
[2] School of Landscape Architecture and Chair in Landscape and Environmental Design, University of Montreal, Montreal, Quebec, Canada.

Introduction

Studies on the natural control of pests by natural enemies are generally done at small scales, such as a single plant, a plot, or more rarely a whole farm. Effects at larger scales remain poorly studied. The objective of this study was to examine the effect of the spatial structure on biological control of aphids by their natural enemies. The specific objectives were (1) to determine if the *landscape composition* and *the physical characteristics of the land* derived from an *ecological classification* are predictive of biological control of aphids by their natural enemies and (2) to identify landscape composition variables that had a significant effect on biological control.

Materials and Methods

Information provided by the ecological classification (Cadre Écologique de Référence) allowed for the selection of 17 circular areas of 1 km in diameter with different landscape structure (type and structure of land use), within the same watershed (Assomption stream, Québec, Canada). In the corn field at the centre of each of these areas, we monitored aphid populations from June 7 to September 28, 2005. Land use was mapped for each of the 17 circular areas. We also recorded information about the agricultural practices.
We tested relationships between insect data and landscape data using variation partitioning redundancy analysis. In a first step, in each of the three groups of variables (landscape composition, physical characteristics of the land, agricultural practice), we selected the variables which contributed significantly in explaining variation in aphid abundance. In a second step, we partitioned variation among the three groups of variables. In a third step, we partitioned variation among the selected landscape variables.

Results

Variable selection:
Landscape composition variables that have a significant effect on the abundance of aphids are: forested area, river area, riparian vegetation area, and area of strawberry fields.
Moreover, there is significantly less aphids in «sandy terrace».
None of the agricultural practices significantly affected aphid abundance.

Variation partitioning: landscape composition – physical characteristic - agricultural practice
Taken all together the selected variables explain 77% of the total variation in aphid abundance (see Fig. on poster). Landscape composition explains 77% of the variation (single contribution: 52%) and the physical characteristics of land unit explains 25% of the variation (single contribution nil).

Variation partitioning: forest - river - riparian vegetation
The forested area explains 32% of the variation (single contribution nil), the river area explains 41% of the variation (single contribution: 33%) and the area of riparian vegetation explains 44% of the variation (single contribution: 19%) (see Fig. on poster).

Consequences of habitat availability and land-use change for the population genetic structure of a grassland bush-cricket

S.I.J. Holzhauer, V. Wolters

Department of Animal Ecology, Justus Liebig University – Heinrich-Buff-Ring 26-32 (IFZ), D-35392 Giessen, Germany. e-mail: Stephanie.Holzhauer@allzool.bio.uni-giessen.de

The impact of temporal changes in habitat availability and land use on the present genetic diversity of the bush-cricket *Metrioptera roeseli* (Saltatoria) was investigated in an extensively used agricultural landscape (Lahn-Dill-Bergland, Germany). By integrating spatial and temporal dimensions, this study thus contrasts to conventional approaches that usually record landscape changes at discrete points in time.

The following hypotheses were addressed: (i) the genetic diversity of *M. roeseli* populations in matured habitat patches is higher compared to younger patches, (ii) the genetic differentiation among younger populations of *M. roeseli* is higher than among older populations (iii) the constant availability of suitable habitat in the surrounding increases the genetic diversity of local populations of *M. roeseli*, and (iv) the frequency of changes in land-use in the surrounding landscape has a negative influence on the allelic richness of local populations. We applied microsatellite markers for the analysis of the population genetic structure of bush-crickets. Genetic diversity was estimated in terms of heterozygosity and allelic richness.

Molecular data suggest population turnover and effects of age structure, though the population genetic structure was more affected by geographical structure. Observed genetic diversity was reduced, with populations from older grassland showing higher diversity and less differentiation compared to those from younger grassland. Furthermore, genetic heterozygosity was positively influenced by grassland age as well as by land-use change towards higher amounts of grassland on the one hand, while on the other hand the influence of grassland age within the study sites could be both negative and positive, presumably depending on differing modes of dispersal. Moreover, allelic richness was negatively correlated with land-use change.

These results prove the strong impact of habitat persistence and turn-over on genetic diversity. Moreover, our findings point to the urgent need for approaches that integrate spatiotemporal changes to determine the cumulative effect of subsequent changes in landscape structure on population genetic structure.

Prediction of future habitat distribution for song birds under climate change in Switzerland

B. Schröder [1], J. von dem Bussche [1], R. Revermann [1], H. Schmid [2], R. Spaar [2] , N. Zbinden[2]

[1] Institute of Geoecology, University Potsdam, Germany.
e-mail: boris.schroeder@uni-potsdam.de
[2] Swiss Ornithological Institute, Sempach, Switzerland.

Content

Statistical species distribution models are a useful tool to determine the distinctive habitat factors governing the spatial and temporal distribution of species and to predict species distributions under changing environmental conditions. The presented study comprehends two parts: (i) large-scale species distribution models for several bird species with different habitat requirements based on the Swiss breeding bird atlas (Schmid et al. 1998), and (ii) an implementation of global change scenarios for climatic predictors in the Swiss Alps. We simulated three scenarios to predict the future habitat of these species in 2030, 2050 and 2070, based on changes in July temperatures and annual precipitation rates according to Frei et al. (2006).

We show that on the grounds of climate change there is an upward shift of the potential habitat of ptarmigan (*Lagopus muta helvetica*) to higher mountain regions with lower temperatures. But since its main food source is not shifting upwards as quickly as temperature is rising, the discrepancy between temperature increase and vegetation development may result in a great loss of adequate habitat (Revermann et al., submitted).

Our models result in a contrary trend of important habitat parameters for blackbird and ring ouzel. Distribution of blackbirds is negatively correlated to precipitation rates and non-vegetated areas but positively to temperature, closed forests and settlement proximity. Sparse highland forests, and subalpine-alpine grasslands in turn reflect the realized niche of the ring ouzel. This species shows also a positive trend concerning precipitation but a negative correlation to temperature. Our scenarios indicate a decline of suitable habitat for the ring ouzel. Blackbird distribution however, shows a slight range expansion to higher altitudes (von dem Bussche et al., submitted).

References

Frei, C.; Schöll, R.; Fukutome, S.; Schmidli, J. & Vidale, P. L. (2006) Future change of precipitation extremes in Europe: an intercomparison of scenarios from regional climate models. *Journal of Geophysical Research* **111**: D06105.

Revermann, R.; Schmid, H.; Zbinden, N.; Marti, C. & Schröder, B. (submitted) Suitable habitat for ptarmigan (*Lagopus muta helvetica*) in the Swiss Alps and its response to rapid climate change in the 21st century – a multiscale approach

Schmid, H.; Luder, R.; Naef-Daenzer, B.; Graf, R. & Zbinden, N. (1998) *Schweizer Brutvogelatlas. Verbreitung der Brutvögel in der Schweiz und im Fürstentum Liechtenstein 1993-1996*. Schweizerische Vogelwarte, Sempach.

von dem Bussche, J.; Spaar, R.; Schmid, H. & Schröder, B. (submitted) Modelling the recent and potential future spatial distribution of ring ouzel and blackbird in Switzerland

Dispersal traits and fragmentation of the habitats

M.O. Vandewalle[1,3], L. Jönsson[1], T. Reitalu[2], M.T. Sykes[1], K. Hall[1], H. C. Prentice[2], S. Lavorel[3] and E. Garnier[4]

[1] Department of Physical Geography and Ecosystems Analysis, Lund University, Sölvegatan 12, 223 62 Lund, Sweden. e-mail: Marie.Vandewalle@nateko.lu.se
[2] Department of Plant Ecology Sölvegatan 37, Ecology Building, Getingevägen 60
223 62 Lund, Sweden

Introduction

To predict plant biodiversity in a changing landscape, information on whether plants can persist and regenerate in their existing habitats and/or can colonize new habitats is needed. Both abilities depend on their biological traits, i.e. vegetative expansion and multiplication, reproduction, seed bank longevity and dispersability. Dispersability or seed dispersal traits correspond to the seed number per ramet, seed weight, seed shape, seed longevity, releasing height and dispersal mode.

The process of isolation might have an unpredictable effect on dispersal capacity of the populations. Recently it was shown that isolated populations of wind dispersed species can lose large part of their dispersal capacity within few generations (Cody and Overton, 1996). Species with long-range seed dispersal (LDD) are indeed expected to respond faster to environmental change (Helm *et al.*, 2006). A possible explanation for this observation is natural selection against dispersal related traits in isolated populations. This can be envisaged in the following way: in a patch isolated by a resistant or uninhabitable area, the selection of producing seeds might be towards low dispersal capacity, as all the propagules with high dispersal capacity will be wasted into the area surroundings. Therefore, it might be expected that the older isolated population would have reduced dispersal capacity. The assumption that fewer but also larger seeds are favoured in long-term isolated fragment is supported by the common opinion that larger seeds have higher recruitment success and that larger seeds may out compete smaller seeds if they end up together at the same site Jakobsson and Eriksson, 2000). We are also expecting that specialist species will be more affected by habitat loss and isolation of the habitat than generalist species (Adriens *et al.*, 2006).

Methods

During my fieldwork, I have been measuring dispersal traits of 32 species in 10 patches of old semi-natural grasslands (more than 275 years old). Each of these patches has been assigned with both an index of connectivity and an index of heterogeneity. Together with the vegetation analysis and a theoretical database, our main goal will be to study the variation in dispersal traits in relation to the fragmentation of the habitat and to identify groups of plant responses to fragmentation and long-term isolation.

References

Adriaens, D; Honnay, O. & Hermy, M. (2006) No evidence of a plant extinction debt in highly fragmented calcareous grasslands in Belgium. *Biological Conservation* **133:** 212-224.

Helm, A; Hanski, I. & Partel, M. (2006) Slow response of plant species richness to habitat loss and fragmentation. *Ecology Letters* **9**: 72-77.

Cody, M. L. and Overton, J. M. (1996) Short-term evolution of reduced dispersal in island plant populations. *Journal of Ecology* **84**: 53-61.

NELI: A landscape index of effective habitat availability

R. Fraser, D. Pouliot, I. Olthof

Canada Centre for Remote Sensing, Earth Sciences Sector, Natural Resources Canada, 588 Booth St, Ottawa, ON, Canada K1A 0Y7
e-mail: Robert.Fraser@NRCan.gc.ca

Metapopulation theory has become a useful framework in conservation biology for modeling the persistence of populations in fragmented landscapes. Its basis is that the dynamics of interacting subpopulations are driven by local extinctions and recolonizations of vacant patches (Opdam, 1991). Vos et al. (2001) proposed using two landscape indices to represent how a metapopulation responds to landscape change: average patch carrying capacity (i.e. habitat area) and average patch connectivity (i.e. dispersal distance for recolonization). These indices are ecologically scaled, as they are calculated based on the scale at which a given species perceives and interacts with the landscape.

We propose combining these indices into a simple, single measure of *effective* habitat amount based on functional home range area. Functional home range is defined as the potential dispersal envelope for each landscape position measured over a cost surface that represents resistance to dispersal over different land covers. This non-Euclidean Landscape Habitat Index (NELI) is then calculated from the area of suitable habitat can be accessed within this envelope. NELI is therefore designed to provide a single, integrated measure of both habitat amount and connectivity that is spatially explicit and species-specific.

We demonstrate how the index is computed for a single cell and over an entire landscape for a hypothetical species profile (Eastern Wolf) within La Mauricie National Park and its greater ecosystem, in Canada. Multi-temporal (1985-2005) habitat maps and dispersal cost surfaces were derived using satellite-based land cover products and GIS vector layers. Functional habitat amounts for five dates were then determined by calculating, for each landscape cell, the total amount of habitat that can be accessed by dispersing over the cost surface in all directions up to the home range limit of the species. The index, derived using an IDL Virtual Machine executable, has modest input requirements for both spatial data and information about a species' habitat preference and dispersal ability. NELI could be used as a coarse filter to monitor changes in habitat quality for focal species over large areas.

References

Opdam, P. (1991) Metapopulation theory and habitat fragmentation: a review of holarctic breeding bird studies. *Landscape Ecology* **5:** 93-106.

Vos, C.C; Verboom, J.; Opdam, P.F.M. & Ter Braak, C.J.F. (2001) Toward ecologically scaled landscape indices. *The American Naturalist* **183:** 24-41.

Long distance dispersers and displacement kernels: effect on resource utilization.

T. Lindström, N. Håkansson, L. Westerberg, U. Wennergren

Dep. of IFM, Theoretical Biology – Linköping University, SE-581 31 Linköping, Sweden.
e-mail: tomli@ifm.liu.se

In ecology we have recognized that dispersal and especially long distance dispersers are key features when species exploit resources in a landscape (Cain et al. 1998). Still one has not explicitly studied the different features of long distance dispersal itself and their effect on the ability of exploiting resources. In this study we have divided long distance dispersal into two different features and by modeling and simulations analyzed populations exploitations of resource in different kinds of lattice landscapes.

Different movement patterns results in different amount of long distance dispersers, mean displacement etc., and can be characterized by displacement kernels. Studies of animal movement often assume a Gaussian displacement since this is the result of random walk and correlated random walk. There are however many reasons for deviations from Gaussian displacement. Properties of the kernel can be categorized by variance which is an over all measure of long or short distance displacement. A second property is the kurtosis which determines whether the kernel is a Gaussian distribution or plateau shaped with a thin tail, or more peaked with a fatter tail. Kurtosis is also a measurement of deviation from Gaussian displacement. In our model we use a kernel equation that actually can separate variance and kurtosis. Hence, it allows us to test the effect of the two features of the kernel separately.

In nature, recourses are usually not distributed randomly. Instead some spatial autocorrelation is expected. It has been shown that both the amount and arrangement of preferred habitat largely influence the populations' ability to exploit the resources in a landscape (Westerberg et al. 2005). Individuals spend more time within their preferred habitat when these are aggregated. To generate neutral landscapes with different amount and aggregation of preferred habitats we use spectral density. We digitalize the landscape to contain only two types of habitat, primary and secondary, in different ratios.

The displacement process was described with a matrix model where movement behavior is assumed to differ between the habitats. This is reflected in a higher variance of the kernel in the non preferred habitat. Exploitation of resources is analyzed via the dominant eigenvector, which is the stable state distribution. We conclude that kurtosis of the displacement kernel is not important for resource exploitation. Hence is the fatness of the tail, which is one of the measures of long distance dispersers, not important for resource exploitation. This has consequences for empirical studies of resources utilization. Variance of displacement is easier to estimate than kurtosis.

Also we find that the landscape parameters (aggregation and amount of habitat) are more important than the movement parameters. This means that much of the resource utilization can be predicted simply from landscape parameters.

References:

Cain, M. L., H. Damman, et al. (1998). "Seed dispersal and the Holocene migration of woodland herbs." Ecological Monographs 68(3): 325-347.

Westerberg, L., O. Ostman, et al. (2005). "Movement effects on equilibrium distributions of habitat generalists in heterogeneous landscapes " Ecological Modelling 188(2-4): 432-447**.**

Synchronization and noise colour: a threat to endangered species?

F. Lögdberg, U. Wennergren

Dep. of IFM, Biology – Linköping University, SE-581 31 Linköping, Sweden.
e-mail: friwa@ifm.liu.se

Introduction

It is known that variation in growth rate will increase the extinction risk. Synchronized variation will also influence the risk of local and global extinctions (Heino *et al.* 1997, Palmqvist & Lundberg 1998, Engen *et al.* 2002). We test how the combined effect of these two features effect the extinction rates in a landscape. Most models deal with an independent stochastic variation, so called white noise. Here we also use positively and negatively autocorrelated variation (red and blue noise respectively) by using 1/f-noise.

Synchrony and variation in space and time

Model and Result

A global growth rate for each time step constitutes the mean of a normal distribution, from which all local growth rates are picked at random. The variance of these distributions sets the level of synchrony among the local populations. A high variance gives a low level of synchrony, and vice versa. We start with a spatial null model where all local populations are equally connected. Then we introduce landscapes with more or less aggregation, by using Fourier transform. We investigate the extinction risk when combining different levels of synchrony and stochastic variation patterns (noise colours). The local dynamic is described by either a density dependent or a density independent discrete function.

Our results show that synchrony, noise colour and impact of density dependence all have a great influence on the extinction risk. A white noise model will underestimate the extinction risk if the true variation is a reddish noise. It is important to be aware of synchrony among local populations and synchronizing factors. A high degree of synchrony, in a reddish environment, will increase the extinction risk even more. Together with high impact of carrying capacity this will really be a threat to endangered species, especially when the landscape configuration and composition affect the dispersal success.

Application

This general model will then be applied on the ecosystem of old oaks in pastures. Old, hollow oak is a species-rich environment. Due to changed agricultural management the amount of old oaks has decreased and many oak-dependent species, for example *Osmoderma eremita*, are threatened today (Ranius, 2002). By analysing the landscape characteristics as above, we identify areas with oak stands where the oak-dependent species can or can not survive in a long-term perspective.

References

Engen, S; Lande R. & Sæther, B.E. (2002) The spatial scale of population fluctuations and quasi-extinction risk. *The American Naturalist* **160:** 439-451.

Heino, M; Kaitala, V; Ranta E. & Lindström, J. (1997) Synchronous dynamics and rates of extinction in spatially structured populations. *Proceedings of the Royal Society of London - Series B: Biological Sciences* **264:** 481-486.

Palmqvist, E. & Lundberg, P. (1998) Population extinctions in correlated environments. *Oikos* **83:** 359-367.

Ranius, T. (2002) Influence of stand size and quality of tree hollows on saproxylic beetles in Sweden. *Biological Conservation* **103:** 85-91.

Habitat quality assessment and evaluation based on remote sensing – a case study for red kite (Milvus milvus)

A. Buschmann, C. Kleinn

Institute of Forest Management, Georg-August-University Göttingen – Büsgenweg 5, 37077 Göttingen, Germany.
e-mail: abuschm@gwdg.de

Introduction

In large-area nature conservation programmes, the focus of *monitoring activities* is on the status of populations of endangered species. The assessment and evaluation of *habitat quality* represents one central element in that context and has to be carried out on different spatial scales depending on the species examined.

On the landscape level and beyond *remotely sensed data* is an indispensable source of information to perform the monitoring task. Habitat resources can be recognised on multiple scales and multi-temporal data sets allow for the assessment of changes in habitat condition. Besides the identification of essential habitat elements high resolution remote sensing further on allows for the characterisation of their spatial configuration. This aspect of *landscape structure* in many cases plays a decisive role when assessing a landscape´s habitat potential for selected species.

Consideration of landscape structure in the assessment and evaluation of habitat quality necessitates consistent and comparable measures of landscape configuration. Remote sensing derived measures of landscape structure (*landscape metrics*) allow for an objective and quantifiable assessment of the spatial composition and configuration of habitat elements. This makes it possible to utilise the metrics besides other spatially explicit environmental variables as input parameters in habitat suitability models.

Methods and results

The poster introduces an approach to integrate spatially explicit structure information in habitat suitability evaluation. A case study for the predator bird species red kite (Milvus milvus) in an EU bird protection area is presented in which an empirical habitat model is used to derive decisive factors of breeding habitat choice of the species. The model considers environmental variables related to landscape composition and configuration as well as land use/land cover, topography, hydrology etc. By comparing the values of the variables at species´ presence locations (nest sites) with the mean values for the entire landscape, as well as the respective ranges of values, the ecological niche of the species is determined against the background of the examined area.

It is pointed out how nature conservation could make use of the procedure in monitoring habitat quality on landscape level. As a result, the integration of landscape metrics and its inclusion (among other environmental variables) into an empirical habitat model has the potential to make habitat quality assessment on landscape level more focused, more operational and possibly also more meaningful.

Preliminary study of ecological connectivity in the region Veneto (Italy)

G. Caravello, C. Gallo

Università degli Studi di Padova, Dipartimento di Medicina Ambientale e Sanità Pubblica – Sede di Igiene, via: Loredan 18 – 35131 Padova.
e-mail: gianumberto.caravello@ unipd.it

Introduction

Conservation biologists generally agree that species viability and diversity are enhanced by well-connected habitats. European projects especially *Natura 2000* (92/43/EEC) intends to preserve natural areas considered important for their flora and fauna characteristics. However, these reserves are usually undersized compared with some animals needs and under the negative effects of habitat fragmentation and patch isolation thus unable to maintain viable populations over the long-term. Therefore, especially in intensively-managed cultural landscape, biodiversity conservation strategies require a land use planning and a following land management process.
Veneto region, located in the north-east of Italy, has a surface of 18.399 Km^2 and circa 4.5 million of residents (2003).It mainly shows a residential, industrial and agricultural landscape, even though 101 SIC and 70 ZPS cover the 20% of regional territory.
In order to get a primary understanding of regional connectivity we considered landscape structural attributes at 3 different scales with an inter-jurisdictional perspective. At regional scale (1:100.000), by using *ArcMap* (GIS), we divided the Corine Land Cover map (version 2000) of the region and its surrounding area in 9 squares and to get more detailed information about potential entrance connections, we create 16 squares on the regional border. On these squares, we selected those land-use categories able to support connectivity enlarging our choice from exclusively Corine Land Cover category 3 to cat. 2.4.3 and cat. 2.2 creating numerous files. Successively, by using *Idrisi* (GIS), we analyzed these files with *Percolation method* obtaining land cover values for the selected categories and indirectly the probability dispersal success values for a hypothetical organism. At inter-regional scale (1:1 million), we got a broaden vision collecting datasets from all the regions surrounding Veneto. Using *ArcMap* we got the possibility to overlay spatial data regarding: natural reserves, major transportation systems, major rivers system and main cities location. At provincial scale (1:25000) we applied, with the same procedure and parameters, the *Percolation method* on 2 adjacent provinces located on the plain regional border.

Results and conclusions

The numerical results, referred to the model threshold (pc= 0, 5927), allowed us to locate areas with good or bad connectivity and at provincial scale showed that percolation values get higher but not enough to ensure ecological connectivity. The visual results allowed us to locate: semi-natural areas and potential ecological corridors, out of protection, but fundamental for landscape connectivity; main challenging spots where potential ecological connection crosses roads and cities.
Conclusions clearly point out the different situation between plain and mountains regional areas, therefore different conservation strategies must be taken. In particular, at this scale, Veneto presents a good connectivity only with other regions sharing its mountain border, in the plain instead, semi-natural areas are located almost exclusively along the rivers, broken up by urbanization centers.

Habitat correlates and distribution pattern of the Tiger (*Panthera tigris*) in the Terai Arc Landscape: a case for landscape ecology in surrogate conservation in India

K. Ramesh, A.J.T. Johnsingh, Q. Qureshi, A. David, G.S. Rawat, S.P. Goyal

Wildlife Institute of India, Post Box # 18, Dehradun – 248001, Uttarakhand, INDIA
e-mail: kramesh_wii@rediffmail.com

The forests along the Himalayan foothills and the Gangetic flood plains in India and Nepal constitute the Terai Arc Landscape (TAL). It is among the globally important ecoregions and supports the highest densities of tiger populations in the world. Because the tiger is a wide ranging species, occupies diverse biomes and its persistence is linked to contiguous forests containing high prey biomass, efforts to conserve tigers at landscape scale clearly underline the 'focal species' and require a surrogate conservation strategy. We assessed the habitat condition and distribution status of the tiger in TAL during July 2002 – March 2004, involving 1001.2km survey efforts, 1530 concentric vegetation plots, high resolution (23.5m) satellite data and spatial analysis. It was found that tiger usage of the habitats was highly variable across the landscape (12% ± 18.1 SD), with higher concentrations in a few Protected Areas. Anthropogenic factors have reduced the once contiguous habitats to nine fragmented units in the Indian side. However, these units together with the habitat contiguity in Nepal comprise five larger units, with no or poor connectivity between the subpopulations. Significantly, each of these units has at least one key forest patch where tigers have higher probability of persistence and potentially act as a source for adjoining patches. The large prey species, Chital (*Axis axis*), Sambar (*Cervus unicolor*), Nilgai (*Boselaphus tragocamelus*) and Wild pig (*Sus scrofa*) occurred interchangeably in considerable proportions (50% or above) in most parts of the landscape. Logistic regression analysis (74% classification accuracy, n = 246) revealed that the species with wider spatial distributions had significant positive influence on tiger occurrence, while the domestic dog was negatively correlated, largely because the dogs closely accompany human disturbances such as livestock herding, wood collection and poaching.

Global conservation agencies, on the basis of expert knowledge and macro analysis, have categorized the extant tiger habitats into varying priority landscapes for rationalizing human and fiscal resources. We argue that if such prioritization is to elicit intended success, further details on patch characteristics, source-sink populations and prey biomass densities need to be considered. Protected Area strategy has so far succeeded to a credible extent in safeguarding tiger populations. Nevertheless, it is unlikely to yield success in the long-term unless the effects of surrounding matrix including habitat connectivity, and securing large contiguous habitats are brought under sincere focus. These requirements of the tiger implicitly benefit several other species, reaffirming the relevance of a tiger centered conservation philosophy despite its shortcomings. With adequate care and addressing local people's concern, the tiger could continue to be a powerful totem for conservation of biodiversity in this landscape, and in the rest of its range.

Setting corridor network priorities for Bogotá's main ecological infrastructure

F. Remolina

Bogotá, District Planning Department, Carrera 30 Nº 24-90 Piso 13, Bogotá, Colombia
e-mail: fremolin@gmail.com

Introduction

Bogota's Main Ecological Infrastructure (BMEI) is designed to guide the land-use planning decision process to ensure the establishment of existing natural areas and their ecological services. Due to BMEI's recent inclusion in Bogota's land-use development plan, BMEI's conceptual framework and implementation are currently in a preliminary stage. An important limitation of this green infrastructure is its corridor system, which neither connects all the protected areas nor identifies which corridors are critical for conservation planning purposes. A central idea of this project is to introduce a corridor system that connects Bogota's protected areas and classifies them according to ecological priorities.

Methods

The methods used in this project are adapted from the Geoplan Center, University of Florida (2002). Landscape-level information is used as criteria in determining corridor priorities and is classified by the level of ecological importance or potential land use conversion. Data sets for ecological importance include: characteristics of critical habitats for native species such as density, size, shape, and relative proximity to protected areas connected by corridors; ecological community representation; presence of either fragile or rare communities linked by the corridor; and the surrounding land-cover. Potential land-use conversion data includes landscape features that encourage transformation from wildland or rural land use to urban land use; pressure drivers include land ownership type, number of primary and secondary crossings, and areas with potential for urban growth.

Ecological importance and potential land-use conversion data are analyzed using Geographical Information Systems. Each data set is combined and weighted by means of matrices, resulting in two sets of variables that are combined in a final matrix to obtain a spatial outcome of corridor classification according to a high, medium or low priority. Corridors with a high priority are described according to their significant ecological value and land-use pressure.

References

Geoplan Center, University of Florida, (2002). *Identification of critical linkages within the Florida ecological greenways network.* Report for the Florida Department of Environmental Protection, Office of Greenways & Trails. Florida, U.S.A.

Estimating species richness of *cerrado* (Brazilian savanna) carnivores by using landscape structural metrics in predictive GARP models

L.R. Tambosi [1], M.C. Lyra-Jorge [1], M.C. Ribeiro [1], G. Ciocheti [1], V.R. Pivello [1]

[1] LEPaC–Laboratório de Ecologia da Paisagem e Conservação, Departamento de Ecologia, Universidade de São Paulo, Rua do Matão, trav. 14, Cidade Universitária, CEP: 05508-090, São Paulo, SP-Brazil.
e-mail: letambosi@yahoo.com.br

Introduction

Data on the occurrence of most native species are scarce and incomplete in most regions, and therefore inadequate for conservation purposes. Predictive models may help to fill up such information gaps. Recent studies show the use of the program DesktopGarp in conservation biology to predict species distribution. A limitation of DesktopGarp is that the models it generates do not consider effects of spatial dependence which may exist in the landscape. Based on that, the objectives of this study were: i) to verify the contribution of landscape metrics in defining models to predict the potential distribution of medium and large mammals, and ii) to evaluate the power of species potential distribution maps to estimate the regional richness of mammal species.

Material and Methods

The study area is in the NE of São Paulo State, Brazil, covering about 50,000 h. It contains remnant forest and savanna patches surrounded by sugarcane and eucalyptus plantations.

To estimate species occurrence and richness of medium and large carnivorous mammals, data were collected through records in track plots and by camera traps during 18 months. Two groups of potential distribution models were generated for each carnivorous species, one considering the environmental variables only (ENV), and the other including a combination of landscape environmental and structural variables (ELS). The independent variables were correlated with the extrinsic omission error by Spearman correlation coefficients, and only those poorly correlated with the error were accepted to produce the final models. For each species and type of model (ENV and ELS), 20 maps were generated, representing the presence or absence of each species. The presence-and-absence maps were then added up to produce two final maps of potential carnivore species richness, one for the ENV models and one for the ELS models. Cluster analyses (Jaccard coefficient, UPGMA) were employed to compare the sampled species according to the independent variables used to generate both the ENV and ELS models.

Results

The values of species richness obtained through field sampling were very similar to those predicted by the ENV models and by the ELS models. The comparison between species richness maps generated by ENV and by ELS models showed an average Spearman correlation coefficient of 0.94 (CI = 0.95). The cluster analysis reflected some responses of the sampled species to the landscape structural variables. However, when considering ENV independent variables, a single class was produced since the environmental variables used for all species were the same.

Discussion

The high similarity obtained when comparing estimates of species richness through ENV and ELS models with the value obtained directly from field samplings shows that the use of landscape metrics is valid to generate DesktopGarp models.

Financial support: CAPES, FAPESP, CNPq and Neotropical Grasslands Conservancy.

Landscape fragmentation as an indicator of coastal landscape quality: an application along the Apulian coast (southern Italy)

F. Minunno[1], V. Leronni[1], C. Tarantino[2], M. Mininni[3], P Mairota[1]

[3] ICAR Department Politecnico of Bari, Italy [1] Dipartimento di Scienze delle Produzioni Vegetali Università di Bari, Italy [2] CNR. ISSIA Bari, Italy .
e-mail: p.mairota@agr.uniba.it

This work has been carried out within the framework of the IMCA (Integrated Monitoring of Coastal Areas) Research Project, among the activities aimed at drawing coastal landscape quality maps through the use of indicators derived from satellite RS images. The present contribution focuses on fragmentation as this phenomenon, as well as the loss of heterogeneity, initiated by urban settlement processes of dislocation and diffusion, represents the main cause of the landscape ecological efficiency decrease, of the area decay and of the beginning of diseconomy in its management (Forman, 1995).
In order to quantify fragmentation, at a given spatial scale (defined in terms of both grain and extent), a set of LPI was computed at the landscape level on a sample plot population, extracted via an unaligned random sampling procedure from the whole southernmost part of the Apulian peninsula (Southern Italy) and for which intepretation of recent aerial photographs had already been performed within the framework of the IMCA research project (Miacola et al. 2006). The same protocol was applied to categorical maps of the same area, derived, both by past aerial photo-interpretation and by segmentation, from medium resolution satellite images of two time steps.
Preliminary results are encouraging in many respects. The distribution analysis performed on the indexes computed on the different data sets show, for this particular landscape at the given scale, a significant trend towards a normal distribution model, thus contributing to the ongoing debate (Remmel and Csillag 2003) on the uncertainties about the possibility of statistically comparing indexes computed at different times and places, derived from a lack of knowledge about their distribution. Principal Component Analysis performend on the indexes obtained from the different data sets, yielded the ordination of sample plots along a fragmentation gradient, that might be used to construct fragmentation intensity maps at the subregional scale, as well as to interpreting the change processes and obtain intelligent maps based upon the integration of field (aerial-photo interpetation) and RS data, thus achieving the twofold purpouse of performing a phenomenological study aimed both at modelling coastal landscape transformations and identifying new survey categories that may have the temporal dimension as the main parameter. As far as the relations between the indexes computed on the different data sets are concerned, they allow for the assessment of the potential for using unsupervised categorical maps for the description and monitoring of landscapes fragmentation, as well as for testing hypotheses concerning fragmentation scaling relations in both space and time (Wu, 2004; Jelinski and Wu 1996).

References

Forman R.T.T. 1995 *Land Mosaics. The ecology of Landscapes and Regions*. Cambridge University Press. Cambridge.
Jelinski D.E. and Wu J. 1996. The modifiable areal unit problem and implications for landscape ecology. Landscape Ecology 11: 129–140.
McGarigal K. Marks B.J. 1995. FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. USDA Forest Service, Pacific Northwest Research Station. 122 p.
Remmel T.K. and Csillag F. 2003 When are two landscape pattern indices significantly different? J. Geograph. Syst. 5:331-351
Wu J. 2004 Effects of changing scale on landscape pattern analysis: scaling relations. Landscape Ecology 19: 125–138, 2004.

Process-based connectivity metrics for conservation corridors

B. Rayfield[1], A. Fall[2], M.-J. Fortin[1]

[1] Department of Ecology and Evolutionary Biology, University of Toronto – 25 Willcocks Street, Toronto, ON, M5S 2L4, Canada.
e-mail: bronwynrayfield@eeb.utoronto.ca
[2] Gowlland Technologies Ltd. – 220 Old Mossy Road, Victoria, B.C., V9E 2A3, Canada.

Introduction

An ongoing challenge for conservation planning is to identify conservation corridors that connect fragments of wildlife habitats. To this end, least-cost path analysis has been combined with graph-theoretical techniques to relate wildlife movement to the spatial pattern of the landscape (Chetkiewicz et al., 2006; O'Brien et al., 2006). This spatial graph approach represents landscape connectivity according to species-specific dispersal abilities by connecting pairs of habitat patches (graph nodes) with a single least-cost route (graph edge) if the effective distance between them is less than a species' dispersal ability. An important modification to this approach has been to identify multiple least-cost routes between pairs of habitat patches that collectively delineate spatial zones (areas) accessible for probable movement within the intervening landscape (Theobald, 2006). In this research we present novel, process-based metrics of connectivity on these spatial graphs that will improve our ability to identify, design, and evaluate corridors for their conservation value. We partitioned landscape connectivity into three essential components that can each be quantified separately: (1) *dispersal likelihood*, (2) *route redundancy*, and (3) *route vulnerability*. Dispersal likelihood is generally thought to decrease exponentially as the effective distance between patches increases and is often also a function of the size, shape, and quality of the connected patches (Urban and Keitt, 2001). Route redundancy is important in stochastic environments when the presence of alternate routes between patches can maintain dispersal if one or more routes become blocked. Route vulnerability can be quantified in terms of the presence of bottlenecks along potential movement routes that are key areas to focus conservation efforts. The components of graph connectivity can be computed locally between patches that are connected by direct least-cost routes or globally between patches that are connected by indirect routes along connected nodes. We generated artificial landscapes to test the predictability of local and global corridor metrics given controlled changes in composition and spatial configurations of habitat and other landscape features. Graph-theoretic techniques have the potential to vastly improve our ability to design and manage corridors (Chetkiewicz et al., 2006) but only if the measures we use to quantify the components of connectivity of these spatial graphs are well-grounded in our current ecological understanding of species-specific movements through heterogeneous landscapes.

References

Chetkiewicz, C.-L.B; Cassidy St. Clair, C. & Boyce, M. (2006) Corridors for conservation: integrating pattern and process. Annual Review of Ecology, Evolution and Systematics **37:** 317-342.

O'Brien, D.; Manseau, M.; Fall, A.; Fortin, M.-J. (2006) Testing the importance of spatial configuration o f winter habitat for woodland caribou: An application of graph theory. Biological Conservation **130:** 70-83.

Theobald, D.M. (2006) Exploring the functional connectivity of landscapes using landscape networks. K.R. Crooks & M. Sanjayan (Eds.) Connectivity conservation, Cambridge University Press, Cambridge, pp. 416-443.

Urban, D.L. & Keitt, T..H. (2001) Landscape connectivity: a graph-theoretic perspective. Ecology **82:** 1205-1218.

Seed flow from a dry calcareous grassland community into the adjacent landscape

J.C. Bolli[1], H.H. Wagner[1], H. Bugmann[2], Ch. Scheidegger[1], P.J. Edwards[2]

[1] Swiss Federal Research Institute WSL, Zürcherstrasse 111, 8903 Birmensdorf, Switzerland, e-mail: jacqueline.bolli@wsl.ch

[2]Swiss Federal Institute of Technology (ETH) Zürich, Universitätsstrasse 16, 8092 Zürich, Switzerland

Dry calcareous grasslands, which are one of the most species-rich habitats in Central Europe, are threatened by habitat loss and fragmentation leading to isolated communities. Conservation or restoration of dry grassland communities requires a seed flow of target species between communities. Actual connectivity between communities, however, does not only depend on the distance between communities but also on the amount of dispersed seeds and the species composition, which is likely to change with dispersal distance. We studied the actual seed flow by wind out of an isolated dry grassland community into the adjacent landscape in the Schaffhauser Randen, Switzerland in summer 2006. Along 10 transects leading in two directions through the dry grassland patch up to 40m into the surrounding landscape, a total of 230 low (0.2m) or tall (0.7m) funnel traps were installed to study the spatial variation of local and middle-distance seed rain. The results suggest that most species disperse the majority of their seeds locally within 1 m of the source plant. With increasing distance from the source patch, the composition of the seed rain changed markedly, and soon did not reflect the species composition typical for the dry grassland patch anymore. The amount of dispersed seeds and mean dispersal distance is species-specific and depends mainly on plant height, seed productivity and seed morphology. Tall grasses followed by tall forbs have the highest dispersal ability as far as distance and quantity is concerned. We conclude that seed dispersal from a dry grassland patch into the surrounding landscape beyond 20m by wind is marginal and does not contain the species composition typical for dry grassland. Unless there are other important vectors, a recolonisation after local extinction might therefore be prevented for many species in many dry grassland communities.

The influence of temperature and irradiation on the behaviour of butterflies

H. Malinowska[1], A. Cormont[2]

[1] Wageningen UR, Environmental System Analysis, Droevendaalsesteeg 4, 6708 PB Wageningen, The Netherlands,
e-mail: agnieszka.malinowska@wur.nl,
[2] Wageningen UR, Landscape Centre, Land Use Planning / ALTERRA Green World Research, Droevendaalsesteg 3, 6708 PB Wageningen, The Netherlands.

Global climate change is a well-acknowledged problem. IPCC (2001) projects higher climate variability and higher frequencies of extreme weather conditions, such as heavy rains, El Niño events or droughts. One of the interesting questions to ask is how this climate change will influence living organisms. Many species in adaptation to climatic conditions change their niche or their distribution ranges (Opdam et Wascher, 2004). A study of non-migratory European butterflies (Parmesan et al., 1999) revealed that during last few decades the ranges of most of them shifted northwards by 35-240km. As genetic adaptations to climate change might be too slow, the spatial configuration of suitable habitat will be of crucial importance to many species (Opdam et Wascher, 2004). Range shifts in response to climate change can be restricted by low habitat coherence. It is likely that the distribution of suitable habitats for some species will also change, being outside of their dispersal possibilities (Walther et al., 2002). Climate change together with anthropogenic land use change can further increase habitat loss and fragmentation. In such a reality population survival depends heavily on successful dispersal. Perhaps the dispersal behaviour itself can be altered by climate change as well.

The behaviour of ectothermic animals is to a large extend influenced by temperatures, therefore can be altered as a result of global climate change. Studies of dispersal, which is a particular kind of behaviour, are of great importance for population viability, especially in fragmented landscape where migration pressures are large. Consequently, these studies can contribute to the conservation and better management of the species.

In our study, the behaviour of four butterfly species *Coenonympha pamphilus*, *Plebejus argus*, *Melitaea athalia* and *Maniola jurtina* living in the open habitats of the National Park 'De Hoge Veluwe' was investigated in relation with temperature and irradiation. According to a research hypothesis butterflies are most active in a species-specific thermal optimum. Field time-budget data were analysed by means of Survival Analysis (Cox's regression). In most cases significant models indicate that the rise in temperature and/or irradiation has a positive effect on butterflies' activity. Active bouts (defined as flying or feeding) as well as flying bouts are longer in higher temperatures. However, it is possible that the range of temperatures recorded was not wide enough to detect optimum trend. More research, focusing on butterflies' behaviour in extremely hot temperatures is thus needed.

References

IPCC (2001) Climate Change 2001: Synthesis Report. Summary for Policymakers.

Opdam P & Wascher D (2004) Climate change meets habitat fragmentation: linking landscape and biogeographical scale levels in research and conservation. *Biological Conservation* **117**, 285-297.

Parmesan C & Yohe G (2003) A globally coherent fingerprint of climate change impacts across natural systems. *Nature* **421**, 37-42.

Walther G, Post E, Convey P, Menzel A, Parmesan C, Beebee TJC, Fromentin J, Hoegh-Guldberg O, Bairlein F (2002) Ecological responses to recent climate change. *Nature* **416**, 389-395.

Plant species co-occurrence patterns on different spatial scales in dry, semi-natural grasslands

T. Reitalu[1], H. C. Prentice[1], M. T. Sykes[2], M. Lönn[3], L. Jönsson[2], K. Hall[2]

[1] Plant Ecology and Systematics, Department of Ecology, Lund University, Sölvegatan 37, SE-223 62 Lund, Sweden.
e-mail: Triin.Reitalu@ekol.lu.se
[2] Department of Physical Geography and Ecosystem Analysis, Lund University, Sölvegatan 12, SE-223 62 Lund, Sweden,
[3] School of Life Sciences, Södertörn University College, SE-141 89, Huddinge, Sweden

Introduction

Landscape-scale factors (habitat area, connectivity, habitat history) are widely recognized as determinants of community diversity (e.g. Bruun, 2000). But few studies have considered the influence of landscape factors on species co-occurrence patterns (Badano *et al.*, 2005). We studied the extent to which patterns of plant species co-occurrence differ from random expectations and explored different landscape and environmental factors.

Material and methods

The study was carried out in a 5 × 5 km "landscape" on the Baltic island of Öland and used three, nested, spatial scales: 50 × 50 cm plots (N = 516), grassland patches (mean area of ca 90 × 90 m, N = 109) and the whole landscape (N = 6). We used a null model approach, with the C-score as the test statistic characterizing species co-occurrence (Stone and Roberts, 1990). The results from the null model analysis were combined with ordination analyses of the species, as well as linear models including information on environment, landscape structure and history.

Results and conclusions

The C-score was significantly higher than expected by the null model in 21 % of the plots, 19 % of the grassland patches and in four, out of six, landscape-scale analyses, indicating that pairs of species were co-occurring less than expected by random. On the plot scale, the species-segregation was in terms of competitive interactions. The degree of segregation was significantly associated with the plots' positions within the grassland patches and with the shrub cover of the grasslands – both variables can be assumed to influence the intensity of the competitive interactions. On the grassland patch scale, we interpreted the species-segregation in terms of environmental heterogeneity within the patches. The degree of segregation was significantly associated with the area of the patches and with vegetation height – both variables are likely to be related to environmental heterogeneity. Species-segregation on the landscape scale was interpreted in terms of environmental heterogeneity among grassland patches and was significantly associated with land-use history. Previously-arable grasslands showed a significantly higher degree of segregation than previously-forested grasslands. Our results demonstrate the importance of incorporating replicated data on multiple spatial scales and including information on environment, landscape structure and history when investigating the patterns of species distributions.

References

Badano, E.I.; Regidor, H.A.; Núñez, H.A.; Acosta, R. & Gianoli, E. (2005) Species richness and structure of ant communities in a dynamic archipelago: effects of island area and age. Journal of Biogeography **32**: 221-227.

Bruun, H.H. (2000) Deficit in community species richness as explained by area and isolation of sites. Diversity and Distributions **6**: 129-135.

Stone, L. & Roberts, A. (1990) The checkerboard score and species distributions. Oecologia **85:** 74-79.

Analysis on Landscape Fragmentation in the Coastal Area of Pearl River Estuary Based on RS and GIS

Z. F. Wu [1], J. Cheng[1], C.P. Chang [2] and H.F Wan[1]

[1] Guangdong Institute of Ecology, Environment and Soil Sciences, Tianyuan Road 808, Guangzhou 510650, China.
e-mail: zfwu@soil.gd.cn
[2] Chung-Chou Institute of Technology,–6,Line2,Sec.3,Shan-Chiao Rd, Yuanlin Changhwa 51003, Taiwan, China.

The speed of urbanization has been most prominent in the Pearl River Delta in South China during the past two decades. The rapid urbanization process caused an unprecedented scale and rate of land use change in the area (Seto, 2005; Li,2004). The Coastal Area of Pearl River Estuary (CAPRE) is the core and sensitive ecotone of Pearl River Delta. As urban built-up areas sprawl, transform, and envelop the surrounding landscape, one of the important changes in land-use were agricultural land loss and landscape fragmentation. Combining GIS with landscape metrics, we attempted to quantify urban expansion and landscape Fragmentation in CAPRE based on the TM remote sensing data. The intent of this analysis is to understand the Spatial-temporal patterns regarding how urbanization and physical characteristics affect landscape fragmentation over time.

Our study region CAPRE (including 4 cities: Zhongshan, Panyu, Dongguan, Shenzhen) is located in the core of Pearl River Delta. Land cover data for CAPRE were captured using the landscape thematic mapper (TM) sensor on 1988,1995,1998,2002. Images were classified into 7 types land cover: urban, developing area, farmland, forest, orchard, grassland, barren , and water (wetland). FRAGSTATS (McGarigal et al., 2002) was used to calculate landscape fragmentation index.

With the economy and population increasing, Urban and developing area underwent the great growth during the entire study period (Table 1). The maximum urban land increase occurred in the period 1988-1995.

Results from the landscape metrics analysis indicated that patch density (PD), edge density (ED), patch number fragmentation index (PNFI) and diversity index increased. At the same time, mean patch area (MPA), mean patch nearest neighbour distance (MPNND) decreased. Landscape fragmentation degree became higher in CAPRE from 1988 to 2002. Landscape fragmentation mainly took place in the end of the1980's and the beginning of the 1990's. The tendency landscape fragmentation became slowly after 1995.

There is obvious correlation between landscape fragmentation and the degree of urbanization, society-economy development in CAPRE. Landform structure and drainage density are intrinsic natural factors influenced landscape fragmentation degree and process.

Acknowledgements

This research was supported by National Natural Science Foundation of China (40571164) and Guangdong Province Natural Science Foundation (04201163, 06105518).

References

Seto K.C. and M. Fragkias. (2005) Quantifying Spatiotemporal Patterns of Urban Land-use Change in Four Cities of China with Time Series Landscape Metrics. *Landscape Ecology* **20:**871-888.

Xia Li and A. G. Yeh. (2004) Analyzing Spatial Restructuring of Land use Patterns in a Fast Growing Region Using Remote Sensing and GIS. *Landscape and Urban Planning* **69:**335-354.

McGarigal, K., Cushman, S.A., Neel, M.C., Ene, E. (2002) FRAGSTATS: spatial pattern analysis program for categorical maps, www.umass.edu/landeco/research/fragstats/fragstats.html

Formation of necessary ecological conditions for sustainable socio-economic development in Armenia

E. Shahbazyan

Maastricht School of Management, Endepolsdomein 150, 6229 EP, Maastricht, The Netherlands.
e-mail: Shahbazyan@msm.nl

Since the beginning of human activity nature has had to undergo many changes, strengthening from day to day. Today we stay before imbalance in the whole nature, which undoubtedly influence on people life. Since the collapse of the Soviet Union a decade ago, Armenia has been catapulted into a severe economic crisis. Nevertheless, Armenia is one of the richest natural areas in the world, notable for its extraordinary biodiversity and wealth of endemic species. Armenia also contains many rare and relict species of animals and plants. The diversity of ecosystems in Armenia includes deserts, semi-deserts, mountain meadows and steppes, forests, wetlands and alpine lands. The Armenian government is in the process of developing policies regarding protected areas, biodiversity conservation, and sustainable use of natural resources. However it still has to improve its natural legislative system, to asses the real situation in ecosystems of Armenia and to monitor and manage them. The ecological situation of Armenia demands urgent measures and long-term strategies for biodiversity management. It is necessary to coordinate conservation strategies across national borders.

Biodiversity of Armenia has maintained a complicated way of conservation measures. In 1958 a system was established of specially protected areas to protect ecosystems, habitats and rare, endemic and threatened species. These areas currently cover around 311,000ha, or 10% of the total area of the country.

For maintaining of balance in nature I suggest the creation of an Ecological Network which will support biodiversity conservation and the achievement of the sustainable development. The formation of Econet between reserves national parks and sanctuaries is a new approach for managing the landscape for the wildlife of Armenia. One of the main issues of this proposed work will be including people either from commercial, governmental and/or nongovernmental sectors, which will, undoubtedly, support nature conservation and will increase human life level in Armenia. This will promote sustainable, economic development either in urban, or in rural areas and will also increase community capacity development.

If we are to go on enjoying wildlife and wildlife habitats in Armenia, new ways need to be found to manage the landscape more sustainable. Ecological networks offer a possible solution to this challenge. And the principal aims of the project should be:

- promote sustainable development,
- halt and reverse the disappearance, fragmentation and isolation of wildlife habitats,
- integrate ecological networks in land use planning and management,
- share the approach and findings with other countries.

This project will work to improve the Armenian landscapes both for people and for wildlife. Constructing the network includes involving people. The network will also complement existing initiatives and agencies working in wildlife conservation. The establishment of ecological network for Armenia should be based on the support and cooperation of local people. The realization of an ecological network will help local authorities and land managers to integrate environmental considerations in land use planning and management.

Increased Human Management Negatively Affects Beetle (Coleoptera) Species Richness in Swiss Cities

T. Sattler[1, 2], P. Duelli[3], M.K. Obrist[3], F. Bontadina[2], R. Arlettaz[2], M. Moretti[1]

[1] Swiss Federal Research Institute WSL, Ecosystem Boundaries Research Unit, Via Belsoggiorno 22, 6500 Bellinzona, Switzerland.
e-mail: thomas.sattler@wsl.ch
[2] Zoological Institute, Division of Conservation Biology, University of Bern, Baltzerstrasse 6, 3012 Bern, Switzerland.
[3] Swiss Federal Research Institute WSL, Biodiversity and Conservation Biology Research Unit, Zürcherstrasse 111, 8903 Birmensdorf, Switzerland.

Introduction

Urban landscapes represent a heterogeneous environment that is constantly changing and expanding due to developing human needs. The biodiversity of such mosaic habitats is influenced by many environmental and man-made characteristics as well as urban-specific processes (Shochat et al., 2006). In a strong ongoing debate, scientists argue which variables are essential for urban species diversity and on which scale (e.g. Clergeau *et al.*, 2006). We contribute to this discussion by analysing the relationship between invertebrate diversity and urban environmental factors in three Swiss cities (Lugano, Lucerne, Zurich). In particular, we tested the influence of (i) sealed area, (ii) human management by lawn- and meadow-mowing (short time scale) and (iii) age of settlement on beetle diversity.

Methods

Recently, Duelli & Obrist (2005) developed a method called 'Rapid Biodiversity Assessment' (RBA) which we applied at 106 study sites. Invertebrates were collected with standard pitfall and flight traps during seven weeks in June/ July, 2006, which is the most favourable time to sample invertebrates due to the maximum number of active species. We separated invertebrates into 14 taxa groups (order and family-level) and subsequently identified beetle specimens to morphospecies level within 14 different families. The various orders and families correspond to different trophic guilds (i.e. herbivores, carnivores, pollinators). The number of morphospecies correlates highly with the total species number. Thus, this so-called RBA-index is an indicator for local α – diversity.

Results & Implications

Analyses of the beetle morphospecies numbers revealed that human management exerts the greatest influence on morphospecies richness. Increasing numbers of lawn cuts negatively affect the beetle diversity. Age of settlement and proportion of sealed area show only minor influence on beetle morphospecies richness. Analyses of the trophic guilds showed that human management negatively affects herbivore and pollinator, but particularly carnivore numbers within beetles. In order to maintain and enhance beetle species richness in urban areas, we recommend reducing the number of lawn and meadow cuts.

References

Clergeau, P., Jokimaki, J. & Snep, R. (2006) Using hierarchical levels for urban ecology. *Trends in Ecology & Evolution* **21:** 660-61.

Duelli, P. & Obrist, M.K. (2005) Eine preiswerte Methode zur Abschätzung der lokalen Arthropodenfauna: "Rapid biodiversity assessment" (RBA). *Schriftenreihe der Forschungsanstalt Reckenholz* **56:** 132-38.

Shochat, E., Warren, P.S., Faeth, S.H., McIntyre, N.E. & Hope, D. (2006) From patterns to emerging processes in mechanistic urban ecology. *Trends in Ecology & Evolution* **21:** 186-91.

Experimental deliberate releases of genetically modified plants near NATURA 2000 sites – using buffer zones to simplify the risk assessment

A. Benzler, U. Euler

Federal Agency for Nature Conservation, Konstantinstrasse 110, 53179 Bonn, Germany.
e-mail: benzlera@bfn.de

Introduction

Recent progress in genetic engineering and increasing efforts in the development of transgenetic plants evidence the need of extended numbers and extended area of experimental sites for the deliberate release of GMOs. Placing experimental sites in the wider agricultural countryside may lead to risks for the agrobiodiversity. In particular nearby or within the experimental area located protected areas like Natura 2000 sites may cause concern. According to the European law, "*any plan or project* […] *likely to have a significant effect thereon* [expl: the Natura 2000 sites], *either individually or in combination with other plans or projects, shall be subject to appropriate assessment of its implications for the site in view of the site's conservation objectives*" (Art. 6 Habitats Directive). In theses cases an extended environmental risk assessment according to the Habitats Directive may be required. This may lead to delay within the regulation process. Therefore the German competent authorities discuss buffer zones around Natura 2000 sites as a measure to facilitate approval of deliberate release.

Approach

In a preliminary approach GIS based buffer zones of 1.000 m were created around Natura 2000 sites. To understand the consequences of this modus operandi for the choice of experimental sites, we overlayed the geographical data with the arable land data of Corine Landcover to identify the share of arable land which is situated within the buffer zones.
The calculation was undertaken separately for every federal state in Germany.

Results

We present the data separated in Sites of Common Interest (SCI) according to the Habitats Directive and the Special Protected Areas (SPA) according to the Birds Directive. Surprisingly, the calculation results had an extremely wide range. The arable land inside the buffer zones (including the arable land inside of Natura 2000 sites) differed between 18% (North Rhine-Westphalia) and 53% (Saarland) for SCI and between 3% (Thuringia) and 33% (Saarland) for SPA, based each on the total area of arable land of the federal state.

Conclusions and consequences

The results indicate the importance of regional distinctions in land use, extent and dispersion of protected areas in the wider agricultural landscape. They may have relevance for other plans or projects, which may have adverse effects on Natura 2000 habitats.

The suitability of this "blanket distance" approach vs. a case-specific approach in respect of the various potential vectors of different GMOs is discussed.

Genetic factors in metapopulation survival - introduction to a PhD-project

M.M.P. Cobben[1], P. Arens[1], J. Verboom[2], M.J.M. Smulders[1]

[1] Plant Research International, Wageningen UR Droevendaalsesteeg 1, Wageningen, the Netherlands.
e-mail: marleen.cobben@wur.nl
[2] ALTERRA, Wagenbingen UR. Droevendaalsesteeg 3, 6708 PB Wageningen, the Netherlands

Introduction

In view of the expected climate change, species may need to either shift elevation or latitude ranges, or genetically adapt to their changing environment. Habitat fragmentation might have partially impeded both options. Furthermore, both responses to climate change can have future genetic consequences in prevailing populations. We will use a spatially explicit metapopulation model to simulate genetic processes in fragmented populations under climate change for the Dutch National Ecological Network (EHS).

Story Content

Genetic factors, particularly affecting small populations, contribute to extinction risk (Frankham 2005). To prevent loss of genetic diversity, N_e should be 500-1,000 (Franklin and Frankham 1998). To maintain long-term genetic security, Lynch and Lande (1998) advise an N_e of 1,000-5,000. The ratio of N_e to N averages 0.10-0.11 (Frankham 1995).[1] Subpopulations in a metapopulation structure suffer maximum inbreeding due to sequences of extinction and recolonisation[2] (Frankham *et al.* 2002), further reducing the N_e to N ratio (Nunney 1999). So 10,000 individuals would be a fairly secure *lower* threshold for a sustained genetically healthy population. However, on average only about 1,000 individuals remain when an animal species makes the endangered list, and only about 120 individuals of plants (Culotta 1995). Threshold for receiving the *vulnerable* status of the IUCN Red List, is 10,000 mature individuals worldwide for a species living in fragmented populations.[3] In contrast, 35 species with the status *least concern* are considered threatened by intrinsic factors indicating unhealthy genetic background (IUCN 2006). We plead for more focus on species that are not on the Red List, to prevent them from getting there in the future.

picture content

1. statement [1] from the above visualised in 1 figure.
2. statement [2] from the above visualised.
3. statement [3] from the above visualised in 1 figure.
4. schematic overview of all IUCN red list categories with their criteria

References

Culotta, E. (1995). Endangered species - minimum population grows larger. *Science* **270**(5233): 31-32.
Frankham, R. (1995). Effective population-size adult-population size ratios in wildlife - a review. *Genetical Research* **66**(2): 95-107.
Frankham, R. (2005). Genetics and extinction. *Biological Conservation* **126**(2): 131-140.
Frankham, R.; Ballou, J. D. & Briscoe, D.A. (2002). Introduction to Conservation Genetics. Cambridge University Press, Cambridge.
Franklin, I. R. & Frankham, R. (1998). How large must populations be to retain evolutionary potential? *Animal Conservation* **1**: 69-73.
IUCN (2006). 2006 IUCN Red List of Threatened Species. <www.iucnredlist.org>. Downloaded on 23 February 2007.
Lynch, M. & Lande, R. (1998). The critical effective size for a genetically secure population. *Animal Conservation* **1**: 69-73.
Nunney, L. (1999). The effective size of a hierarchically structured population. *Evolution* **53**(1): 1-10.

Spatial analysis of landscape patterns and their relevance for large mammal conservation in the dry-deciduous forests of Central India

A. Paliwal, V.B. Mathur

Wildlife Institute of India, Post Box # 18, Dehradun – 248001, Uttarakhand, India
e-mail: ambica@wii.gov.in

Introduction and methodology

Ecological processes and landscape structures are interlinked (Milne,1992). Spatial structure and configuration of the landscape govern the distribution and abundance of the organisms. The importance of spatial dynamics is reflected in the availability of numerous landscape metrices (Ritters *et al.,* 1995). It is useful if the species-environment relationship is explained in spatially explicit form, specifically for conservation and management of natural resource management. In this study, we analyze the landscape pattern in the context of large mammal conservation in Tadoba-Andhari Tiger Reserve (TATR) of Central India.

Unsupervised classification of Indian Remote Sensing P6 data (5.8m spatial resolution) was done in ERDAS IMAGINE 8.7 supported by hierarchical clustering of 520 sampling vegetation plots. Accuracy assessment was done based 700 random points. The classified image was then subjected to analysis using Fragstats software (McGarigal and Marks, 1994) to determine the structure and composition of landscape. Information distribution and relative abundance of large mammals were obtained by 300 line transects of 2 km each, and also the daily monitoring data of the Forest Department. Encounter rates and density of these mammals were related to land cover type, and patch properties.

Results, discussion and conclusion

Twelve land cover classes, including six major vegetation types were mapped. The resultant map had 84.8% accuracy. The landscape matrix was of mixed forests thickly interspersed with bamboo (*Dendrocalamus strictus)*. This also offered intact habitat with largest patch size, while riparian habitat though under represented (3%) appeared to provide viable connectivity for large mammal assemblages. The entire landscape consists of highly heterogeneous elements, represented by 9000 forest patches with mean patch size of 0.6ha (± 62.5 SD). Among the habitat mosaic, mixed trees with bamboo is more fragmented with 17.8 patches per hectare, while teak (*Tectona grandis*) dominant mixed forest is the most intact habitat with lowest patch density of 0.6 patches per hectare. The variation in the patch properties is significantly linked to status of distribution and abundance of wild ungulates in the study area. It can be concluded that the northern parts of study area which have high level of heterogeneity and interspersion, supports substantial wild ungulate populations.

Given that northern portion of TATR contains large number land cover types along with wide range of patch sizes, it depicts high diversity in composition and configuration, which in turn offers favourable habitat for the large mammals. Interestingly, though habitat fragmentation is an issue at higher thresholds, but at the small scales, it reflects habitat diversity, and that current pattern of management effort, with focus in northern portion is possibly justified.

References

McGarigal, K. & Marks, B., (1994) Fragstats- Spatial Pattern Analysis Programme for Quantifying Landscape Structure. Forest Science Department, Oregon State University, Cornvallis

Milne, B. (1992) Spatial aggregation and neutral models in fractal landscapes. *Amer. Natur.* 139(1): 32-57.

Ritters, K.H.; O'Neill, R.V.; Hunsaker, C.T.; Wickham, J.D.; Yankee, D.H.; Timmins, S.P.; Jones, K.B.; and Jackson, B.L. (1995) A fractal analysis of landscape pattern and structure metrics. *Landscape ecology*.10: 23-39.

Indicative map of the Pan-European Ecological Network in Western Europe

R.H.G. Jongman, I.M. Bouwma, A. van Doorn

Alterra, Wageningen UR, PO Box 47 Wageningen, The Netherlands
e-mail: rob.jongman@wur.nl

The objective of the Pan-European Ecological Network is to develop a vision for a coherent network of internationally and nationally protected areas and other suitable habitat areas for long term favourable conservation of Europe's key ecosystems, habitats and species. As the European strategy to reach the goals of the Convention on Biological Diversity the establishment of the Pan-European Ecological Network (PEEN) has been one of the priority issues for nature conservation in Europe since 1995 as formulated in the Pan-European Biological and Landscape Diversity Strategy (PEBLDS).
The project resulted in an indicative map of PEEN which identifies the core nature areas of European importance, existing corridors between these areas, and where new corridors could and should be established to meet the connectivity requirements of key species.
The map illustrates the relevance of national and regional biodiversity within a European context; it communicates the concept of nature as a coherent entity, rather than an agglomerate of individual sites and species. The map also draws attention to the changes in land use and infrastructure development that can have an impact on biodiversity, even when core nature areas are not directly affected. As such, the indicative map of the Pan-European Ecological Network in Western Europe is a powerful communication and education instrument.
The indicative map of the Pan-European Ecological Network for Western Europe shows areas that are vital for biodiversity in this part of Europe. It indicates possibilities to reinforce the long term existence and possible return of internationally important species following the strategy of a coherent and robust network. It summarises insights and data in a way that is readily understandable, useful and inspiring for policy makers responsible for nature protection and land use planning.
The map is strictly *indicative*, i.e. it only gives a *tentative indication* of the possible or likely location of core areas and corridors of Pan-European importance on a scale of 1: 3,000,000. Therefore the map cannot and should not be used to draw conclusions concerning the actual location and boundaries of core areas and corridors of the Pan-European Ecological Network or the location of (inter)nationally designated or acknowledged sites. The map does not suggest that the identified areas should be designated under international or national protection instruments, nor does it wish to comment on or influence the way in which national governments apply their sovereign rights to designate areas for nature conservation purposes.
The map is no blueprint for decisions and implementation; it indicates important areas where further investigations, arguments for concrete decisions should lead to more concrete and balanced plans taking into account interests of different stakeholders. The indicative map is based upon many data, insights, assumptions and targets which are explained in the following chapters. The map can be used together with other maps presenting underlying and more detailed data on habitat types or designated areas with an international status.
One of the main conclusions of the project is that due to the high degree of fragmentation there is a huge task in Western Europe for reconstructing coherence in nature. For this area the challenge is to reconstruct coherence in biodiversity areas of importance.

The Development of a Site Inventory for *Triturus cristatus* in Cheshire

J. Hollinshead, A.P. Hull

Ponds Research Unit, Liverpool John Moores University, Liverpool, UK.
e-mail: j.m.hollinshead@ljmu.ac.uk

Triturus cristatus, or Great Crested Newt, is the most stringently protected amphibian species in the UK. Declining throughout its range, *T. cristatus* is locally common in North West England. The species is vulnerable to pond loss due to changes in agricultural practice and succession, since it is reliant on vegetated mid succession ponds and the availability of woodland and un- or semi improved grassland terrestrial habitat, for foraging and refugia. The protection afforded the species demands licensing of activities which will disturb or destroy individuals or the species' aquatic habitat and rigorous mitigation measures where habitat is lost. Often, the presence of the species is only discovered at a development site once work has commenced, resulting in unnecessary ecological damage and, unexpected delay and expense for developers. The Site Inventory is a compilation of records from a wide variety of sources and has been developed for use by researchers, ecological consultants, planners and developers. It maps known *T. cristatus* breeding sites, providing details including capture figures and population estimates, details of survey methodology, site characteristics and levels of protection afforded the site. Additionally, details of ponds located within home range and short distance dispersal distance of the breeding sites, and details of surveys showing negative results for *T. cristatus* presence are held in the database. The inventory is kept in database and GIS formats, and served via the web through the National Biodiversity Network Gateway. The MAGIC Land based data portal may be used to disseminate GIS and other data formats not compatible as yet with the NBN Gateway systems. The data compiled has provided the basis for the GIS modeling of *T. cristatus* distribution and habitat correlates presented.

Landscape effects on anuran pond occupancy in an agricultural countryside: barrier-based buffers predict distributions better than circular buffers

F. Zanini[1,2], A. Klingemann[3], R. Schlaepfer[4] and B.R. Schmidt[5,6]

[1] Geographical Information Systems Laboratory, Swiss Federal Institute of Technology Lausanne, CH-1015 Lausanne, Switzerland.
e-mail: flavio.zanini@epfl.ch
[2] Swiss Federal Research Institute for Forest, Snow and Landscape (WSL), CP 96, Lausanne, Switzerland.
[3] Geobotanical Institute, Swiss Federal Institute of Technology Zurich, CH-8008 Zurich, Switzerland
[4] Institute for Environmental Sciences and Technologies, Swiss Federal Institute of Technology Lausanne (EPFL), 1015 Lausanne, Switzerland.
[5] Zoologisches Institut, Universität Zürich, Winterthurerstrasse 190, CH-8057 Zürich, Switzerland
[6] KARCH, Passage Maximilien-de-Meuron 6, CH-2000 Neuchâtel, Switzerland

Species movement and consequently occupancy of suitable habitat patches are dependent on landscape permeability. Some land use types, such as canalized rivers and roads, may be complete barriers to animal movement. We therefore expect that such barriers affect species distributions. In analyses of landscape effects on animal patch occupancy it is the common practice to use landscape variables extracted from circular buffers around patches. The main assumption of this methodological approach is that species are affected by a particular landscape element equally in every direction from a given pond. This assumption is likely not to hold if animal movement is restricted by barriers. Barriers or inhospitable land use types may reduce movement patterns and reshape the ideal circular surface into a non-circular buffer. In this study, we developed a method to determine the effect of landscape variables on amphibian distribution by considering physical barriers on their movement into the landscape surrounding breeding ponds. We studied two amphibian species, the common toad (*Bufo bufo*) and the common frog (*Rana temporaria*), in a highly fragmented landscape in Switzerland. We extracted landscape variables (up to 3 km from ponds) within (i) “circulars buffers” (CB) and (ii) “barriers-based buffers” (BBB). BBB were produced by reducing the boundaries of CB according to major impassable barriers in the study area (highways and canalized rivers). Our results show that the BBB approach almost doubles the explained deviance of multiple regression models and clearly fits the distribution data better than the CB approach. This suggests that the proposed BBB approach is ecologically more useful than the traditional CB analyses of species-habitat relationships. Moreover, the BBB method can be used to identify putative barriers. Our study shows the necessity to consider ecological barriers in species distribution models in order to improve their explicative power and avoid incorrect conclusions.

Theme 4 Ecohydrology, water and Rivers

4.1 Symposium 8: Landscapes and rivers

Landscape characteristics and aquatic habitats

E.A. Steel[1], D. Jensen[1], B.E. Feist[1], M.B. Sheer[1], I.A. Lange[2], A. Odle[2], R. Brannom[2], M. Danielsdottir[2]

[1]NW Fisheries Science Center, NOAA Fisheries, 2725 Montlake Blvd East, Seattle, USA.
e-mail: Ashley.Steel@noaa.gov
[2]University of Washington, Seattle, WA 98119, USA

Introduction

Viewing river systems within a landscape context is a new and rapidly developing approach to river ecology (Allan et al. 2004, Weins 2002, Richards et al 2006, Hughes et al. 2006). Although the linkages among landscapes and associated physicochemical and biological characteristics of rivers have long been recognized, the development of conceptual frameworks and tools for measuring and synthesizing such linkages is relatively recent. We present a series of spatial and statistical analyses to test the hypothesis that landscape conditions have a controlling influence on aquatic habitats by examining four response variables: (1) stream width and the density of pool habitats; (2) water quality in lowland streams; (3) the variability of water flow and temperature patterns; and (4) salmon population status. These analyses identify several key mechanisms by which large-scale land-use patterns may impact aquatic resources.

Predicting aquatic habitat features over vast extents

Many aquatic taxa rely on pool habitats, including threatened and endangered salmonids. Because the formation of streams, rivers, and pool habitats is driven by landscape-scale features such as underlying geology and climate as well as by landscape-scale processes such as sediment and water routing, we hypothesized that strong correlative relationships would exist between large-scale landscape features and both stream width and percent pool habitats. We generated a stream network for the Willamette basin, OR, USA, from a digital elevation model and attributed each stream reach with field-based measurements of percent pools and stream width, where available, and existing remotely-sensed data such as climate, geology, and land-use. We were able to develop strong correlative models for both percent pools and stream width that allow large-scale predictions of both habitat quantity and distribution.

Watershed versus riparian predictors of water quality

We present new data on water quality in floodplain streams in King and Skagit Counties, WA, USA. We compare the predictive ability of land-use (traditional agriculture, organic agriculture, golf course, natural, high-impervious commercial) in the riparian area to land-use in the watershed draining to each stream.

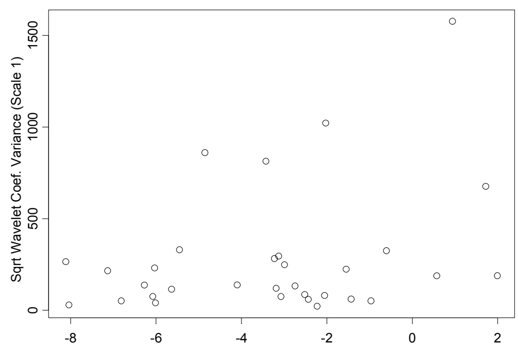


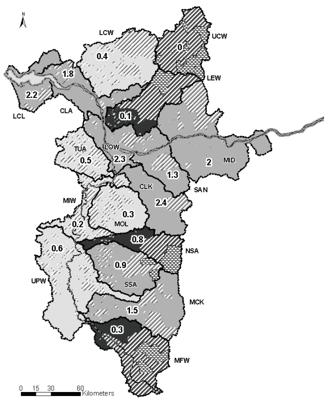
Figure 1: Increase in flow variability, as measured using the variance of the wavelet coefficients at scale 1 = 1 day, as a function of the percent of the watershed draining to the gage that is urbanized.

Impact of landscape alterations on water flow and temperature variability

Alterations of flow and temperature regimes are another potentially common, yet poorly understood, impact of landscape-scale anthropogenic change (Steel and Lange In Press). We used wavelet analysis to quantify fluctuations in both water temperature and flow at a series of USGS gages in the Willamette basin and correlated these patterns with descriptors of anthropogenic change within the watersheds draining to those USGS gages; early results indicate that development within a watershed may impact water flow patterns (Figure 1).

Predicting population viability using simple landscape features

Many complex habitat models aim to predict the historical, current, or potential performance of endangered salmonid populations. Using only simple landscape-scale data on percent of habitat lost to anthropogenic barriers and the number of barriers in lowland habitats, we were able to provide reasonable estimates of population viability ($r^2 = 0.80$) for spring chinook salmon and to classify watersheds as to the type of impact from barriers: a large number of downstream barriers blocking a small amount of habitat, a large area of upstream habitat being blocked, or a mixed, intermediate impact (Figure 2, Table1).



Linear regression model to used to predict square root of the spring Chinook population performance score

Parameter	*Value*	*Standard error*	*t-statistic*	*P-value*
Intercept	0.1352	0.2703	0.5002	0.634
Fraction of historical habitat	1.6823	0.4119	4.0840	0.0065
Number of barriers under 500 m	-0.0042	0.0013	-3.2300	0.0179

Figure 2 and Table 1: Watershed classification; shading indicates type of barrier impact: downstream (light gray), moderate (dark gray), large area (black). Watersheds are labeled with the modeled population performance score. Cross-hatch pattern indicates natural exclusion zones and diagonal line shading indicates blocked areas. Table describes parameters of the linear regression model that best predicted the square root of the spring Chinook population performance score. (Figure from Sheer and Steel 2006).

References

Allan, J.D. 2004. Landscapes and riverscapes: the influence of land use on stream ecosystems. *Annual Review of Ecology, Evolution, and Systematics* 35:257-284.

Hughes, R.M., L. Wang, & P.W. Seelbach, editors. 2006. *Landscape influences on stream habitat and biological assemblages*. American Fisheries Society, Symposium 48.

Richards C., Johnson L.B., & Host G.E. 1996. Landscape-scale influences on stream habitats and biota. *Canadian Journal of Fisheries and Aquatic Sciences* 53(Supp.1):295-311.

Sheer, M.B. & E.A. Steel. 2006. Lost watersheds: barriers, aquatic habitat connectivity, and species persistence in the Willamette and Lower Columbia basins. *Transactions of the American Fisheries Society* 135:1654-1669.

Steel, E.A. & I.A. Lange. *In press.* Alteration of water temperature regimes at multiple scales: Effects of multi-purpose dams in the Willamette River basin. *River Research and Applications*.

Wiens, J.A. 2002. Riverine landscapes: Taking landscape ecology into the water. *Freshwater Biology* 47:501-515.

Altered river landscapes in the alpine region: patterns of land use as a crucial factor for the status of the aquatic environment

M. Poppe, S. Muhar, A. Melcher, C.Trautwein

Institute of Hydrobiology & Aquatic Ecosystem Management; BOKU – University of Natural Resources and Applied Life Sciences, Max Emanuel Straße 17, A-1180 Vienna, Austria
e-mail: susanne.muhar@boku.ac.at

Introduction

The pattern of river landscapes is characterised by the composition and structure of natural as well as human induced elements and patches. Under natural conditions, the patterns and the spatial heterogeneity of these patterns are determined by physiographic characteristics and by particularly driven hydro-morphological dynamics. However, since hundreds of years these patterns and processes have been altered by human uses. In Europe and North America, up to 90% of flood plains are already “cultivated” and therefore functionally extinct (Tockner and Stanford, 2002).
The objective of this paper is to illustrate the land use- and habitat composition of near natural as well as anthropogenically altered riverine landscapes at three different spatial scales as a determinant attribute of the status of the aquatic environment.

Methods

For analysis at the ***catchment scale*** remote sensing data (SINUS - Spatial Indicators for landUSe sustainability - Wrbka, 2003) are used. With a resolution of 30 m, the land cover of the whole Austrian catchment area, divided into four biogeographic regions (Muhar *et al.,* 2004) is characterised by three <u>land use intensity classes</u>: (1) low use intensity, (2) moderate use intensity, (3) high use intensity. The status quo of all large Austrian rivers (n=53, with a catchment area >500 km^2 and a total length of 5625 km) within these four regions is described by three <u>habitat quality classes</u> (Muhar *et al.,* 2000): (1) high habitat status, (2) good habitat status, (3) moderately to heavily impacted.
Concerning the ***flood plain scale***, the adjacent area (defined by a 50 m wide riparian buffer within the flood plain) along the large rivers of Austria is categorised by four <u>land use classes</u>: (1) forest, (2) grassland, (3) cropland and (4) urban land. The status of the large river systems is assessed by large scale surveying (minimum stretch length is 1 km) using historic data to characterise reference conditions (Poppe *et al.,* 2004). As an integrative parameter, the <u>river type index</u> is calculated, which reflects the degree of impacts on the river: (1) only local stabilisation measures, (2) continuous stabilisation measures, however the river course still reflects the morphological river type, (3) moderately altered morphological river type (4) altered morphological river type, (5) heavily channelised/straightened river course or impoundment.
The investigations at the ***reach scale*** comprise 13 rivers (with a total length of 1155 km) in Lower Austria, one of the nine federal states of Austria. Land use pattern is again characterised by the <u>land use classes</u> within the 50 m riparian buffer as explained above. The rivers are investigated by detailed field mapping (minimum stretch length is 100 m) using five parameters to describe the physical environment: (1) current river course, (2) river bed morphology (3) instream structures (4) riparian structures, (5) land use structures. The total <u>ecomorphological evaluation index</u> is calculated as the arithmetical mean of all five parameters within a range of 1 (high quality) to 5 (bad quality - NRL, 2001).

Results

<u>Catchment scale</u>

At this nationwide scale the differences between the four biogeographical regions in Austria are evident. Within the Alpine region and the Bohemian Massif the share of “low use intensity” is between 50 and 70%. Corresponding, in these two mountainous regions there are still 25-30% of the river stretches with “high and good habitat status”. In the lower situated Alpine Foothills and the lowlands of the Tertiary Basin and Hill Country 42-28% of the regions are “intensively used” by agriculture and settlement/infrastructure. In both regions more than 90% of the large rivers are “moderately or heavily impacted”.

Flood plain scale

An hierarchical cluster analysis (Ward-Method) results in five land use clusters: (1) >80% forest, (2) approx. 50% forest, 50% grassland, (3) >50% grassland, (4) up to 40% urban land, (5) >40% cropland. These land use clusters reflect the different degree of impacts on river morphology, expressed by the river type index (Fig. 2). Clusters with low or moderate land use intensity types (Cluster 1-3) are characterised by river sections showing minor impacts on river morphology (river type index 1-3).

Reach scale

The same land use clusters described above are now linked to the ecomorphological evaluation index of the 13 investigated rivers in Lower Austria. Also at that small spatial scale the intensity of land use within the 50 m riparian zone corresponds with the evaluation index (see Fig. 3). Land use clusters dominated by forest and/or grassland (Cluster 1-3) are connected to river stretches with an evaluation index <3 (moderate quality).

Conclusions

At a nationwide spatial scale, comprising the entire catchment areas of Austrian large rivers, land cover types and their proportion within four biogeographic regions document the different degree of human uses within these regions and indicate the pressure on the physical environment of the rivers depending on the regions characteristics. Both at the flood plain and the reach scale the intensity of land alteration in the flood plain is reflected in the habitat status of the river. These results correspond to Wang *et al.* (2006), who describe “forested rivers” with the least degraded physical habitat conditions, and “agricultural rivers” lacking buffers as the most impacted.

References

Muhar, S.; Schwarz M.; Schmutz, S. & Jungwirth, M. (2000) Identification of rivers with high and good habitat quality: methodological approach and applications in Austria. *Hydrobiologia* **422/423***:* 343-358.

Muhar, S.; Poppe M.; Egger, G.; Schmutz, S. & Melcher, A. (2004) *Flusslandschaften Österreichs*. Forschungsprogramm Kulturlandschaft. bm:bwk **16**, Wien.

Niederösterreichische Landesregierung (NLR; 2001) *NÖMORPH. Strukturkartierung ausgewählter Fließgewässer in Niederösterreich.* Endbericht Teil I: Methodik. Freiland Umweltconsulting. Wien.

Poppe M.; Muhar, S.; Egger, G. & Schmutz, S. (2004) Status quo der österreichischen Flusslandschaften. *Österreichische Wasser- und Abfallwirtschaft*. **55** (7-8): 122-129.

Tockner, C. & Stanford, J.A. (2002) Riverine flood plains: present state and future trends. *Environmental Conversation* **29** (3): 308-330.

Wang, L.; Seelbach, P.W. & Hughes, R.M. (2006) Introduction to landscape influences on stream habitats and biological assemblages. *American Fisheries Society Symposium* **48**: 1-23.

Wrbka, T. (2003) *Landschaftsökologische Strukturmerkmale als Indikatoren der Nachhaltigkeit.* Endbericht zum Forschungsprojekt SINUS (Spatial INdicators for Land USe Sustainability). Forschungsprogramm Kulturlandschaft - bm:bwk **13**, Wien.

Management of nutrient fluxes in large river basins – the River Danube as an example

M. Zessner

Institute for Water Quality, Vienna University of Technology, Karlsplatz 13,Vienna, Austria.
e-mail: mzessner@iwag.tuwien.ac.at

Introduction

During the period between the seventies and the early nineties the North-Western and Western Black Sea coastal area has suffered from chronic harmful algal blooms, permanent hypoxic situations, as well as mass mortalities of benthic and pelagic organisms including fish. An excessive input of nutrients (nitrogen (N) and phosphorus (P)) was the main reason for this development. The river Danube can be identified as the major source for nutrients in this part of the Black Sea ecosystem. Especially eutrophication problems close to the mouth of the Danube Delta as well as on the coast south of the Delta, are a direct result of the influence of the Danube. However, moving north along the Ukrainian coast the influence from the rivers Dniestr and Dniepr increases.

Good news – for the moment

The situation in the Western Black Sea has improved considerably since the early 90s due to: (i) reduced eutrophication (reduced phytoplankton biomass, frequency of blooms and extension of high chlorophyll area), (ii) a considerable increase in water transparency, (iii) improvement of river bed oxygen regime (Figure 1), (iv) regeneration of phytoplankton species (*Diatoms*) diversity, (v) regeneration of phytobenthos and (vi) regeneration of macrozoobenthos with an increase in species number. The zooplankton community in the N-W and W Black Sea is still controlled by the gelatinous macrozooplankton (*Mnemiopsis, Aurelia, Pleurobrachia*), with corresponding consequences on the recovery of the pelagic fish stocks (daNUbs, 2005).

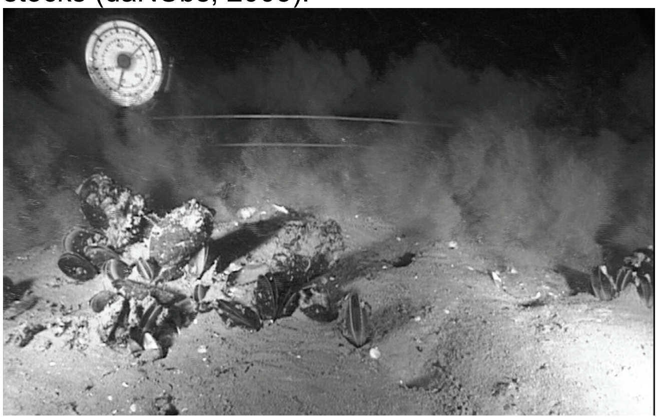


Figure 1. *Mytilus galloprovincialis* in front of the Danube Delta as an indicator, that anoxic conditions have disappeared (Horstmann *et al.*, 2002)

The limiting factor for phytoplankton growth in the eutrophic areas of the N-W-Black Sea is P (since 1997). In the off shore waters N mainly limits primary productivity. The improvement of the shelf ecosystem is a result of decreasing nutrient discharges (especially phosphorus) to this part of the Black Sea (Figure 2). Current low discharges of N and P to the Black Sea by the Danube river are the result of (i) improved nutrient removal from waste water in Germany, Austria and the Czech Republic, (ii) reduced phosphate discharges from detergents and (iii) the consequence of the economic crisis in central and eastern European countries which lead to: (iiia) closure of large animal farms (agricultural point sources), (iiib) a dramatic decrease of the application of mineral fertilizers and (iiic) closure of nutrient discharging industries (e.g. fertilizer industry). (daNUbs, 2005)

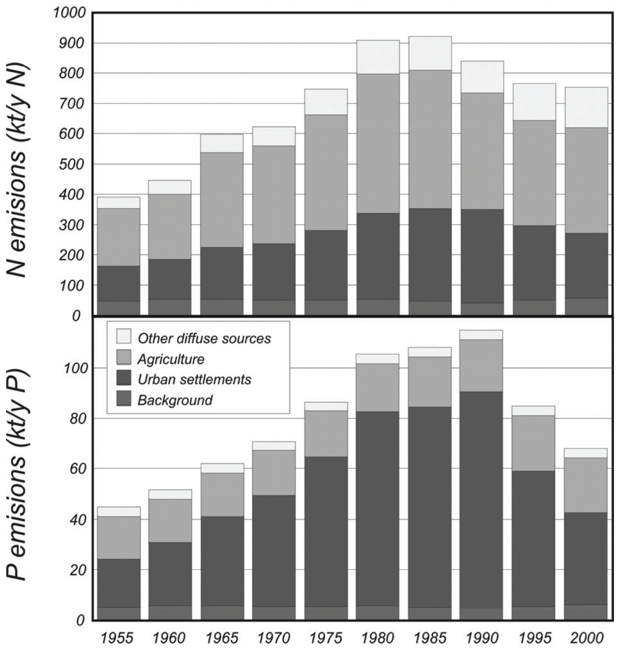


Figure 2. Changes of nitrogen and phosphorus emissions into the river system of the Danube from 1955 to 2000, (Behrendt et al., 2005)

New challenges

For sustainable development of the western Black Sea ecosystem, the nutrient discharge from the Danube River should be further lowered or at least maintained at the present level. It has been shown that the economic development in the Danube Basin may reverse the improvement of the quality of the north-western and western Black Sea ecosystem, if nutrients are not managed properly. In order to avoid deterioration of the current situation, national governments should declare the total area in the Danube Basin as sensitive area to facilitate the financial support of investments for waste water treatment with nutrient removal from international donor funds. Furthermore, a consequent implementation of measures to limit nutrient emissions from agriculture is necessary. These measures should be based on the best available agricultural practices for reduction of nutrient losses from agricultural areas and a limitation of the intensity of agricultural production. (daNUbs, 2005)

References

Behrendt, H; van Gils, J.; Schreiber, H. & Zessner, M. (2005) Point and diffuse nutrient emissions and loads in the transboundary Danube River Basin. *Large Rivers* **Volume: 16,** No. 1-2 Arch. Hydrobiol. Suppl. 158/1-2, p. 221-247.

daNUbs (2005) Nutrient Management in the Danube Basin and its Impact on the Black Sea, Institute for Water Quality and Waste Management, Vienna University of Technology, final report, supported under contract EVK1-CT-2000-00051 by the Energy, Environment and Sustainable Development (EESD) Programme of the 5th EU Framework Programme, http://danubs.tuwien.ac.at/, 78 pages

Horstmann, U., Davidov, A., Cociasu, A. & Velikova, V. (2003) Der Einfluss verringerter Nährstofffrachten der Donau auf das Schwarze Meer, Österreichische Wasser- und Abfallwirtschaft, **Heft 11-12**, 55 Jahrgang, 205-211.

Impacts of climate and land use change scenarios on water quality of stream

C.P. Tung[1], Y.J. Chen [2], Y.P. Lin[1], N.M. Hong[3]

[1] Department of Bioenvironmental Systems Engineering, National Taiwan University, No. 1 Sec. 4 Roosevelt Rd., Taipei 106, Taiwan.
e-mail: cptung@ntu.edu.tw
[2] Environmental Restoration and Disaster Reduction Research Center, National Chung-Hsing University, No. 250 Kuo Kuang Rd., Taichung, 402, Taiwan.
[3] Department of Environmental Resources Management, The Overseas Chinese Institute of Technology, No. 100 Chiao Kwang Rd., Taichung 407, Taiwan

Introduction

Climate and landuse changes could have a potentially adverse effect on water quality and then ecosystems. This study focuses on the watershed scale. The possible impacts of climate and landuse changes on water quality are assessed in this study. Besides, assimilative capacity of a stream and allowable pollutant discharges of sub-watersheds may also be changed and require re-assessment. At last, this study provides several important suggestions in water quality management to decision makers to mitigate the effects of climate and land-use changes.

Methodology

Two simulation models and one multi-objective optimization model are utilized to assess the impacts of climate change on water quality and assimilative capacity. A hydrologic model, Generalized Watershed Loading Functions (GWLF), is applied to simulate the stream flow under different climate and landuse scenarios. Meanwhile, a water quality model, Enhanced Stream Water Quality Model (QUAL2E), is used to estimate the concentrations of Biochemical Oxygen Demand (BOD) after the hydrological model provide simulated design flows. The QUAL2E is then applied to determine a response matrix for an optimization model. The optimization model for estimating the assimilative capacity has two objective functions. One is maximum allowable discharge pollutant, while the other one is achieving equity between different sub-watersheds. The Gini coefficient is an index to assess socio-economic equitable in economics and is used to assess the equality of allowable maximum discharge pollutant in this study. Constrains here are that pollutant discharge must meet the water quality standard and conservation of mass function.

The climate change scenarios are derived from transient experiments. The two transient experiment scenarios are A2 (Medium-High Emissions) and B2 (Medium-low emissions) of Special Report on Emissions Scenarios (SRES), respectively. Four GCMs (General Circulation Models) were used to construct climate change scenarios: the HadCM3 (Hadley Centre for Climate Prediction and Research), the CGCM2 (Canadian Center for Climate Modelling and Analysis), the CCSR (Center for Climate Resrearch Studies), and the GFDL30 (Geophysical Fluid Dynamics Laboratory). In this study, the changes of climate at a location are assumed to be the same as those of a nearest grid of GCMs. The changes are applied to modify historic weather statistics for generating weather data.

Analysis and results

The Tochen River watershed is selected as a case study. The Tochen River is a principal water resource for the Hsinchu water supply district, which is located in the Northern Taiwan. The Hsinchu Science Park, a high tech industrial zone, is located in this watershed. This park has a primary role in Taiwan's spectacular economic growth. The Tochen River watershed is divided into 10 sub-watersheds to analyze the impacts of climate change on BOD concentration and assimilative capacity. Except of the results based on the CGCM scenarios, the BOD concentration is raised conspicuously in other three GCM models. The results also show that BOD concentration deterioration in downstream is more significant than in upstream. Even the BOD concentration has exceeded the water quality standard in some of the downstream reaches. The results indicate that total assimilative capacity is reduced in B2 scenarios, but is increased in the A2 run of CGCM2 and HADCM3 model due to increase of streamflow. Analyzing the results, it is concluded that impacts caused by changing flow are more significant than changing water temperature.

A hypothetical case which a 100ha developing area in upstream NaHo sub-watershed is shifted to downstream CanShia sub-watershed is applied to assess the variation of the allowable discharge pollutant with considering equity. According to the Figure 1, it is found that if the equity coefficient is increased, the allowable discharge pollutant will be decreased. Furthermore, after the landuse change, the allowable discharge pollutant is decreased. Hence, the developing area shifted from upstream to downstream does not improve the allowable discharge pollutant.

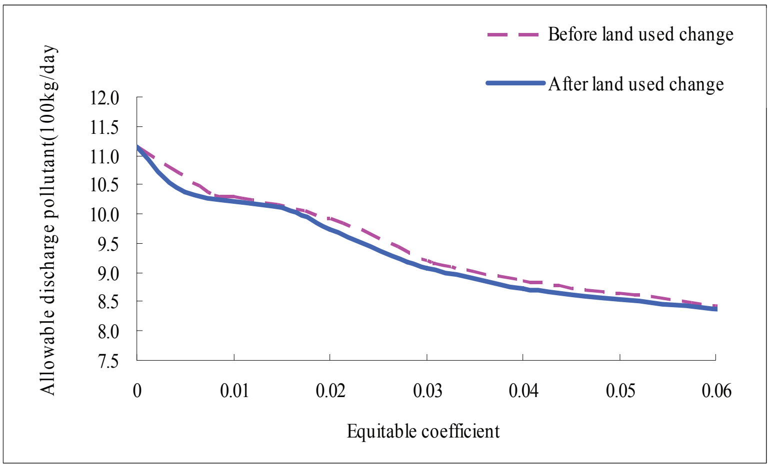


Figure 1. The allowable discharge pollutant variation curve of before and after landuse change

Conclusion

A simulation-optimization approach is applied to assess the impacts of climate and landuse changes. The results show that impact of climate change on BOD assimilative capacity at Tochen river watershed may requires decision makers to redistribute assimilative capacity or reduce the pollutant to avoid that pollutant discharge exceed water quality standard in the future. Based on the simple case study of impact of landuse change on assimilative capacity, when a developing area is changed to downstream, where stream flow is low and there are many water withdrawals, the assimilative capacity does not increase. Climate and landuse changes significantly influence water assimilation capacity and then feedback to limit land developing. Landuse and climate changes are a long-term processes, and thus it is necessary to establish a long-term early warning system to provide information to modify landuse plans and/or enhance adaptive capacity of environmental management. Besides, there are still many uncertainties which may influence the conclusions of this study and certainly require further studies.

How do landscape scales influence riverine fish in Europe?

S. Schmutz, C. Trautwein

Institute of Hydrobiology & Aquatic Ecosystem Management; BOKU – University of Natural Resources and Applied Life Sciences, Max Emanuel Straße 17, A-1180 Vienna, Austria; e-mail: stefan.schmutz@boku.ac.at

Introduction

Spatial patterns of fish assemblages are poorly understood at large scales. Landscape classifications (LC), e.g. ecoregions, are supposed to reflect fish assemblage patterns at large scales, however, the significance of different LC commonly used in Europe never has been tested for the ability to explain spatial structures of fish assemblages. Here, we analyse the relationship between fish diversity and LC associated with different spatial scales and compare the results with grid-based classifications reflecting species-area relationships.

Methods and data

We used 6 ecological and hydrological LC. (1) The European Biogeographic Regions (EBR) of the Habitats Directive are based on a map of natural vegetation (EEA, 2005). (2) Illies's Ecoregions (IER), representing the only aquatic LC, is used for delineating river typologies for the Water Framework Directive (WFD). (3) The Digital Map of European Ecological Regions (DMEER) is based on climatic, topographic and geobotanical data (EEA, 2000). (4) Catchments of European Sea Outlets (CESO) were derived from the project "Catchment Characterisation and Modelling – CCM" (Vogt *et al.*, 2003). (5) European River Catchments (ERC) are based on an aggregation of CESO and represent main European ocean watersheds (EEA, 2006). (6) The Main River Groups (MRG) have been developed in the FAME project based on fish assemblage similarity among catchments (FAME consortium 2005, Pont *et al.* 2006).

The 6 ecological and hydrological LC were compared with 7 grid-based LC computed as squares with progressing grid side lengths of 31.25, 62.5, 125, 250, 500, 1000 and 2000 km. Fish data have been provided by the FIDES database collated in the FAME project (FAME consortium 2005). Only fishing occasions with no or minimal human pressures (1 608 reference sites) were selected for analyses as defined in the FAME project (Pont *et al.* 2006). All data were available as GIS layers. The study area was defined by overlaying the 6 LC and extracting the common cutting area. The area and the total number of fish species was calculated for each LC unit. Finally, the median area and mean number of fish species (+-CI) was calculated for each LC classification.

Results and Discussion

In total 80 fish species are recorded in FIDES for selected reference sites considering the entire study area. At the largest spatial level ERC LC splits the study area into 5 large catchment units (median area: 641 371 km^2) with a mean number of fish species of 47. EBR LC consist of 6 regions (median area: 436 596 km^2) with a mean of 43 species. IER LC with 12 regions (median area: 203 402 km^2) hosts 30 species at the average. DMEER LC (median area: 103 426 km^2) splits Europe in 16 regions with a mean of 26 species. There are 11 MRG LC units (median area: 96 603 km^2) with 28 species at the average. The smallest units (N=141) are derived from CESO LC (median area: 1 273 km^2) with a mean number of species of 10 (Figure 1).

The species-area curve derived from the grid-based LC reveals the form of an upper part of a power function. Number of grid units increases from the largest scale (2000 km grid side length) with 4 units to 454 units at the smallest scale (31.25 km grid side length) and the mean number of species decreases from 46 to 9 species, respectively.

LC located above the curve indicate a higher number of fish species than suggested by the area of the LC. Only EBR and MRG are above the curve and host about 5 species more than expected, however, due to the high variation within LC and low number of samples (i.e. LC units) the difference is statistically not significant (Figure 1). On the other hand, IER, used for river classifications in the WFD, do not contribute to species diversity beyond the information given by the species-area relationship. Therefore, we conclude that for analysing spatial patterns of fish diversity or for developing European ecological river typologies EBR, MRG or similar LC should be used instead of the IER.

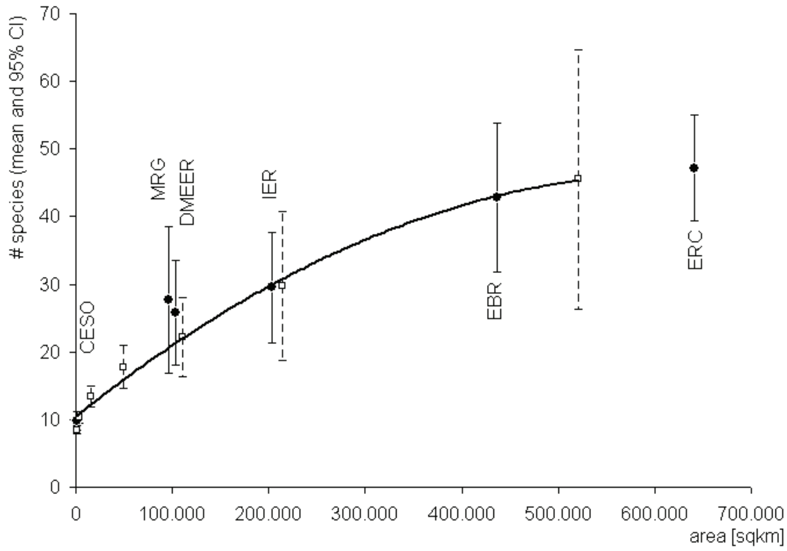


Figure 1 Mean number of fish species (± CI) in different landscape classifications of Europe (solid circles) in relation to median area of landscape classifications and compared with grid-based classifications (squares and hand-fitted curve). EBR: European Biogeographic Regions, IER: Illies's Ecoregions,DMEER: Digital Map of European Ecological Regions, MRG: Main River Groups, ERC: European River Catchments, CESO: Catchments of European Sea Outlets.

Acknowledgements

We would like to thank all institutions delivering data for the FAME project (Contract n°: EVK1 -CT-2001-00094).

References

European Environmental Agency (EEA) (2005) Biogeographical regions, Europe. Retrieved on 20.11.2006 from: http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=839.

European Environmental Agency (EEA) (2000) Digital Map of European Ecological Regions - DMEER. Retrieved on 14.12.2006 from: http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=192

FAME Consortium (2004) Manual for the application of the European Fish Index - EFI system. A fish-based method to assess the ecological status of European rivers in support of the Water Framework Directive. Version 1.1, January 2005. http://fame.boku.ac.at. 3.3.2005.

Pont, D; Hugueny, B. Beier, U; Goffaux, D; Melcher, A; Noble, R; Rogers, C. & Roset, N. (2006) Assessing **river** biotic condition at a continental scale: a European approach using functional metrics and fish assemblages. *Journal of Applied Ecology* **43**:70-80.

Vogt, J.V; Colombo, R; Paracchini, M.L; Soille, P & De Jager, A (2003) CCM River and Catchment Database for Europe, Version 1.0. EC-JRC. EUR 20756 EN.

Landscape characteristics and Pacific salmon distribution: consistent patterns across watersheds

B.E. Feist, E.A. Steel, G.R. Pess, D. Jenson

Northwest Fisheries Science Center, 2725 Montlake Blvd E., Seattle, WA 98112, USA.
e-mail: blake.feist@noaa.gov

Introduction

Habitat loss and alteration is the leading cause of species' declines worldwide, therefore, habitat restoration and protection is an important conservation strategy. The current dogma is that there is a strong connection between habitat and threatened or endangered species; however, conservationists are often hard-pressed to explicitly link abundance or population health with habitat quality or quantity. Given that habitat relationships with species are often characterized at a spatial scale that does not account for the functional relationships between habitat and populations, it's not surprising that the habitat-population disconnect persists. There have been a series of analyses completed in various subbasins of the Pacific Northwest of the United States, where coarse-grained GIS representations of habitat have been linked to Endangered Species Act (ESA) listed anadromous Pacific salmon (*Oncorhynchus* spp.) population performance (Pess et al. 2002; Feist et al. 2003; Steel et al. 2004). Lacking in these studies is synthesis of across-subbasin patterns in habitat significance as well as the importance of observation scale. In this paper, we attempt to synthesize and build on the work of the aforementioned authors by using their methodology to analyze habitat and population connections in three additional subbasins in the Columbia River basin. We posed three questions in this project: at what extent is each potential predictor variable best correlated with salmon performance; at what extent does one find the best model fit; and how does a combined extent model compare with a single extent model?

Methods

In order to explore the influence of spatial scale on the apparent relationship between habitat and animal populations, we examined the relationship between GIS-based habitat data and various anadromous Pacific salmon (*Oncorhynchus* spp.) populations in three subbasins of the Columbia River basin, USA. We characterized habitat and ran our models at three different spatial extents: local or stream reach ($\bar{X}$ = 11.9, *SE* = 2.4 km^2), intermediate ($\bar{X}$ = 230.2, *SE* = 33.8 km^2), and watershed or landscape ($\bar{X}$ = 644.5, *SE* = 221.7 km^2). Our population data were derived from annual redd (spawning nests built by females) count surveys (StreamNet 2002), collected for many decades by various state agencies. Our "habitat" GIS data included land use and land cover, geology, terrain, precipitation, temperature, dams, diversions, mining hazards, and grazing allotments.

We used mixed models to explore the relationships between redd density and candidate explanatory variables. We then used the Bayesian Information Criterion (BIC) to select the most appropriate covariance structure, as well as to compare models (Littell et al. 1996). All statistical analyses were run using SAS/STAT (V 8.2).

Four random-coefficients models were evaluated. The slope and intercept were initially modeled as random effects. The slope and intercept for each year was allowed to vary randomly from an average slope and intercept. These are also referred to as hierarchical linear models (Byrk & Raudenbush 1992). The appropriateness of these models was assessed by noting whether the variance of the slope and/or intercept was significantly different from zero, which was assessed with Wald tests (Casela & Berger 1990), as well as by comparing the BICs of the various models. The intercept was also modeled as a random function of both year and reach. Lastly, the intercept was allowed to vary randomly by year only.

Models were fit to the covariates from each of the three spatial extents independently, and the best models from each were compared at the end of the model-selection process. The variable selection process primarily identified those models with undesirable properties and those models were eliminated. Among the criteria and methods used to evaluate models were high pairwise correlation, large Cook's distance (Cook 1977), multicolinearity and a cross-validation procedure.

Results

Overall, redd densities were most often correlated with land use variables, while land cover, structure and geology were also correlated, but not as frequently. Climate variables were not included in any of the final models. Certain categories of variables were better correlated with salmon redd density at a particular extent. However, our intermediate-extent models usually provided poor predictive power compared with our local- and landscape-extent models, and r^2 values for these models were higher as well. In addition, the suite of habitat characteristics most often associated with spawner density changed as a function of our observation extent.

Discussion

It appears as though certain types of habitat are correlated with Pacific salmon redd density in the three subbasins of the Columbia River basin we studied. It is also clear that the amount of variation explained in redd density over time is contingent upon the size of our analysis window. Based on these results, we conclude that our perception of which habitat attributes are important is clearly a function of our extent of observation, and that restoration efforts should focus on different habitat characteristics depending on the "scale" of the restoration effort. This is a significant result in general for conservation efforts, and an important practical result for salmon recovery planning in particular.

References

Byrk, A.S. & Raudenbush, S.W. (1992) *Hierarchical Linear Models*. Sage Publications, Newberry Park, CA, USA.

Casella, G. & Berger, R.L. (1990) *Statistical Inference*. Duxbury Press, Belmont, CA, USA.

Cook, R.D. (1977) Detection of influential observation in linear regression. *Technometrics* **19:** 15-18.

Feist, B.E.; Steel, E.A.; Pess, G.R. & Bilby, R.E. (2003) The influence of scale on salmon habitat restoration priorities. *Animal Conservation* **6(3):** 271-282.

Littell, R.C.; Milliken, G.A.; Stroup, W.W. & Wolfinger, R.D. (1996) *SAS® System for Mixed Models*. SAS Institute Inc., Cary, NC. USA.

Pess, G.R.; Montgomery, D.R.; Bilby, R.E.; Steel, E.A.; Feist, B.E. & Greenberg, H.M. (2002) Correlation of landscape characteristics and land use on coho salmon (*Oncorhynchus kisutch*) abundance, Snohomish River, Washington State, USA. *Canadian Journal of Fisheries and Aquatic Sciences*. **59:** 613-623.

Steel, E.A.; Feist, B.E.; Jensen, D.; Pess, G.R.; Sheer, M.; Brauner, J. & Bilby, R.E. (2004) Landscape models to understand steelhead (*Oncorhynchus mykiss*) distribution and help prioritize barrier removals in the Willamette basin, Oregon, USA. *Canadian Journal of Fisheries and Aquatic Sciences* **61:** 999-1011.

StreamNet Spatial Data (2002) Current anadromous chinook salmon and steelhead distribution at a 1:100,000 scale. Pacific States Marine Fisheries Commission. URL: <http://www.streamnet.org/>.

Limiting factors controlling the spatial distribution of redband trout (Oncorhynchus mykiss gairdneri) and their implications across a basin

L.F. Madriñán [1-2], S. White [1], H.W. Li [2] and G. Giannico [1]

[1] Department of Fisheries and Wildlife, 104 Nash Hall, Oregon State University, Corvallis, OR, 97331, USA . [2] Oregon Cooperative Fishery Research Unit, 104 Nash Hall, Oregon State University, Corvallis, OR, 97331, USA.
e-mail: madrinal@onid.orst.edu

Introduction

Temperature relationships between aquatic organisms and their surrounding environment need to be understood to insure protection of threatened stocks of fish. Aquatic organisms respond to thermal heterogeneity and require specific ranges of temperature to survive and reproduce. Several studies in stream ecology (Fausch *et al.,* 2002) have recognized that streams are strongly influenced by the surrounding landscape in which they flow. Elevated stream temperatures are the result of ecological and physical processes interacting at the same time, and are directly related with land-use practices, with negative consequences for aquatic ecosystems.

Monitoring longitudinal summer stream temperatures may be useful to asses the carrying capacity of threatened and endangered salmonids. However, to understand expressions of habitat heterogeneity in stream systems it is necessary increase research efforts to understand how multi-scale patterns of stream temperature and habitat quality affects fish community distribution (Torgersen *et al.* 1999).

This study attempts to classify habitat quality for *Oncorhynchus mykiss gairdneri* (Redband trout) in the south fork of the John Day River, Oregon, USA using spatially continuous data on fish assemblage structure and habitat data.

Methods

To standardize the extent of our sampling design we developed a method to classify valley river segments (reaches) using a 10 m digital elevation model in which we divided the SFJD and the two tributaries using three metrics (elevation, slope of the stream channel and aspect). After this initial classification we overlapped the FLIR (Forward looking infrared) imagery and subdivided some of the reaches if the difference in temperature was greater than 3°C per each section

Once the reaches were defined we identified potential limiting factors for Redband trout using an information-theoretic approach based on Akaike's information criteria (AIC), were the relative importance of the predictor variables of each model was ranked using data from different spatial scales.

Existing land use - land cover maps, LiDAR (light detection and ranging) geomorphic information, longitudinal temperature profiles from FLIR images and extensive *in situ* habitat and fish community surveys were used in these models

Once all the fish information was collected, we used a cluster and outlier analysis (Anselin Local Moran's I) to identify possible spatial autocorrelation among sets of clusters of distribution points with values similar in magnitude and clusters of distribution points with very heterogeneous values. To identify possible high density areas for fish distribution we used the "Hot Spot Analysis" with rendering to calculate the Getis–Ord Gi statistic by rendering features quantitatively

Results

Our results confirmed the presence of different strata in the watershed. Differences in landscape and land use attributes showed that continuous sampling is most useful that site-specific sampling in order to detect limiting factors and cumulative effects. We found that Redband trout distribution in the principal tributaries and in reaches within tributaries have different limiting factors.

The cluster and outlier analysis shows that there was not any clustering in fish distributions that was not detectable at the reach scale. It was also found three principal "hotspots" for Redband trout distribution that are principally associated with cooler water temperatures, higher sinuosity and stream gradient.

Conclusion

Reach analysis (1 to 8 km) is the most appropriate scale to understand Redband trout distribution patterns in the South Fork Jon Day River, Or, USA. We found that among reaches Redband trout distribution is delimited first by physiological tolerance to temperature and secondly by competition with warm water fishes.

Redband trout was principally correlated with relative higher gradients and shallow reaches in the warmer sections of the SFJD, in contrast in the coolest tributary (Black canyon creek) RBT was associated with smaller gradients and deeper pools.

This study also found that the cross over point between warm water – cool water fish assemblages was 22 Cº.

This approach will provide managers with hypotheses for restoration experiments in specific areas (e.g., wood additions, beaver dams, culvert replacements). This is consistent with the concept of Adaptive Management.

References

Fausch, K. D.; Torgensen, C. E.; Baxter, C.V.; Li, H.W. (2002). Landscapes to riverscapes: Bridging the Gap between Research and Conservation of Stream Fishes. BioScience. Vol. 52 No. 6. pp 1 – 16.

Torgersen, C.E; Price, D.M; Li, H.W; and McIntosh, B. A. (1999). Multiscale Thermal Refugia and stream Habitat associations of Chinook salmon in Northeastern Oregon. Ecological Application. 9 (1) pp. 301 – 319.

Relating fish assemblages to environmental patterns at three multistate scales

R.M. Hughes[1], A.T. Herlihy [1], and J.C. Sifneos [2]

[1] Department of Fisheries & Wildlife, Oregon State University, 200 SW 35th St., Corvallis, OR, 97333, USA.
e-mail: hughes.bob@epa.gov
[2] Department of Geosciences, Oregon State University, 200 SW 35th St., Corvallis, OR, 97333, USA..

Introduction

Wang et al. (2006a) identified several key challenges to studying and managing landscape-river systems. These included understanding how factors measured at various spatial-scales influence aquatic biota. Biological assemblage responses to natural gradients and anthropogenic disturbances have been studied at multiple spatial scales (Roth *et al.* 1996) because large scale patterns are believed to influence local conditions (Frissell *et al.* 1986). However because of study objectives, assemblage responses to environmental conditions are often largely focused at the catchment (Steedman 1988) or local (Southwood 1977) scale. Such studies hinder critical evaluation of the relative importance of proximal and distal environmental factors to aquatic assemblages. In addition, the types, intensities, and locations of major environmental gradients alter the relative importance of environmental factors (Wang et al. 2006b), as do the assemblages studied (Allen *et al.* 1999).

Aquatic ecosystem classification has long been used for predicting fish assemblages in streams and rivers. These have included fish zones (Hawkes 1975), physiographic regions (Pflieger 1971) ecoregions (Hughes *et al.* 1994), and river basins (Hocutt and Wiley 1986). However, large quantitative fish assemblage data sets linked with quantitative physical and chemical habitat data and landscape data are becoming increasingly available (Pont *et al.* 2006).

Our objectives were to determine (1) fish clusters at three spatial scales in the western USA, (2) how predictor variables for those clusters changed with spatial scale, and (3) the amount of variability in the fish clusters that could be explained by those predictor variables.

Methods

Using cluster and indicator species analysis, we analyzed a 780-site database obtained from USEPA's EMAP western survey to determine 12-15 fish clusters from those sites at three spatial scales (Pacific Northwest mountains, all mountains, all 12 conterminous states). We next determined the predictor variables for those clusters through use of discriminant function analysis and classification tree analysis. We applied Bray-Curtis mean similarity analysis to assess fish assemblage similarity within a number of geographic and data classification schemes.

Results & Discussion

Longitude, dams and temperature were the best predictors for all sites; longitude, dams and catchment area were the top predictors for mountain sites; and latitude, turbidity, and canopy density ranked highest for Pacific Northwest mountains. However, landscape and site variables alone only accounted for half of the mean within-cluster similarity demonstrated by the fish clusters. We conclude that, when available, using large fish assemblage, physical and chemical habitat, and landscape data sets to predict fish assemblage patterns is preferable to using preexisting landscape classifications, or only one set of site-scale quantitative data.

References

Allen, A. P., Whittier, T. R., Kaufmann, P. R., Larsen, D. P., O'Connor, R. J., Hughes, R. M., Stemberger, R. S., Dixit, S. S., Brinkhurst, R. O., Herlihy, A. T., and Paulsen, S. G. (1999) Concordance of taxonomic composition patterns across multiple lake assemblages: effects of scale, body size, and land use. *Canadian Journal of Fisheries and Aquatic Sciences* **56**: 2029-2040.

Frissell, C. A., Liss, W. J., Warren, C. E., and Hurley, M. D. (1986) A hierarchical framework for stream habitat classification: viewing streams in a watershed context. *Environmental Management* **10**:199-214.

Hawkes, H.A. (1975) River zonation and classification. B. A. Whitton (Ed.). *River Ecology.* University of California Press, Berkeley, pp. 312-374.

Hocutt, C. H., and Wiley, E. O. (1986) *The Zoogeography of North American Freshwater Fishes.* Wiley, New York, New York.

Hughes, R. M., Heiskary, S. A., Matthews, W. J., and Yoder, C. O. (1994) Use of ecoregions in biological monitoring. S. L. Loeb and A. Spacie (Eds.). *Biological Monitoring of Aquatic Systems*. Lewis, Boca Raton, Florida. pp.125-151.

Pfleiger, W.L. (1971) A distributional study of Missouri fishes. *University of Kansas Publication Museum Natural History* **20**:225-570.

Pont, D., Hugueny, B., Beier, U., Goffaux, D., Melcher, A., Noble, R., Rogers, C., Roset, N., and Schmutz, S. (2006) Assessing river biotic condition at a continental scale: a European approach using functional metrics and fish assemblages. *Journal of Applied Ecology* **43**:70-80.

Roth, N. E., Allan, J. D., and Erickson, D. L. (1996) Landscape influence on stream biotic integrity assessed at multiple spatial scales. *Landscape Ecology* **11**:141-156.

Southwood, T. R. E. (1977) Habitat, the templet for ecological strategies? *Journal of Animal Ecology* **46**:337-365.

Steedman, R. J. (1988) Modification and assessment of an index of biotic integrity to quantify stream quality in southern Ontario. *Canadian Journal of Fisheries and Aquatic Sciences* **45**:492-501.

Wang, L., Seelbach, P. W., and Hughes, R. M. (2006a) Introduction to influences of landscape on stream habitat and biological assemblages. R.M. Hughes, L. Wang, and P.W. Seelbach (Eds.). *Landscape Influences on Stream Habitat and Biological Assemblages.* American Fisheries Society, Bethesda, Maryland. pp. 1-23.

Wang, L., Seelbach, P. W., and Lyons, J.(2006b) Effects of levels of human disturbance on the influence of catchment, riparian, and reach-scale factors on fish assemblages. R.M. Hughes, L. Wang, and P.W. Seelbach (Eds.). *Landscape Influences on Stream Habitat and Biological Assemblages.* American Fisheries Society, Bethesda, Maryland. pp. 199-219.

Impact of barriers on aquatic species composition in Japan

M. Fukushima[1], S. Kameyama[1], M. Kaneko[2], K. Nakao[3]

[1] National Institute for Environmental Studies, Tsukuba, Ibaraki 305-8506, Japan.
e-mail: michio@nies.go.jp
[2] Faculty of Environment Systems, Rakuno Gakuen University, Ebetsu, Hokkaido Japan.
[3] Hokkaido Aquaculture Promotion Corporation, Sapporo, Hokkaido, Japan

Introduction

Instream barriers such as dams have affected freshwater fish populations around the globe (Bunn and Arthington, 2002). The effects of barriers are particularly detrimental to diadromous fish species because they need to perform marine-freshwater migration during their life cycles (Joy and Death, 2001). Previous studies have therefore focused on the effects of dams on migratory species. In this study, however, we assessed the effects of dams on both migratory and nonmigratory freshwater fish taxa in Hokkaido, Japan. Our aim was to identify fish taxa that are either negatively or positively impacted by dams and to predict the spatial extent and magnitude of the impacts.

Methods

Fish and dam data

We prepared a fish database that contains information about the presence or absence of 46 dominant fish taxa based on 13,701 surveys conducted during 1953–2003 (Fukushima, 2005; Fukushima and Kameyama, 2006). Based on the presence/absence data, we obtained species richness data by counting the number of taxa captured in each survey. We combined 167 large dams (>15 m in height) and 1040 low-head dams that existed in Hokkaido as of 2000. These dams were mapped in a geographical information system (GIS), and sub-basins fragmented by the dams were delineated across Hokkaido (Kameyama *et al*., 2004). All the survey sites were then superimposed on the map of habitat fragmentation in the GIS to determine whether each survey was conducted above dam(s) or not at the time sampling was conducted, producing a covariate representing the presence or absence of the impact of dams. Another covariate representing the length of time after being isolated from the sea due to dams was prepared by subtracting a year of dam construction from a year of fish sampling for every survey site with the impact of dams.

Statistical analysis

Both fish species richness and occurrence of each of the 46 taxa were modelled with a series of generalized additive models (GAMs) using dam variables described above together with other environmental variables as candidate predictors. The models were cross-validated, and the discrimination performance was assessed by producing the receiver operating characteristic curves.

Results and discussion

Fish species richness was plotted against elevation above sea level after dividing the data into 3 groups with different survey periods (Fig. 1). The data were further divided into those with no impact of dams (top 3 panels of Fig. 1) and those with the impact of dams (bottom 3 panels). The species richness exponentially decreased with increasing elevations regardless of survey periods and damming impact. However, the richness appears to be slightly higher during 1990s and after than the previous periods. This may be due to increased fish sampling efficiency with the advent of electrofishing in Japan in early 1990s. Most importantly, the fish species richness with the impact of dams was much lower at lower elevations than species richness without the damming impact regardless of survey periods.

The GAMs of the fish taxa revealed that the occurrence probability of 19 taxa had been either positively or negatively influenced by dams. All but one of the 10 taxa on which damming had a negative influence were migratory taxa, indicating a strong barrier effect on their migration. A positive damming impact was noted for five fish taxa, comprising three strictly freshwater, one landlocked, and one anadromous (but commonly propagated) taxa. The influence of dams on the fishes either occurred immediately after dam construction or was gradual over time.

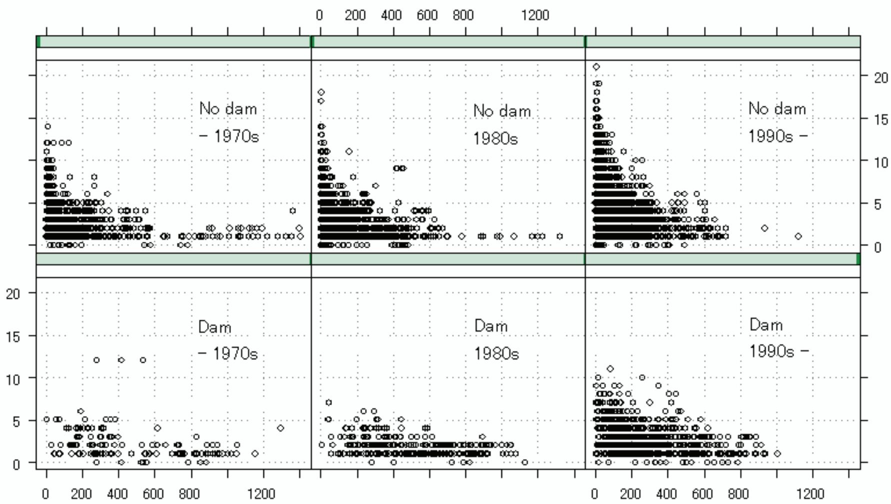


Figure 1. Freshwater fish species richness plotted against elevation for three periods with and without dam(s) below the survey sites.

References

Bunn, S.E. & Arthington, A.H. (2002) Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. *Environmental Management* **30:** 492-507.

Joy M.K. & Death R.G. (2001) Control of freshwater fish and crayfish community structure in Taranaki, New Zealand: dams, diadromy or habitat structure? *Freshwater Biology* **46:** 417-429.

Kameyama, S; Fukushima, M.; Shimazaki, H.; Takada, M. & Kaneko, M. (2004) The watershed fragmentation by dams and its impacts on freshwater fishes. N. Sappington (Ed). *ESRI MAP Book* vol. 19. ESRI Press, New York, p. 89.

Fukushima, M. (2005) The dam-related decline of freshwater fish diversity—analyses of the data collected from Hokkaido during the last half century. *Japanese Journal of Ecology* **55:** 349-357 (in Japanese).

Fukushima, M. & Kameyama, S. (2006) The effects of damming on masu salmon and the Sakhalin taimen and the assessment of their conservation areas based on predictive habitat models. *Ecology and Civil Engineering* **8:** 233-244 (in Japanese).

The influence of population dynamics and landscape condition on pacific salmon (*Oncorhynchus spp.*) re-colonization

G.R. Pess[1,2], T. Quinn[2], R. Hilborn[2], K. Kloehn[1]

[1]United States Department of Commerce (DOC), National Oceanic and Atmospheric, Administration (NOAA), National Marine Fisheries Service (NMFS), Northwest Fisheries, Science Center (NWFSC), 2725 Montlake Blvd East, Seattle, WA, U.S.A. 98112, e-mail: george.pess@noaa.gov
[2]University of Washington, School of Aquatic and Fishery Sciences (SAFS), Box 355020, Seattle, WA, U.S.A. 98195-5020

Introduction

The colonization or re-colonization of aquatic habitats by salmonid fishes (*Salmo, Oncorhynchus, Salvelinus*) at a watershed scale is related to the compatibility between specific life history variation and landscape conditions that determine aquatic habitat characteristics. Salmonids are well-suited for rapid colonization of newly created or opened habitats because of two converse behaviours – homing and straying. Homing is defined as the return of mature salmon to the general location of where their parents bred to spawn (natal site), whereas straying is the return of mature salmon to a non-natal site to spawn. The majority of salmon home to their natal sites, however straying has allowed salmonids to colonize new habitats over their evolutionary history. Salmon can thus disperse, colonize habitats, and establish self-sustaining populations. Natal sites are not static because habitats change with anthropogenic alterations and other disturbances that force dispersal and colonization of new habitats. What causes the strays to succeed and become colonists in some cases? When do colonists become self-sustaining populations?

Background and Objectives

To answer these two questions we investigate how the establishment of pink salmon (*Oncorhynchus gorbuscha*) populations in the Fraser River, British Columbia, Canada in newly reopened habitats is related to specific life history variation and landscape conditions. Pink salmon in the Fraser River were cut off from most of the watershed between 1913 and the 1940s due to a rockslide at Rkm 209 that altered flow conditions and made adult fish passage impossible (Roos 1996). Local spawning populations above the slide area disappeared. Fish passage facilities developed in the 1940s allowed adult pinks to migrate past the flow barrier and re-colonize the Upper Fraser. Re-colonization allowed pink salmon to establish large self-sustaining populations above the landslide in one decade.

We hypothesize self-sustaining populations of colonists can be established when the population growth rate of the colonizing population is greater than one. This occurs when specific population and landscape factors are met. This includes an increasing population size, a distance from source population that is comparable to existing migrations, a lack of barriers, and the appropriate habitat type, quantity, and quality in the newly colonized habitats.

Methods

We developed a general population model with multiple parameters to fit observed spawning population growth for each watershed above the historic barrier. The models include the colonizing population growth rate, harvest rate, immigration to the colonizing population from the source population, a distance-dependent dispersal effect, an annual relative population size effect, and a habitat area and habitat quality effect. We use maximum likelihood techniques to estimate each of the parameters, and likelihood ratios to compare each of the models to determine the one which best fit the observed data.

Results and Discussion

We found that self-sustaining spawning populations of pink salmon can be established within 10 to 30 years of habitat being reopened to access. However, a self-sustaining population in the uppermost watershed was not established during the dataset time period, and instead became a sink population for two of the nearest spawning populations. Factors that enabled pink salmon to successfully re-colonize included a physiological ability to swim and efficiently migrate to newly opened habitats (MacNutt *et al.* 2006), an expanding population size irrespective of the newly opened habitats, and life history variation that was compatible with the newly opened habitat types and quantity. Differences in colonization rates between the self-sustaining and non self-sustaining populations were related to distance from source population, population growth rate, habitat area, and annual relative population size. Environmental variables such as stream discharge also effected annual variation redistributing upstream populations below natural flow barriers during low stream discharge years. The results suggest that the combination of distance from source population, habitat suitability, natural barriers, and population dynamics helped determine the spatial and temporal patterns of Fraser River pink salmon re-colonization.

References

Roos, J. F. (1996) *Restoring Fraser River Salmon*. Pacific Salmon Commission, Vancouver, British Columbia, Canada.

MacNutt, M.J.; Hinch, S.G.; Lee; C.G. Phibbs; J.R., Lotto; A.G. Healey, M.C. and Farrell, A.P. (2006) Temperature effects on swimming performance, energetics, and aerobic capacities of mature adult pink salmon (*Oncorhynchus gorbuscha*) compared with those of sockeye salmon (*Oncorhynchus nerka*). *Canadian Journal of Zoology*. **84**: 87-91.

Multiscale analysis of the relationship among land use cover and streams water quality in the Venice lagoon watershed

L. Favero[1], A. Zuin [2], E. Mattiuzzo [2], G. Zanetto[1], P. Ghetti[3], D. Franco[3]

[1] IDEAS – San Giobbe 873, 30121 Venice (Italy).
e-mail: ideas@unive.it
[2] Planland – Cannaregio 3841, 30121 Venice (Italy).
[3] Università Cà Foscari – Dorsoduro 3246, 30123 Venice (Italy).

Introduction

The Venice lagoon is a fragile habitat threatened by water pollution. A regional plan has been created to reduce nutrients inputs to Venice lagoon to 3000 t yr^{-1} for nitrogen and 300 t yr^{-1} for phosphorus. The analyses of the relationships between the watershed Land Use (LU) and the surface water quality could provide important information for management and planning purposes. The LU patterns can be represented by simple percent values or by metrics that consider the landscape spatial patterns. Together with LU, natural watershed characteristics such as soil texture and permeability can influence water quality. The aim of this study was (1) to analyse the relationship between streams nutrients concentrations and LU patterns; (2) to verify the role of soil properties in this relationship; (3) to analyse the role of landscape pattern; (4) to highlight a scale effect, (5) valuing the hedgerow network effect.

Methods

The Venice lagoon watershed covers about 2,124 Km^2 and is 70% cultivated, mainly for cereal crops. It is an alluvial, almost entirely flat plain, with clay loam sediments and is divided into 8 monitored sub-basins (*ca.* 90% of the total watershed). Three years (2002-2004) of ammonium and nitrate loads at the sub-basins outlets, digitised land use/land cover maps, digitised soil characteristics maps, streams and basins boundaries were obtained from Veneto Regional Agency for the Environment Protection.

LU types were aggregate into 7 classes: urban, agriculture, industrial, tree farming and orchard, natural zones, vineyards, zootechnics. Among soil characteristics, soil texture classes and soil hydrologic groups were used. Landscape metrics were selected from literature studies; in particular, we used the Shannon-Wiener index for heterogeneity (Franco, 2000) and the Effective Mesh Size index for fragmentation (Jaeger, 2000). Landscape proximity analysis was conducted by buffering concentric zones around the streams within each sub-basin. Zone widths (0-50 and 0-100 m from streams) were chosen based on the size of the sub-basins and the literature analysis (Sliva and Williams, 2001).

The autocorrelation among variables was studied by means of correlation and Principal Components Analysis (PCA). The selected independent set of variables was then regressed against the water quality variables by means of multivariate models. The significance of the obtained models was evaluated first for their ecological relevance and then using the Akaike Information Criterion, corrected for small sample size (AICc, e.g.: Hamer *et al.*, 2006).

Results

The correlation analysis revealed a strong correlation among soil texture and hydrologic groups, which characterized also the first extracted component of PCA and MDS (data not shown). The soil characteristics were thus represented by the PCA first extracted component in the regression analysis (F1), in order to reduce the redundancy among predictors.

The models obtained by the regression analyses, selected for their ecological relevance and their □AICc are listed in Table 1. The two competing models for ammonium indicated that NH_4 loads were dependent on industrial LU at the whole watershed scale and on urban LU at the 50m buffer scale, and on soil characteristics at both scales. Nitrate loads were dependent on agriculture at the three scales, and on heterogeneity at the whole watershed scale. The regressions performed using the most significant variables at the three spatial scales were not significant ($p>0.05$, data not shown).

Discussion and conclusions

Ammonium loads were dependent mostly on industrial and urban LU: this may reflect a higher concentration of sewage and waste disposal associated with urban and industrial areas (Jones *et al.*, 2001). The relationship with soil characteristics indicated that finer textured, low permeable sub-basins have a higher NH_4 content. In facts, clay minerals and clay humics have a larger potential for adsorption of nutrients such as ammonia, and the low permeability enhances overland flow that may easily carry particulates with adsorbed nutrients into rivers (Sliva and Williams, 2001). The relationship among nitrate loads and agriculture is frequently reported in literature (e.g. Sliva and Williams, 2001) and represents the contribution of fertilizers to the non-point source pollution. The negative relation with heterogeneity at the watershed scale can be explained by the impact of ecotone density (generally matching with ditches in this ancient reclaimed land) on nitrate dynamic.

Several researchers have addressed the issue of whether LU near rivers is a better predictor of water quality than LU over the whole watershed (e.g. Sliva and Williams, 2001), obtaining contrasting results. Our results show that in the Venice watershed there were not significant differences among spatial scales. This could be due to the highly impacted structure of this landscape, where agriculture was 60-75%, urban LU 9-28% and natural habitats covered less than 8%, even in the 50m buffer zone.

Table 1. Competing models. AG: agriculture; URB: urban; IND: industrial; F1: PCA factor (soil texture and permeability); Shannon: heterogeneity index; AICc: corrected Akaike Information Criterion. In brackets the sign of the relationship.

Nutrients	Variables	R^2	AICc	ΔAICc	Scale
Ammonium	IND(+), F1(+)	0.83	-60.53	0.00	Watershed
	URB(+), F1(+)	0.81	-58.81	1.72	50m
Nitrate	AG(+)	0.69	-26.85	0.61	Watershed
	Shannon(-)	0.67	-25.70	1.76	Watershed
	AG(+)	0.71	-27.47	0.00	100m
	AG(+)	0.67	-25.69	1.78	50m

References

Franco, D. (2000) *Paesaggio, reti ecologiche e agroforestazione*. Il Verde Editoriale, Milano, p. 24.

Hamer, T.L; Flather, C.H. & Noon, B.R. (2006) Factors associated with grassland bird species richness: the relative roles of grassland area, landscape structure, and prey. *Landscape Ecology* **21:**569-583.

Jaeger, J.A.G. (2000) Landscape division, splitting index, and effective mesh size: new measures of landscape fragmentation. *Landscape Ecology* **15:**115-130.

Jones K.B; Neale A.C; Nash M.S; Van Remortel R.D; Wickham J.D; Riitters K.H. & O'Neill R.V. (2001) Predicting nutrient and sediment loadings to stream from landscape metrics: a multiple watershed study from the united states mid atlantic region. *Landscape Ecology* **16:**301-312.

Sliva L. & Williams D.D. (2001) Buffer zones versus whole catchment approaches to studying land use impact on river water quality. *Water Resouces* **35:** 3462–3472.

Aquatic ecosystems in the core Cerrado: environmental impacts and conservation

F.L. Tejerina Garro

Centro de Biologia Aquática, Universidade Católica de Goiás, Campus II, Av. Bela Vista s/n Jardim Olímpico, CEP 74605010, Goiânia, Goiás, Brazil, Phone/Fax 62 32271722, e-mail: garro@ucg.br

Introduction

The Cerrado is the second greatest Brazilian biome covering originally $2 \cdot 10^6$ km^2, that is, fourteen Brazilian States (Ratter *et al*., 1997). Actually, the Cerrado core region (Goiás and Tocantins State) is represented by 45.1% of the originally vegetation cover, but only 22.7% remains in the Goiás State (Galinkin, 2003). It is classified as a hotspot (Myers *et al*., 2000). Recent efforts have been conducted to qualify and quantify regional biodiversity, but these have been limited to the terrestrial environment. This study aims to characterize the aquatic ecosystems in Goiás based on the character of the hydrographic basins, their conservation, biodiversity and the associated environmental impacts.

Hydrographic basins and human occupation

Four drainage basins are present in Goiás: the Araguaia River (86,109 km²), the Tocantins River (102,120.6 km²), the Paraná River (149,488 km²) and the São Francisco River (3,400 km²). The human occupation of these basins has increased since 1900 in the south-north direction. Actually, the demographic density varies from low (e, g., São Miguel do Araguaia 3.7 inh/km²) to high numbers (e. g., Brasília 352.16 inh/km²) (IBGE, 2002).

Conservation of the aquatic environment

The objectives of conservation in Goiás were determined between the 1960's and the 1980's, but do not include specified parts of the aquatic regional ecosystems. This seems to be related to a) the predominant viewpoint that the aquatic environment is a component of the terrestrial landscape; b) the fact that people are more familiar with terrestrial than aquatic environments. However, based on actual knowledge about aquatic landscape ecology, because the present Brazilian conservation policy is influenced by a terrestrial conservation viewpoint, it is not very effective for the aquatic environment. On the other hand, a new approach based on the hydrographic drainage basin (MMA, 2002) seems to be more efficient to regional aquatic conservation process, despite the biological, political and social-economic problems that it represents (Agostinho and Gomes, 2002).

Aquatic biodiversity

Data about aquatic biodiversity in Goiás is scarce. Among the nineteen aquatic taxonomic groups considered for Brazilian continental water ecosystems, twelve (63.2%) do not have available data in Goiás drainage basins. Systematized studies are irregular and mainly focused on the Paraná River. This situation reflects the regional lag between the slow generation of scientific knowledge and the rapid environment transformation because of anthropogenic activities. Indeed, the aquatic environments in Goiás include headwaters, where the probability of finding endemic species is considerable (Sá *et al*., 2003).

Environmental impacts

The deforestation, agriculture, the implantation and expansion of urban and industrial areas, the construction of water reservoirs with different outcomes, and the introduction of exotic species are the main anthropogenic activities that affect the aquatic environment in South America (Pringle *et al*., 2000). This is also observed in the Goiás State.

Conclusion

There is a lag between the knowledge about the aquatic diversity and the rate of modification of the Cerrado biome. Urge systematized studies about the aquatic flora and fauna considering conserved and impacted environments.

The actual governmental policy do not has effective contribution to the conservation of the aquatic environment. It is necessary a broad approach considering not only the terrestrial environment but also the aquatic one.

References

Agostinho, A.A. & Gomes, L.C. (2002). Biodiversity and fisheries management in the Paraná River Basin: successes and failures. In: World Fisheries Trust (org.). *The Blue Millennium Project Workshop: Managing fisheries for biodiversity*. Victoria, BC., Canada. pp. 30.

Galinkin, M. (2003). *Geo-Goiás 2002*. Agência Ambiental de Goiás, Fundação Centro Brasileiro de Referência e Apoio Cultural (CEBRAC), PNUMA, Secretaria do Meio Ambiente e Recursos Hídricos de Goiás (SEMARH), Brasília, pp. 272.

IBGE Instituto Brasileiro de Geografia e Estatística (2002). *Atlas Nacional do Brasil*. 4ta. Edição. Available in: <http://mapas.ibge.gov.br>.

MMA. Ministério do Meio Ambiente (2002). *Recursos Hídricos: conjunto de normas legais.* 2.ed. Brasília: Secretaria de Recursos Hídricos, pp. 141.

Myers, N.; Mittermeier, R.A.; Mittermeier, C.G.; Fonseca, G.A.B. & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature* **403**(24):853-858.

Pringle, C.M.; Scatena, F.N.; Paaby-Hansen, P. & Núñez-Ferrera, M. (2000). River conservation in Latin America and the Caribbean. In: P. J. Boon, B. R. Davies, G. E. Petts (eds.). *Global perspectives on river conservation: science, policy and practices*. John Wiley & Sons. Chichester, pp. 41-78.

Ratter, J.A.; Ribeiro, J.F. & Bridgewater, S. (1997). The Brazilian Cerrado vegetation and threats to its biodiversity. *Annals of Botany* **80**:223-230.

Sá, M.F.P. de; Fenerich-Verani, N. & Fragoso, E.N. (2003). Peixes do cerrado em perigo. *Ciência Hoje* **34**(200): 68-71.

Rivers and roads controlled by, and central players in, urban regions

R.T.T. Forman

Harvard University, Graduate School of Design, Cambridge, MA 02138, USA e-mail: rforman@gsd.harvard.edu

Introduction

Two central questions are explored: (1) the effect of an urban region on rivers; and (2) the role of rivers and roads in the region.

Analysis and Discussion

Analyzing 38 urban regions of large-to-small cities on all continents (plus an intensive ecological planning study of the Barcelona Region; Forman 2004) found 40% of the cities by major rivers, and another 10% at the intersection of major rivers (Forman 2007). Cropland is the predominant human land use around rivers and major streams in almost all of the urban regions, suggesting extensive sediment and agricultural chemicals in river water. Forty percent of the regions have considerable (10-40%) built area around rivers/streams, implying much urban-pollutant runoff and other human impacts. Most regions have <33% natural vegetation cover near rivers/streams, while only a fifth of the regions has >80% to support good water quality, aquatic ecosystems and fish populations; another fifth has 40-70% natural cover.

The typical urban region worldwide offers many unusual and powerful attributes that affect the river, including: widespread built areas and hard surface on slopes; diverse heavily used infrastructure along the river; intense straightening and squeezing of river and tributaries; elimination of most wetlands; a huge human population with manifold daily effects; low percent of natural vegetation cover remaining; very little stream-corridor vegetation remaining; intense conversion of groundwater and river-water to water vapor; a huge human wastewater source; commonly a single pipe system for draining stormwater and wastewater; an enormous density of big and little roads; and a large and rapidly growing mass of moving vehicles.

Little roads cross and run along floodplains for maintenance and repair of the city's major infrastructure conduits. Grids of little roads in the city and on the slopes help accelerate stormwater and pollutant flows, raising peak flows and flooding (Forman et al. 2003). In general, little roads cross streams, while highways parallel rivers. Roads and vehicles provide linear streaks of pollutants that reach rivers. Fill on the lower side of roads provides much sediment to streams and rivers. In addition, highways cut the regional connectivity of movement for terrestrial wildlife, highlighting the importance of wildlife underpasses and overpasses.

All this results in normal low-water flows, periodic floods with major damage to human structures, heavily polluted downslope flows, blockage of fish migration, cleaning of the city by river carrying away wastes, and severely degraded water quality, aquatic ecosystems and fish populations. Contrasting patterns normally appear upriver and downriver of the major city.

Conclusion

In brief, urban region characteristics, including roads, almost overwhelm river ecosystems, or render them outliers to be mainly modeled by urban-region parameters. At the same time these rivers and roads are the major conduits and barriers in the urban region, effectively determining where species and people live and move. Landscape ecologists seem to have more to offer for understanding and solutions for society than any other field.

References

Forman, R.T.T., Sperling, D., Bissonette, J. A., et al. (2003) *Road Ecology: Science and Solutions*, Island Press, Washington, D.C.

Forman, R.T.T. (2004) *Mosaico territorial para la region metropolitana de Barcelona*, Editorial Gustavo Gili, Barcelona.

Forman, R.T.T. (2007) *Urban Regions: Ecology and Planning Beyond the City*, Cambridge University Press, Cambridge (in press).

4.2 Symposium 9: Biogeochemical Hotspots in a Landscape Context: implications for catchment water management

Approaches to Link Microbial Structures and Processes at the Microscale to Ecosystem Functioning

A. Ogram[1], R. Corstanje[2], M. Christman[3]

[1] Soil and Water Science Dept., University of Florida, Gainesville, FL 32611-0290 USA.
e-mail: aogram@ufl.edu
[2] BAB Division, Rothamsted Research, Harpenden, AL5 2JQ, UK
[3] Statistics Dept., University of Florida, Gainesville, FL, 32611-0339, USA

The functions of soil microbial communities constitute essential links in biogeochemical cycles, such that knowledge of the factors that control the structures and activities of these communities is essential for a mechanistic understanding of biogeochemical cycling. Thanks to the development of increasingly sophisticated tools based in molecular biology, the ability to characterize the structure of soil microbial communities has increased dramatically over the last ten years. Environmental factors that determine the structures and activities of these extraordinarily complex communities are poorly understood, however, as are the quantitative relationships between individual community structures and activities, and the pathways and rates of the major biogeochemical cycles.

Of particular interest are quantitative relationships between microbial communities and the processes they control at landscape scales. Many DNA-based procedures utilize sample sizes of 0.25 g soil. Samples of this size provide great opportunities for spatial resolution of microbial communities on small scales, but present challenges when attempting to extrapolate to the landscape scale. More research, including development and application of advanced methodological and statistical approaches, is required to successfully establish quantitative links between DNA-based data concerning community structure and environmental parameters across large scales.

A limitation to scaling from 0.25 g samples to landscape scales has been the high cost and labor involved in most standard molecular ecological methods, which preclude their use in analysis of large numbers of samples typically required for landscape analysis. These limitations are being overcome, however, thanks in large part to advances made in genomics. Rapid fingerprinting approaches such as terminal restriction fragment length polymorphism (T-RFLP) analysis are in common use, and microarray analyses are being developed for ecological applications. Perhaps of greatest potential for analysis of microbial community structure is high-throughput sequence analysis of clone libraries from disparate sources. DNA-based approaches such as these have little meaning, however, if they are not combined with biogeochemical parameters that control, and are controlled by, their activities.

Most studies that attempt to link DNA-based analyses with environmental parameters have relied on relatively simple analytical approaches such as Principal Components Analysis (PCA). PCA can be useful when analyzing aspects of community structure that are linked to a dominant characteristic of the landscape, such as in the cases of sulfate reducing prokaryotes (SRP) and methanogens along nutrient gradients in the Florida Everglades (Castro et al., 2005). In this study, the distribution of genes representative of SRP and methanogens in monthly samples were characterized via T-RFLP analysis. Distributions of genotypes characteristic of SRP and methanogens depended on position along the gradient, and knowledge of the general physiological attributes of cultured representatives of those genotypes allowed development of hypotheses to explain the distribution. In general, genes characteristic of SRP capable of utilizing a broad range of electron donors (“generalists”) dominated soils from high nutrient regions, while genes characteristic of SRP limited to a few electron donors (“specialists”) dominated the low nutrient soils. Possible reasons for selection of specific methanogens may be related to differing H_2 concentrations along the nutrient gradient. This general approach has been used in many applications, such as to define relationships between microbial community structure and plant community (Blume et al, 2005), and between methanotrophs land use and (Ogram et al., 2006).

PCA and related approaches can be valuable but are limited in scope; they provide information on correlations between observed species distributions an environmental factors, but are of less value in identifying complex relationships that control community structure and activity. A drawback of some of the ordination techniques is the ambiguity and general descriptive nature of the factor, specifically that PCA factor scores have a large degree of associated ambiguity, too large to be used as composite environmental indexes (Yu et al.1998). As a result, alternative multivariate approaches have been used in many soil microbial ecology studies. One such study was to investigate the controls on microbial community structure on global scales (Fierer and Jackson, 2006). The analytical approaches for community structure were similar to those described above (T-RFLP analysis), but the links between T-RFLP derived diversity indices and environmental parameters were defined using non-metric multidimensional scaling and partial Mantel tests. Noteworthy in their findings was that microbial community diversity is determined primarily by soil biogeochemical characteristics related to pH.

Biogeochemical processes and multiple constituent measures have complex inter-relationships. The relationship between those processes and the diversity and composition of soil bacterial communities is equally complex. The common thread in many studies linking communities with processes is that there are some underlying factors or latent variables that link the observed variables describing the biogeochemistry or community composition. Relationships between community composition and biogeochemistry are established by determining the degree one explains the variation in the other through either regression or another measure of association or dependence. This process can be formalized using structural equation modeling (SEM) (Shipley, 2000). SEM is based on the premise that there is a directed graph (or web) describing the relationships among the variables of interest (a path model) but that the underlying latent causal variables are described by other variables observed with measurement error. For example, microbial community composition is not directly measured but is represented by T-RFLP fingerprinting. In a statistical analysis of an SEM, the observed variables 'load' onto the latent factors, which are the constructs representing some meaningful process or characteristic. The relationships between the latent factors then are described by path coefficients. To illustrate an analysis using SEM, we constructed a structural equation model for the soil biogeochemistry and microbial community using the same dataset as used by Castro et al. (2005).

References

Castro, H., S. Newman, K.R. Reddy, and A.V. Ogram (2005) Distribution and stability of sulfate reducing prokaryotic and hydrogenotrophic methanogenic assemblages in nutrient-impacted regions of the Florida Everglades. *Appl. Environ. Microbiol.* 71: 2695-2704.

Fierer, N. and R.B. Jackson (2006) The diversity and biogeography of soil bacterial communities. *PNAS USA* 103:626-631.

Shipley, B. (2000) *Cause and Correlation in Biology: A User's Guide to Path Analysis, Structural Equations and Causal Inference.* Cambridge University Press: Cambridge, UK.

Yu, C.C., Quinn, J.T., Dufournaud, C.M., Harrington, J. J., Rogers, P. P., and Lohani, B. N. (1998) Effective dimensionality of environmental indicators: a principal component analysis with bootstrap confidence intervals. J. of Environ. Manage. 53:101–119.

Progress and challenges in demonstrating riparian buffer effects on nutrient discharges from whole catchments

D.E. Weller[1], M.E. Baker[2], T.E. Jordan[1]

[1] Smithsonian Environmental Research Center, 647 Contees Wharf Rd., Edgewater, MD, 21037-0028, USA. e-mail: wellerd@si.edu.
[2] Utah State University, Dept. of Watershed Sciences, 5210 Old Main Hill, Logan, Utah 84322-5210, USA.

Introduction

Riparian forests and wetlands are important nutrient-retaining landscape elements. Many field studies report strong nutrient retention along sampling transects from source areas through riparian buffers to streams. Efforts to demonstrate the impacts of buffers at the whole catchment scale often use statistical models which relate observed nutrient discharges from many catchments to variables describing catchment land use and riparian buffers. These studies have not consistently demonstrated that riparian buffers are important to predicting nutrient discharges from whole catchments (Johnson *et al.* 1997, Weller *et al.* 1998, Jones *et al.* 2001). We have developed new approaches to testing for the effects of buffers in GIS-based statistical models of whole catchment nutrient discharges.

Functionally-based riparian buffer metrics

Efforts to quantify the effects of riparian buffers in whole catchments have been confounded by a commonly used analysis which estimates buffer potential as the percentage of forest or wetland within a fixed distance of streams. This method of estimating buffer potential is not based on a clear conceptual model and does not match the scale at which field studies have documented buffer nutrient uptake. To better quantify the distribution of riparian buffers in a catchment, we developed new functionally-based metrics that account for the length of buffer traversed by every hydrologic flow path connecting a nutrient source area to a stream (Baker *et al.* 2006). This approach correctly “scales up” from transects (flow paths) considered in field studies to whole catchments. We applied the new approach to 503 catchments in four different physiographic provinces of the Chesapeake Bay Drainage. For comparison, we also analyzed land cover within a fixed distance of streams. There were distinct patterns of relationship between catchment and near-stream land cover in each physiographic province and strong correlations with catchment land cover confounded fixed-distance metrics. In contrast, our flow-path metrics were more independent of catchment land cover than fixed-distance measures and provided greater detail, interpretability, and flexibility than the fixed-distance approach (Baker *et al.* 2006)

Effects of stream map resolution

Geographic studies of buffer effects in whole catchments have also used stream maps of different resolutions without explicitly considering the possible effects of map resolution on estimates of source-stream connectivity and overall buffer effectiveness. For 503 catchments of the Chesapeake Bay drainage, we applied our functionally-based riparian metrics (Baker *et al.* 2006) to explore how differences in stream map resolution affect inferences about the effective placement of buffers within a catchment (Baker *et al.* in press). Increasing stream map resolution reduced the mean distance from source areas to streams, reduced mean buffer width, and increased the frequency of buffer gaps. Overall, increasing stream map resolution led to reduced estimates of nutrient retention potential in riparian buffers. In some catchments, switching from a coarse resolution to a fine resolution stream map completely changed the perception of a stream network from well buffered to very poorly buffered. Previous broad-scale analyses of riparian buffers based on coarse-resolution stream maps may have overestimated landscape-level buffer prevalence and effectiveness.

Relating buffer prevalence and distribution to catchment nutrient discharges

We developed statistical models that explicitly test the statistical significance of a riparian buffer effect as an addition to non-spatial models relating nutrient discharges to land use proportions. In the Chesapeake Bay drainage, information on riparian buffer distribution explained a small but statistically significant amount of the variation in nitrate discharges among rural Coastal Plain catchments, but not among rural catchments in the other physiographic provinces of the Bay's drainage. This result is consistent with our previous finding that Coastal Plain catchments retain more riparian forest along flow paths connecting croplands to streams than do catchments in the other physiographic provinces (Baker *et al.* 2006, in press).

Conclusions and challenges

Our new functional riparian metrics and our analysis of the effects of stream map resolution address problems that have confounded efforts to demonstrate and quantify the effects of riparian buffers on catchment nutrient discharges. Despite these advances, our statistical models relating buffer patterns to stream nutrient measurements still found only weak evidence of buffer effects on catchment nitrate discharges and only in one of four physiographic provinces of the Chesapeake Bay drainage. It may be possible to document stronger buffer effects after improving analyses by using land cover data of finer spatial resolution and greater categorical accuracy, by incorporating methods to identify and map buffers that are more likely to be biogeochemically active, and by considering watersheds with broader ranges of riparian configurations. In the meantime, our new methods already offer improvements in accounting for buffers in statistical nutrient models, in quantifying spatial patterns for process-based modeling, and in targeting management actions such as buffer restoration (Baker *et al.* 2006, in press).

References

Baker, M.E.; Weller, D.E & Jordan, T.E. (in press) Effects of stream map resolution on measures of riparian buffer distribution and nutrient retention potential. *Landscape Ecology*.

Baker, M.E.; Weller, D.E & Jordan, T.E. (2006) Improved methods for quantifying potential nutrient interception by riparian buffers. *Landscape Ecology* **21:**1327-1345.

Johnson, L.B.; Richards, C.; Host, C.E.; & Arthur, J.W. (1997) Landscape influences on water chemistry in Midwestern stream ecosystems. *Freshwater Biology* **37**:193-208.

Jones, K.B.; Neale, A.C.; Nash, M.S.; Van Remortel, R.D.; Wickham, J.D.; Riiters, K.H. &. O'Neill, R.V. (2001) Predicting nutrient and sediment loadings to streams from landscape metrics: A multiple watershed study from the United States Mid-Atlantic region. *Landscape Ecology* **16**:301-312.

Weller, D.E.; Jordan, T.E. & Correll D.L (1998) Heuristic models for material discharge from landscapes with riparian buffers. *Ecological Applications* **8**:1156-1169.

Linkages between surface and subsurface hydrology and ecological functioning of mangrove ecosystems in Ft. Pierce, Florida

D.F. Whigham[1,3], C.E. Stringer[2], M.C. Rains[2], J.T.A. Verhoeven[3], P. Baas[3], P.J.M. van der Ven[3]

[1]Smithsonian Environmental Research Center, P.O. Box 28, Edgewater, MD 21037, USA. email:whighamd@si.edu
[2]Department of Geology, University of South Florida, Tampa, USA
[3]Landscape Ecology, Institute of Environmental Biology, Utrecht University, P.O. Box 80084, 3508 TB Utrecht, The Netherlands

Introduction

Hydrological processes have a dominant impact on the structure and function of wetland ecosystems, including coastal wetland that in the tropics are dominated by mangroves. Globally, mangroves have been impacted by a variety of activities that result in significant modifications of the original hydrologic conditions. Mangrove systems comprise ~2,500 km^2 of south Florida and many are located in the Indian River Lagoon, a series of connected estuaries that extends ~250 km along the east coast of Florida. Most of the mangrove systems in the Indian River Lagoon have been ditched and impounded for mosquito control but are still hydrologically linked by surface water and groundwater pathways to the Indian River Lagoon. Our study site is a mosquito impoundment located on a carbonate barrier island near Ft. Pierce, Florida. A consequence of mangrove alterations has been the development of a complex matrix of vegetation within the impoundment that ranges from high salinity salt pannes in which no mangrove trees grow to areas adjacent to open water that support tall mangroves.

This paper focusses on the relationships between the structure and functioning of mangroves and variations in hydrologic conditions. A goal of the research is to understand the relationships between hydrologic conditions at a range of scales from small-scale processes associated with nitrogen, the nutrient that limits the growth of mangroves at this site (Feller et al. 2003), cycling to the relationship between surface and subsurface hydrology and the distribution, structure and function of different variants of vegetation. Dominant mangroves at the study site are *Rhizophora mangle* (Red mangrove), *Avicennia germinans* (Black mangrove), and *Laguncularia racemosa* (White mangrove).

Hydrologic setting

The common conceptual model of carbonate barrier island hydrogeology is that a freshwater lens rests on top of saline groundwater and that salinity variations are largely due to spatial and temporal variations in precipitation and subsequent freshwater runoff and recharge. Results of our preliminary hydrologic studies suggest that this conceptual model is incorrect. Salinities vary spatially, with surface water and groundwater salinities ranging from ~10 ppt in the upland groundwater, to ~30 ppt in the regularly-flushed mangrove surface water and groundwater, to ~75 ppt in the irregularly-flushed mangrove surface water and groundwater. These high salinities extend to depths of many meters. However, salinities do not significantly differ temporally, and relative cation and anion concentrations do not vary spatially or temporally. These results indicate that salinity variations are largely due to variable mixing between precipitation and lagoon water and the subsequent evapoconcentration in the irregularly-flushed areas rather than to variations in precipitation and subsequent freshwater runoff and recharge.

Hydrology and vegetation patterns

The spatial variations in salinities correlate with spatial variations in species composition and abundance, with maritime hammock, Red mangrove, dense Black mangrove, sparse Black mangrove, and salt pannes being arranged on a gradient of increasing salinities. Vegetation structure varies from one habitat type the other.

Hydrology and nitrogen cycling

Spatial variations in nutrient concentration in soils and plants and rates of nitrogen mineralization, denitrification, and nitrification correlate with spatial variations in species composition and abundance and vary from one habitat to another. Based on preliminary DNA analyses of ammonia-oxidizers in the β-proteobacteria there are also clear differences across the gradient in the composition of the microbial community responsible for nitrification (Figure 1), especially in the habitats (sparse Black mangrove, salt pan) with high salinities.

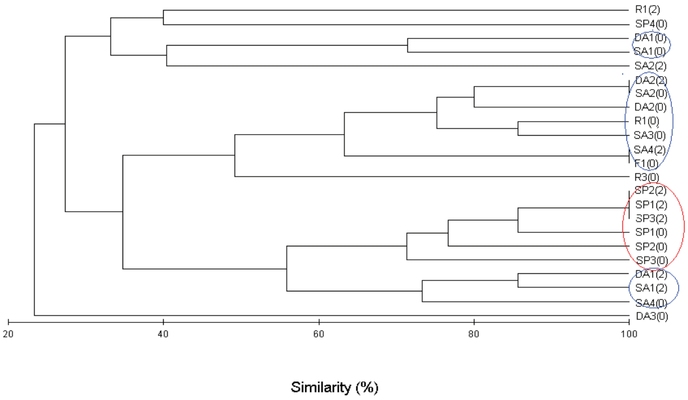


Figure 1: Dendrogram illustrating the similarity in species composition at t=0 and the fertilized sub-plots at t=2 in five different mangrove habitats. The results of t=0 and t=2 are shown in one dendrogram to indicate a possible fertilization caused clustering. Between brackets the measurement time at which the samples were collected is indicated. R: *R. mangle*; SP: salt panne; DA: dense *A. germinans*; SA: sparse *A. germinans*; F: forest. The circles indicate branches in the Dendrogram indicting a cluster with a similarity of above 60 percent.

References

Feller, I.C., D.F. Whigham, K.L. McKee and C.E. Lovelock. 2003. Nitrogen limitation of growth and nutrient dynamics in a disturbed mangrove forest, Indian River Lagoon, Florida. Oecologia 134: 405-414.

From the micro- to the macroscale: effects of microbial Fe(III) and sulfate reduction on element fluxes in acidic peatlands

K. Küsel

Limnology Research Group, Institute of Ecology, Friedrich Schiller University Jena, 07745 Jena, Germany.
e-mail: Kirsten.Kuesel@uni-jena.de

Introduction

Since wetlands are considered a major unknown regarding the influence of global climate change on element dynamics, knowledge of processes and conditions controlling the sink and source function of redox processes is crucial. Over more than a century wetlands received sulfate, nitrate and acid impact either from direct atmospheric deposition or from the desorption and release of matter from upland sites (Wieder, 1985). Athough peatlands are known to be significant sources of the green house gas methane, minerotrophic acidic fens can receive nitrate, sulfate and Fe(II) from groundwater flow: Thus, nitrate, Fe(III) and sulfate can be available as alternative electron acceptor for the oxidation of organic matter especially under alternating redox conditions in minerotrophic fens.

Redox processes and microbial populations in fens

Fens located in northern Bavaria receive sulfate and Fe(II) from groundwater flow. Thus, considerable amounts of Fe(III) (up to 18 g kg^{-1} soil) and small amounts of sulfate (up to 300 µM) are available (Paul et al., 2006). Biogeochemical parameters measured in the fen soil solution during 5 years documented that the upper 5 to 10 cm can be exposed to drying and oxygenation. Periodic oxygenation reached a maximum depth of 25 cm in the water saturated fen and was concomitant with relative high concentrations of nitrate and sulfate. The fen soil was permanently anoxic below 30 cm depth with average concentrations of sulfate below 40 µM and maximum concentrations of methane. Anoxic incubation experiments with peat samples from the oxidized surface layer demonstrated high Fe(III)-reducing but negligible sulfate-reducing or methanogenic activities. Reduction of Fe(III) can be accompanied by a release a phosphorous to the soil water leading to an export to adjacent surface waters.
Numbers of Fe(III)-reducing bacteria cultured at pH 5.5 approximated 10^5 to 10^6 cells g (fresh weight soil)$^{-1}$ and did not decrease with soil depth. Detection of sulfate reducers with Terminal-Restriction Fragment Length Polymorphism (T-RFLP) analysis of amplified dissimilatory (bi)sulfite reductase genes (*dsrAB*) separated three subgroups along the depth profile (Schmalenberger et al., 2007). Cloning of *dsrAB* PCR products yielded a total of 84 distinct *dsrAB* restriction patterns (genotypes). Most of the genotypes were unique. Differences in the sulfate-reducing community structures suggested that sulfate reducers present in the upper fen soil have to tolerate O_2 and even drying, whereas sulfate reducers present in deep anoxic zones may act as synthrophic fermentors in cooperation with H_2-utilizing methanogens. Under short term conditions, fixation of sulfur as inorganic reduced sulfur seems to play a major role in peatlands. However, this pool appears to be rapidly oxidized, and sulfate is exported to adjacent ecosystems during heavy rainfall. The majority of reduced sulfur, which is stored as organic sulfur, seems to be more stable.

Conclusions

Thus, despite ongoing Fe(III)- and sulfate-reducing activities, these peatlands can not be considered as effective sinks for sulfur. Drying or oxygenation of the top soil favors Fe(III)- or sulfate-reducing activities due to a renewal of the electron acceptor pools. Enhanced drying events caused by climate change might accelerate not only carbon mineralization processes but also further inhibit methanogenesis. An increase of extreme meterological conditions can turn peatlands temporarily to a source for carbon which might effetc the global carbon carbon budget. In addition, rewetting of drained Fe(III)-rich peatlands can enhance eutrophication of adjacent surface waters.

References

Paul, S., Küsel, K., & Alewell, C. (2006). Reduction processes in forest wetlands: tracking down heterogeneity of source/sink functions with a combination of methods. Soil Biology & Biochemistry, **38**: 1028-1039.

Schmalenberger, A., Drake, H. L. & Küsel, K. (2007). High unique diversity of sulfate-reducing bacteria in a depth gradient in an acidic fen, Environmental Microbiology (in press)

Wieder, R.K. (1985). Peat and water chemistry at Big Run Bog, a peatland in the Appalachian mountains of West Virginia, USA. Biogeochemistry **1**, 277-302.

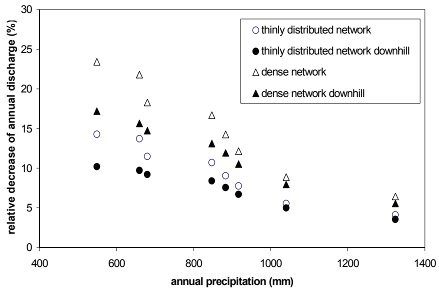
Spatio dynamic modelling of the hydrological processes to investigate the functionality of nutrient-retaining landscape features

P. Merot, P. Durand

INRA, Agrocampus Rennes, UMR1069, SAS. F-35000 Rennes, France.
e-mail: philippe.merot@rennes.inra.fr

It is largely recognised that the functionality of Nutrient-Retaining landscape Features (NRLFs) depends both on the local hydrological processes and on the hydrological setting of the catchment (Haycock et al. 1997). Due to the complex nature of a catchment, understanding the NRLF impact at the catchment scale, and accounting for these structures in the management of water resources call for the use of spatio-dynamic hydrological modelling.

The purpose of this paper is threefold: First, a generic scheme of the buffer functions is given to understand the multiple ways NRLF can act as a buffer (Viaud et al. 2004); then, the major part of the paper proposes a review of the NRLF hydrological modelling at the catchment scale; lastly we present some critical issues that modelling is facing.
Two types of modelling are distinguished, status driven and structure driven; the status driven models do not consider separately the buffering landscape structures, but are based on a continuous representation of the spatial distribution of the soil and subsoil water content in the catchment. MODFLOW (Mc Donald and Harbaugh 1988) or TOPMODEL (Beven and Kirkby 1979) are such models that allow to include the impact of some natural buffer zones such as riparian wetlands without any a priori description or conceptualisation on buffer structures. By contrast, in structure driven modelling, the natural or the man-made landscape structures are considered as distinct entities. Depending of the objective, these models are used either as heuristic models (Weller et al. 1998), generally applied to crudely described catchments, testing quite specific assumptions on some buffering structure (Beaujouan et al. 2001), or as scenario based modelling, taking into account complex interactions (Figure 1, Viaud et al. 2005). The machine learning approach for evaluating the impact of land use and management practices is an original approach based on a high-level scenario language.



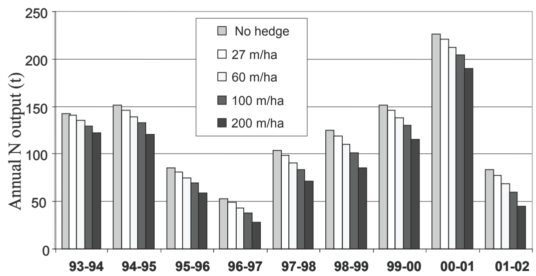


Figure 1 : Simulations of the effect of different hedge network density and distribution on annual discharge (left) and annual N flux (right) at the outlet of a Brittany rural catchment.

The current development of virtual landscapes for modelling is the more recent attempt to capture the complexity of the landscape, and specifically nutrient-retaining landscape features. They allow controlled virtual experiments based on environmental, economic or social scenarios. These different models and ways to apply them are explored (Ruiz et al. 2004, Weiler and McDonnell 2004).
Whatever the model, modellers of NRLFs hydrology are facing difficult issues. The first one is the question of the topology of the water pathways and their connectivity with the NRLFs. The second one is the question of the spatial scale: to what extent does the NRLF affect the catchment as a whole? Does it depend on the size –or order- of the stream? The last point - and from a hydrological perspective it may be the most important-, is the question of what we

can call the hydrological time (figure 2). Is the model able to take into account the non-linearity and the thresholds of the NRLF functioning? Is the model able to integrate a topology and connectivity that is variable in time? Is the model of NRLF able to simulate the different temporal phases of the hydrological system, during which the NRLF functioning is really different, namely the dry period, the flow resume period, the wet period, and the crisis periods (periods of rainfall-runoff event)?

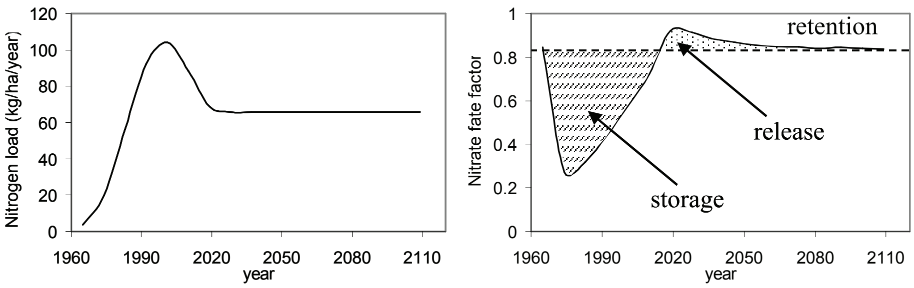


Figure 2 Simulated time series of nitrogen input (left) and nitrogen fate factor (output/input, right) for a high rainfall, high nitrogen input catchment. (Basset-Mens et al. 2006)

Finally, a large set of models is available to simulate the functionality of NRLFs. They vary widely in complexity and have been applied for a diversity of objectives, from a heuristic to a management perspective. They confirm that the hydrological processes at the catchment scale are key factors for the functioning of retaining nutrient landscape features. However, there is still a strong need for experimental studies and observations in the real world to improve and validate these models.

References

Basset-Mens, C., L. Anibar, P. Durand, and H. M. G. van der Werf. (2006) Spatialised fate factors for nitrate in catchments: Modelling approach and implication for LCA results. *Science of the Total Environment* **367**:367-382.

Beaujouan, V., P. Durand, and L. Ruiz. (2001) Modelling the effect of the spatial distribution of agricultural practices on nitrogen fluxes in rural catchments. *Ecological Modelling* **137**:93–105.

Beven, K., and M. J. Kirkby. (1979) A physically based variable contributing area model of basin hydrology. *Hydrological Sciences Bulletin* **24**:43-69.

Haycock, N. E., T. P. Burt, K. W. T. Goulding, and G. Pinay. (1997) *Buffer zones: their processes and potential in water protection.* Quest Environmental, Hardfordshire UK.

Mc Donald, M. G., and A. W. Harbaugh. (1988) *A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model.* U.S. Geological Survey.

Ruiz, L., P. Aurousseau, B. J., V. Beaujouan, P. Cellier, P. Curmi, P. Durand, C. Gascuel-Odoux, P. Leterme, J. L. Peyraud, C. Thenail, and C. Walter. (2004) Conception de bassins versants virtuels : vers un outil pour l'étude de l'influence de l'organisation spatiale de l'activité agricole et du milieu physique sur les flux d'azote dans les bassins versants. pp 337-354 *in* P. Monestiez, S. Lardon, and B. Seguin, editors. *Organisation spatiale des activités agricoles et processus environnementaux*. INRA Editions.

Viaud, V., P. Durand, P. Merot, E. Sauboua, and Z. Saadi. (2005) Modeling the impact of the spatial structure of a hedge network on the hydrology of a small catchment in a temperate climate. *Agricultural Water Management* **74**:135-163.

Viaud, V., P. Merot, and J. Baudry. (2004) Hydrochemical buffer assessment in agricultural landscapes: from local to catchment scale. *Environmental Management* **34**:559-573.

Weiler, M., and J. McDonnell. (2004) Virtual experiments: a new approach for improving process conceptualization in hillslope hydrology. *Journal of Hydrology* **285**:3-18.

Weller, D. E., T. E. Jordan, and D. L. Correll. (1998) Heuristic models for material discharge from landscapes with riparian buffers. *Ecological Applications* **8**:1156-1169.

The Operational Landscape Unit concept as a guidance for landscape restoration and water quality enhancement

J.T.A. Verhoeven, M.B. Soons

Landscape Ecology, Institute of Environmental Biology, Utrecht University, P.O. Box 80084, 3508 TB Utrecht, The Netherlands.
e-mail: j.t.a.verhoeven@bio.uu.nl

Introduction

The scope of nature conservation has widened to include spatial considerations in nature conservation strategies, aimed first predominantly at preservation of large areas and later also at preservation of networks of habitat areas, the 'ecological networks'. The need for this approach to nature conservation in densely populated regions arises from the increasing degree of landscape fragmentation. This fragmentation has been shown to have dramatic consequences for biodiversity and for environmental quality. In this paper, we want to emphasize the importance of lateral connections and their pivotal role in maintaining biodiversity and ecological functioning at a much higher level than would be possible for unlinked ecosystems within the same landscape. We propose the Operational Landscape Unit concept, which combines biotic and hydrological connectivity to analyze the best options for restoration of wetland ecosystem functioning and plant biodiversity in fragmented landscapes.

Consequences of landscape fragmentation

A first consequence of landscape fragmentation is the transformation of large natural landscape patches connected by wide, continuous corridors into a large number of small patches, many of which are not connected to each other (Soons et al. 2005). This development results in a loss of area because of habitat destruction, e.g. for housing or agriculture, and a decrease in connectivity because of destruction of corridors or the construction of barriers such as roads. As predicted by the ecological theory on island biogeography, the fragmentation of the landscape into small patches leads to high extinction and a high degree of isolation, resulting in low rates of colonization and a loss of species richness from patches and the landscape as a whole (Hanski 2005).

A second consequence of fragmentation is the drastic change in the hydrological functioning of catchments. Measures to drain agricultural land have led to lower groundwater tables, loss of groundwater discharge in (semi-)natural landscape patches, straightening of lower-order streams, dampening of stream water level fluctuations, loss of floodplain habitat, loss of meandering as a natural stream habitat process and a deterioration of stream water quality (Brierley & Stankoviansky 2002). These changes have led to drastic changes in ecosystem functioning, often reducing (the diversity of) habitat site conditions all across the landscape, even in protected reserves with appropriate internal management. It is evident that landscape-scale modifications, including hydrological measures and land amelioration such as levelling of microtopography, have resulted in additional losses of biodiversity, which have probably been just as severe as those caused by fragmentation per se.

Operational Landscape Units

In fragmented landscapes, the lack of colonization or movement of organisms or particles between sites may reversed through the restoration of connectivity by corridors or by water flow. Two types of spatial processes (biological and hydrologic), both mostly lateral landscape flows parallel to the earth surface are important. In population biology, the dispersal of organisms is important and dispersal processes operates at a variety scales, depending on life history strategies (i.e, dispersal mechanisms) of individual species. At the landscape scale, the larger the number of target species, the larger the variety of dispersal mechanisms and dispersal capabilities, and the larger the variety of relevant spatial scales. In wetlands, hydrological processes shape the diversity of habitats and linkages between wetlands typically operate at a larger scale than the scale of a single site as materials (i.e., sediments, nutrients) move in ground and surface water. Groundwater flows have a lateral component and flows in the landscape from groundwater recharge areas at higher elevations towards groundwater discharge areas at lower elevations may be important. In many stream catchments, hydrology has been drastically altered. The main goal was often to quickly drain water from precipitation from the major part of the catchment and bypass the normal routes through groundwater recharge and (sub)surface runoff.

We define Operational Landscape Units as '*combinations of landscape patches with their hydrogeological and biotic connections*'. An example of an OLU in a stream valley is (from high to low elevation) a combination of flat or sloping patches with groundwater recharge, the patches with groundwater discharge to which they are connected through local groundwater flow or overland run-off, the floodplain or stream bank patches and the stream itself (Fig.1). OLU's in stream catchments are characterized by connections through surface water flow in the stream or through regional groundwater flow. An important notion is that the connections that characterize OLU's are often disrupted in fragmented landscapes: groundwater recharge areas are being drained so that water short-circuits to the stream and groundwater discharge is strongly diminished; streams have been straightened to maximize hydraulic flow rates; floodplains have strongly decreased because of flood control schemes by building dikes or water level control structures. This has also a direct bearing on water-dispersed organisms, and, through effects on fauna dispersal, on animal-dispersed organisms. The OLU concept can be a valuable tool to analyze the scales on which key landscape connections for species richness operate, and to define the best strategy for restoration and conservation of biological diversity in stream catchments. The OLU concept has been tested in the Dinkel catchment in East Twente, The Netherlands, in the process of developing nature restoration targets, water management policies and land use changes at a regional scale.

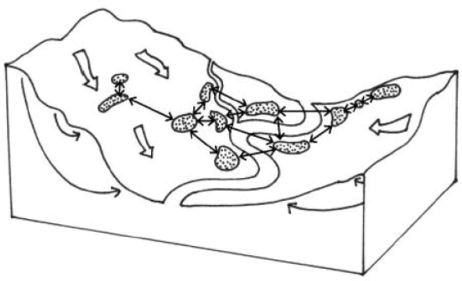


Figure 1. The OLU concept. Lateral connections in a stream corridor: hydrological flowpaths and dispersal of organisms and diaspores among (semi-)natural landscape patches.

References

Brierley, G., & Stankoviansky, M. (2002) Geomorphic responses to land use change: Lessons from different landscape settings. *Earth Surface Processes and Landforms* 27:339-341.

Hanski, I. (2005) Landscape fragmentation, biodiversity loss and the societal response - The longterm consequences of our use of natural resources may be surprising and unpleasant. *Embo Reports* 6:388-392.

Soons, M. B., Messelink, J. H., Jongejans, E. & Heil, G. W. (2005) Habitat fragmentation reduces grassland connectivity for both short-distance and long-distance wind-dispersed forbs. *Journal of Ecology* 93:1214-1225.

Scaling up denitrification in heterogeneous landscapes

G. Pinay[1], T.P. Burt[2]

[1]CEFE – CNRS, 1919 route de Mende, F-34293 Montpellier cedex – France;
e-mail: Gilles.pinay@cefe.cnrs.fr
[2] Department of geography, University of Durham, Sciences Laboratories, South Road, Durham, DH1 3LE, UK

Biogeochemical hot spots are areas, or patches, that exhibit disproportionately high reaction rates relative to the surrounding area, or matrix (McClain et al. 2003). Hot spots can be delineated at spatial scales ranging from molecular to global, while hot moments can be delineated at time scales ranging from instants to millennia. As with all other forms of heterogeneity, the identification of hot spots and moments depends on the system of interest or the chosen scale for a study. As the extent under consideration increases, new, 'hotter' hot spots may be encountered from the surrounding area. With increases in grain, hot spots might also disappear as they fall below the resolution of the study. Here, we describe how hot spots change with scale for the process of denitrification

Denitrification is the conversion of NO_3^- to gaseous N (N_2O or N_2). It is performed by particular groups of ubiquitous heterotrophic bacteria that have the ability to use NO_3^- as an electron acceptor during anaerobic respiration. The factors controlling denitrification rates are C and NO_3^- supply and anoxia. Appropriate conditions for the formation of denitrification hot spots are found at oxic-anoxic interfaces crossed by a continual water flow; oxic conditions are needed for NO_3^- production by nitrification, denitrification requires anoxic conditions, and water serves as the transport medium. The underlying physiological basis for denitrification remains the same irrespective of the scale of analysis. However, since direct measurement of denitrification is impossible at larger scales, different metrics can be used as indices of the denitrification occurring. In the following paragraphs, we review the different metrics used to assess denitrification hot spots across spatial scales ranging from soil profiles to large basins.

At the scale of a soil profile (1-10 m), denitrification hot spots exist around patches of labile organic matter, e.g., plant detritus, manure, at the anaerobic center of large soil aggregates or in earthworm casts. Reactants are transported into these hot spots by percolating soil water or ground water. Note that in the unsaturated zone, hydrological flowpaths will be intermittent, with strong seasonal variations. Thus, denitrification hot spots within unsaturated soil profiles will be active during hot moments.

At the catena scale (10-100 m), the distribution of anoxic zones is controlled by differences in soil texture and natural drainage that affect the duration and timing of soil saturation and the accumulation of organic matter. These factors also indirectly influence carbon and nitrate availability through their influence on plant community type and microbial activity.

At the scale of the upland to stream toposequence (circa 100-1000 m) the interface between the upland and riparian zones is typically a hot spot for denitrification. Denitrification is triggered by allochthonous NO_3^- input from uplands along ground water flow paths. As mentioned earlier, in most cases the hot spots for denitrification are a only few metres wide at the upland margin of these features, though they can occur at the riverbed-wetland interface or within the wetland or riparian zone, depending on the location of groundwater flow paths and seasonal variations. At the same scale, hot spots of denitrification have been identified within rivers in association with hyporheic zones, regions of saturated sediments and subsurface water beneath and lateral to streams that are hydrologically connected to surface and ground waters. Instream denitrification is most prevalent at downwelling sites, i.e. locations of surface water infiltration into hyporheic zones, where anoxic, organic-carbon-rich subsurface zones receive downwelling NO_3^- from surface water.

At the scale of 10 to 100 km, the width of the riparian zone is no longer resolvable and must be replaced by the length of contact between upland and wetland, where NO_3^- from upland sources is delivered to anoxic sites.
At very large scales (100 km and above), the amount of N lost due to denitrification is related to the percentage of land covered by wetlands.

References

McClain, M.E., Boyer, E.W., Dent, C.L., Gergel, S.E., Grimm, N.B., Groffman, P.M., Hart, S.C., Harvey, J.W., Johnston, C.A., Mayorga, E., McDowell, W.H., Pinay, G. 2003. Biogeochemical hot spots and hot moments at the interface of terrestrial and aquatic ecosystems. *Ecosystems*, **6**: 301-312.

Hotspots for denitrification and nitrous oxide emission in riparian zones

M.M. Hefting, R.N. van den Heuvel

Landscape Ecology, Institute of Environmental Biology, Science Faculty, Utrecht University, e-mail: M.M.Hefting@bio.uu.nl

The hot spot approach

Riparian wetlands bordering lower order streams and river floodplains have a high potential to remove nitrogen from through flowing water. Denitrification is the dominant process in the effective removal of nitrate by conversion of nitrate to nitrous oxide and nitrogen gas. However, the denitrification process is extremely variable in space and time which complicates the extrapolation of process rates to larger surfaces and longer time scales. A hot spot and hot moment approach focusing on patches and periods where the process is operating at disproportionately high rates might be of major importance in quantifying process rates in many ecosystems (McClain *et al.,*2003).

Water as a master variable

Generally, denitrification hot spots occur where hydrologic flow paths carry nitrate into a substrate containing easily degradable carbon. This indicates the importance of water flow in determining the process rates involved with denitrification. The presence of water also causes anoxia and affects the diffusion of denitrification end products. Many studies on driving factors for denitrification showed with multivariate techniques that water-related factors such as water level, water filled pore space or soil moisture content are the most important predictors of denitrification rate, while nitrate concentrations are second in importance (Machefert and Dise, 2004; Pinay et al.,2006; Hefting et al.,2003). Hence, water availability is the master variable determining the height of the potential process rates of denitrification and nitrous oxide emission. Nitrate and carbon availability, temperature and pH determine the actual rates.

A lot of data on denitrification and nitrous oxide emission from riparian zones are available nowadays. It is, however, still challenging to extrapolate these data to the catchment scale at which water resources management operates. In this presentation we focus on the role of water in controlling denitrification and nitrous oxide emissions at multiple scales and investigate whether hydrological models can be used to scale up process rates to the catchment scale.

Water related parameters at different scales

At the landscape scale riparian zones are hotspots of nitrogen transformation and removal. The nitrate removal capacity of these zones is strongly related to catchment characteristics which influence hydrology such as differences in lithology and topography (Vidon and Hill, 2004, Burt *et al.,*2002).

An analysis of a large data set on nitrogen transformation rates in riparian zones and floodplains measured across continental gradients of climatic, hydrological and land use conditions showed that hydrology, rather than climate and land use, tended to be the most important control of the nitrogen transformation processes. Flat riparian zones with their water table close to the soil surface were more effective at removing nitrogen compounds than drier sites where water tables were below 30 cm (Burt *et al.,*2002, Sabater *et al.,*2003, Hefting *et al.,*2004). In another study performed in a range of European river floodplains the most important control variable of denitrification appeared to be soil moisture, which was determined by flooding and precipitation events (Pinay *et al.,*2006)

Within riparian zones hydrological flow paths are important carriers of nitrate into the biologically active riparian system. The actual pathway of water flow through riparian substrates is often complex and creates spatial differences in residence time and material encountered. Hence the riparian zone contains a mosaic of suitable and unsuitable flow paths for nitrate removal with distinct spatial and temporal patterns of denitrification and nitrous oxide emissions (Hefting *et al.,*2006).
Even within active patches of denitrification and nitrous oxide emission within flow paths, there is substantial spatial and temporal variability. Nunan *et al.,*(2003) identified water and nutrient movement through soil columns as a possible structuring agent for short scale (<1 mm) spatial patterns. At this scale the percentage of water filled pores is an important variable showing an exponential relationship with denitrification rates above a threshold of 60-80%. This variable proved to be robust and comparable across a range of soil texture classes and ecosystems (Machefert and Dise, 2004).

References

Burt, T.P., Pinay, G.,Matheson, F.E., Haycock, N.E., Butturini, A., Clement, J.C., Danielescu, S., Dowrick, D.J., Hefting, M.M., Hillbricht-Ilkowska, A. & Maitre, V. (2002). Water table fluctuations in a riparian zone: comparative results from a pan-European experiment. *Journal of Hydrology* **265:** 129-148.

Hefting M.M., Bobbink R. & Caluwe, H. (2003). Nitrous oxide emission and denitrification in chronically nitrate-loaded riparian buffer zones *Journal of Environmental Quality* **32:**1194-1203.

Hefting M.M., Bobbink R. & Janssens M.P. (2006). Spatial Variation in Denitrification and N_2O emission in relation to nitrate removal Efficiency in a N-Stressed Riparian Buffer Zone. *Ecosystems,* **9:** 550-563.

Hefting, M.M., Clement, J.C., Dowrick, D., Cosandrey, A.C., Bernal,S.,Cimpian, C., Tatur, A., Burt,T.P. & Pinay, G. (2004). Water table controls on soil nitrogen cycling in riparian wetlands alomg a European climatic gradient. *Biogeochemistry* **67:**113-134.

Machefert, S.E. & Dise, N.B. (**2004)**. Hydrological controls on denitrification in riparian ecosystems. *Hydrology and earth System Sciences,* **8:** 686-694.

McClain, M.E., Boyer, E.W., Dent, C.L., Gergel, S.E., Grimm, N.B., Groffman, P.M., Hart, S.C., Harvey, J.W., Johnston, C.A., Mayorga, E., McDowell, W.H. & Pinay, G. (**2003)**. Biogeochemical hot spots and hot moments at the interface of terrestrial and aquatic ecosystems. *Ecosystems*, **6:** 301-312.

Nunan, N., Wu,K., Young, I.M., Crawford, J.W., Ritz, K., Spatial distribution of bacterial communities and their relationships with the micro-architecture of soil. *FEMS microbiology ecology* **44:**203-215.

Pinay,G., Gumiero, B., Tabacchi, E., Gimnez, O., Tabacchi-Planty, A.M., Hefting, M.M., Burt, T., Black, V.A., Nilsson, C., Iordache, V., Bureau, F., Vought, L., Petts, G.E. & Decamps, H. (2007) Patterns of denitrification rates in European alluvial soils under various hydrological regimes. *Freshwater Biology,* **5:** 252-266.

Sabater, S., Butturini, A., Clement, J.C., Burt, T., Dowrick, D., Hefting, M.M., Maitre, V., Pinay, G., Postolache, C., Rzepecki, M. & Sabater, F. 2003 Nitrogen removal by riparian buffers along a European climatic gradient: patterns and factors of variation. *Ecosystems* **6:**20-30.

Vidon, P. & Hill, A.R. (2004). Denitrification and patterns of electron donors and acceptors in eight riparian zones with contrasting hydrogeology. *Biogeochemistry* **71:**259-283.

Learning from the past: the impact of human-induced changes to landscape (dis)connectivity on biophysical fluxes

G. Brierley

School of Geography, Geology and Environmental Science, University of Auckland, NZ.
email: g.brierley@auckland.ac.nz

In a sense, swamps and wetlands such as discontinuous watercourses, trapped tributary fills, and backswamps at floodplain margins, are topographic expressions of landscape disconnectivity. These low relief landforms accumulate and store materials (sediments, nutrients, contaminants, etc), acting as environmental filters that influence water transfer and water quality. In many instances, swamps and wetlands are found in cut-and-fill landscapes that are characterised by long periods of sediment accumulation interspersed by short intervals of incision, channel expansion and 'release' of materials. Among other names, these landscapes are referred to as *arroyos* (American south-west), *ndongas* (southern Africa), *oued* and *wadis* (North Africa/Middle east), chains of ponds, dells and swampy meadows (Australia). Shifts in climate, extreme storms, or exceedance of intrinsic (slope-induced) thresholds may interrupt the 'natural' tendency of these landscapes to accumulate materials over the long term. However, human efforts to 'make dry lands wetter and wet lands drier' have promoted much more consistent and permanent connectivity, disrupting the storage and filtering roles of these landscape elements (Ward, 1989).

Conceptually, swamps and wetlands can be considered as barriers that impede the movement of materials through landscapes (Fryirs et al., in press (a)). Analyses of slope-valley floor, tributary-trunk stream, and channel-floodplain connectivity based on DEMs can be used to map these forms of landscape connectivity (Fryirs et al., in press (b)). However, other sets of resources must be used to place contemporary conditions in context of past environmental relationships. Such insights present a critical basis with which to assess the trajectory of landscape change, and associated implications for environmental health.

In many parts of the colonial world the impacts of human disturbance have been so profound over such a short period of time that the vestiges of former landscape behaviour can be unravelled from historical documents and field evidence. Extensive research of this ilk has been used to unravel the operation of biophysical fluxes in the period since European settlement of Bega Catchment in southeastern Australia (i.e. since 1860; see Brierley et al., 1999; Brierley & Fryirs, 2005; Fryirs & Brierley, 2001, 2005).

Since European settlement, the channel network in Bega Catchment has become longitudinally connected, as discontinuous watercourses that characterised base of escarpment and mid-catchment locations prior to European settlement have been transformed into continuous ephemeral channels. An associated increase in channel capacity along the lowland plain ensures that higher magnitude flows are now retained within the channel. This increase in longitudinal connectivity has increased the rate and efficiency of downstream transfer of flow, sediment, organic matter and other nutrients, decreasing their retention within the system. Base flow contributions from the middle and upper catchment have been reduced. Deposition of extensive sand sheets in downstream reaches has induced a greater proportion of subsurface flow, affecting the viability of backswamps.

Changes to channel form have also altered lateral exchanges of water, sediment, organic matter and nutrients between the channel and its floodplain. Deeply incised channels that cut through former swamps at the base of the escarpment have severed lateral linkages, inhibiting inundation of perched valley floors. In contrast, deposition of coarse sands atop the formerly fine-grained floodplain of the lowland plain has partially infilled backswamps, inhibiting the capacity of this area to act as a nutrient sink.

The development of a continuous channel network, associated changes to channel-floodplain relationships, and the highly degraded riparian vegetation cover, have altered vertical water exchange and depth of the water table along river courses throughout Bega catchment. Incision of swamp deposits at the base of the escarpment has lowered the water table. In contrast, aggradation in lowland areas has raised the water table. These changes, along with the homogeneity of bed material size (contrasting with the fine-grained swamps, bedrock pools and sand bars of the pre-disturbance channel), have modified the hydrologic regime, hydraulic diversity and hyporheic zone functionality, impacting profoundly on the ecological condition of these rivers (Chessman et al., 2006).

Geomorphic changes have compromised the potential for rivers in Bega catchment to regain structural and functional attributes that characterized their pre-European settlement condition. These insights have been used to predict realistic target conditions for river rehabilitation, using a conservation-first catchment-scale prioritisation framework to protect remnant swamps and develop rehabilitation strategies that extend from areas that are in good condition (Fryirs and Brierley, 2005).

Three primary implications of this work are noted:

1. It is contended that we seldom appreciate the extent to which discontinuous watercourses in lower order basins have been modified by human disturbance, in a wide range of environmental settings.
2. Changes to landscape configuration provide a biophysical template with which to appraise geoecological and water quality considerations. As swamps and wetlands are key components of landscape (dis)connectivity, changes to their distribution over time exerts a critical influence upon hydrologic regimes and water quality.
3. Fine-resolution mapping using DEMs presents a remarkable opportunity to apply conceptual frameworks to model catchment-scale changes to landscape connectivity, and associated biophysical responses, over time (e.g. Fryirs et al., in press (b)).

References

Brierley, G.J., Cohen, T, Fryirs, K. & Brooks, A. (1999) Post-European changes to the fluvial geomorphology of Bega catchment, Australia: implications for river ecology. *Freshwater Biology* **41**, 1-10.

Brierley, G.J. & Fryirs, K.A. (2005) *Geomorphology and River Management: Applications of the River Styles framework*. Blackwell Science, Oxford, UK. 398pp.

Chessman, B.C., Fryirs, K.A. & Brierley, G.J. (2006) Linking geomorphic character, behaviour and condition to fluvial biodiversity: implications for river rehabilitation. *Aquatic Conservation: Marine and Freshwater Ecosystems* **16**, 267-288

Fryirs, K. & Brierley, G.J. (2001) Variability in sediment delivery and storage along river courses in Bega catchment, NSW, Australia: Implications for geomorphic river recovery. *Geomorphology* **38**, 237-265.

Fryirs, K. & Brierley, G.J. (2005) Practical application of the River Styles® framework as a tool for catchment-wide river management: A case study from Bega catchment, New South Wales, Australia. Retrieved on 28.11.06, from www.riverstyles.com.

Fryirs, K., Brierley, G.J., Preston, N. and Kasai, M. (In press (a)) Buffers, barriers and blankets: The (Dis)continuity of catchment-scale sedimentary cascades. *Catena*.

Fryirs, K. Brierley, G.J., Preston, N. & Spencer, J. (In press (b)) Catchment-scale (dis)connectivity in sediment flux in the Upper Hunter catchment, New South Wales, Australia. *Geomorphology*.

Ward, J.V. (1989) The four-dimensional nature of lotic ecosystems. *Journal of the North American Benthological Society* **8**, 2-8.

4.3 Open Session 17: Ecohydrology, rivers and wetlands

Quantifying lost opportunities in conservation: an evaluation of current and proposed scenarios to protect the Pantanal wetland in Brazil.

R. Lourival[1,2], H. McCallum[2], G.Grigg [2] , C.Arcangelo[3], R. Machado [3], H.Possingham [2]

[1] The Capes Foundation – Ministry of Education – Brasília - Brazil
[2] University of Queensland - Goddard building – St. Lucia Campus. Brisbane – QLD – 4072 – Australia – r.lourival@sols.uq.edu.au
[3] Conservation International – Brasília - Brazil

Introduction

The Pantanal is the world's largest contiguous freshwater wetland. It is shared by Brazil, Bolivia and Paraguay. Designated by the Brazilian constitution as a National Heritage and considered by the RAMSAR convention for wetland conservation a key site for wetland protection, it combines healthy populations of endangered species with the greatest wildlife densities of the Neotropics. Whilst the majority of threats to the Pantanal are generated externally (e.g. siltation, pollution and water diversion), there are many internally generated threats, such as expansion of cultivated pasture, selective logging and damage from invasive species (Mittermeier 1990), all connected in some way to global issues (Harris, Tomas et al. 2005).

There is an array of conservation scenarios proposed to protect the Pantanal in all three countries. We evaluate in this article the efforts on the Brazilian side, exemplified by: (1) the existing protected areas, (2) the core areas proposed by the Cerrado & Pantanal-Priority Setting Workshop CP-PSW, (3) the Pantanal Biosphere Reserve and (4) the core areas added to corridors, recommended by the CP-PSW, (BRASIL 1999). Our primary aim is to evaluate the complementarity and compare the efficiency of these conservation scenarios in achieving the protection of its physiognomies.

We use 17 classes of vegetation as appropriate surrogates for regional biodiversity (Da Silva, Mauro et al. 2000). We tested each surrogate's representation for each conservation scenario at three target levels; 10%, 20% and 50% achievement (Pressey and Taffs 2001) using irreplaceability scores generated by the conservation planning software MARXAN (Ball and Possingham 2000).

Results and Discussion

We found that large fractions of the area of each conservation scenario considered are not needed to meet targets, while important planning units are missing from them, and we use this metric to determine and to compare *lost opportunities* under each scenario (Figure 1).

We conclude that none of the scenarios were simultaneously comprehensive and efficient in representing the vegetation classes. Although scenario (4) was able to represent all vegetation classes at 10% and 20% targets; it comprised 50% of all planning units, making it the least efficient of all scenarios.

In summary, neither the existing Pantanal reserve system nor any the proposed conservation scenarios guarantees efficient and comprehensive protection of the vegetation classes and, therefore, none is effective for safeguarding regional biodiversity.

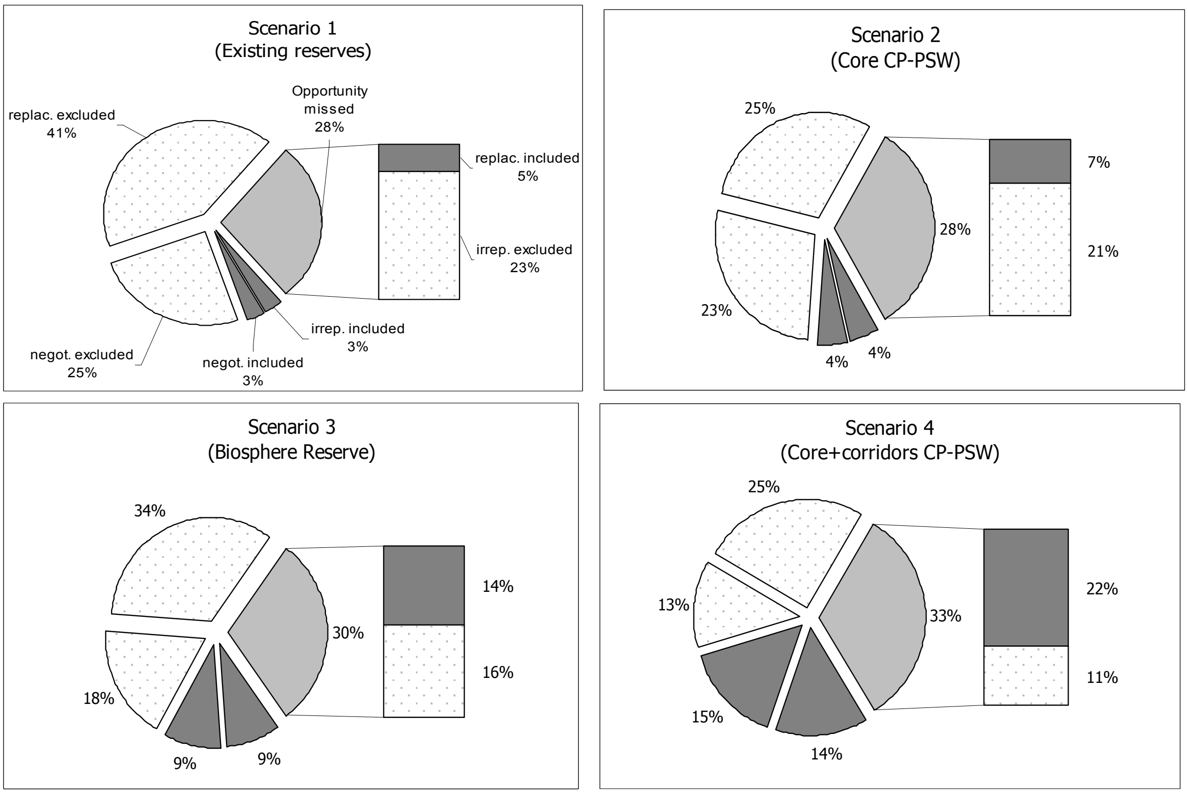


Figure 1 – Opportunities lost by each conservation scenario in the Pantanal, represented by the percentage of irreplaceable planning units excluded by scenario and replaceable PU included in each scenario, according to their selection frequency in 10000 runs of MARXAN-CLUZ.

References

Ball, I. R. and H. P. Possingham (2000). Marxan v1.8.6 Marine Reserve Design; using Spatially Explicit Annealing.

BRASIL (1999). Ações Prioritárias para a Conservação da Biodiversidade do Cerrado e Pantanal. Brasília, PROBIO**:** 27p.

Da Silva, M. P., R. Mauro, et al. (2000). "Distribuição e quantificação de classes de vegetação do Pantanal através de levantamento aéreo." Revista Brasileira de Botânica **23**(2): 143-152.

Harris, M. B., W. Tomas, et al. (2005). "Safeguarding the Pantanal wetlands: Threats and conservation initiatives." Conservation Biology **19**(3): 714-720.

Mittermeier, R. A. C., I.G.; Pádua, M.T.J. and Blanck J. (1990). "Conservation in the Pantanal of Brazil." Oryx **2**(24): 103-112.

Pressey, R. L. and K. H. Taffs (2001). "Scheduling conservation action in production landscapes: priority areas in western New South Wales defined by irreplaceability and vulnerability to vegetation loss." Biological Conservation **100**(3): 355-376.

The relationship between floodplain sedimentation and the succession of rare riverine grasslands in the Netherlands; implications for conservation strategies

H.P. Wolfert, G.J. Maas, B. Makaske, P.W.F.M. Hommel, B.S.J. Nijhof

Alterra, Wageningen University and Research Centre, P.O. Box 47, 6700 AA Wageningen, the Netherlands,
e-mail: henk.wolfert@wur.nl

Introduction

Medicagini-Avenetum occurs on relatively high sandy ridges on embanked floodplains in the Netherlands. The rare riverine grassland type Medicagini-Avenetum, which is reported to have occurred more extensively in the past, is generally appreciated because of its abundant colourful flowers in spring. Nowadays, remaining patches of Medicagini-Avenetum seem to degrade slowly, despite local conservation measures. This study addresses the prerequisites for development of Medicagini-Avenetum, and an appropriate conservation strategy.

Methods

In our research (Maas et al., 2003) we investigated the geomorphological processes leading to suitable physiotopes for Medicagini-Avenetum. We applied various methods for measuring floodplain sedimentation rates in the field (Maas and Makaske, 2003) and linked these data to soil analyses and vegetation data (Nijhof and Hommel, 2003). Sedimentation on embanked floodplains was measured in three study areas along the rivers Waal and IJssel, in order to investigate its influence on vegetation succession. The amount of sedimentation during the flood season of 2001 was measured using sediment traps (Fig. 1). Grain size analysis was carried out on each of the trapped sediment samples. Average sedimentation rates for the period 1960-2001 were deduced from radiometric properties (137Cs activity) of undisturbed sediment cores. In total 62 vegetation relevées, following the simplified Braun-Blanquet methodology, were made. These were clustered by Twinspan and further ordinated by hand.

Conceptual model

A conceptual model, following from our field research, illustrates the link between fluvial morphodynamics and vegetation succession. Overbank deposition results in natural levees, a physiotope which is favoured by Medicagini-Avenetum (Fig. 1) because of its sandy, nutrient-poor and calcareous soil conditions (Wolfert et al., 2002). Optimal conditions occur when the levees have grown to a height corresponding with an inundation frequency of once every 4 to 5 years. However, with increasing height deposition of calcareous sand will decrease, thus favouring enrichment by nutrients during occasional floodings, and a decline of the vegetation type. Optimum floodplain conditions for Medicagini-Avenetum thus are shown to be the result of a long landform and substrate evolution, and are only a temporary situation. In natural river systems the inevitable degradation of Medicagini-Avenetum at one place is compensated for by the development of new suitable physiotopes elsewhere in the river system.

Conservation strategies

With restriction of natural river dynamics, due to groynes and revetments, this cyclic process has come to an end. Any conservation strategy for Medicagini-Avenetum should aim at (partial) restoration of natural river morphodynamics, or at least should incorporate a floodplain management mimicking basic geomorphological processes. Our work enabled to identify the locations along the river where conservation of existing Medicagini-Avenetum vegetation should deserve priority on the short term, but also raised awareness that we have to prepare sites for future development. Maps are being made to support nature conservation strategies.

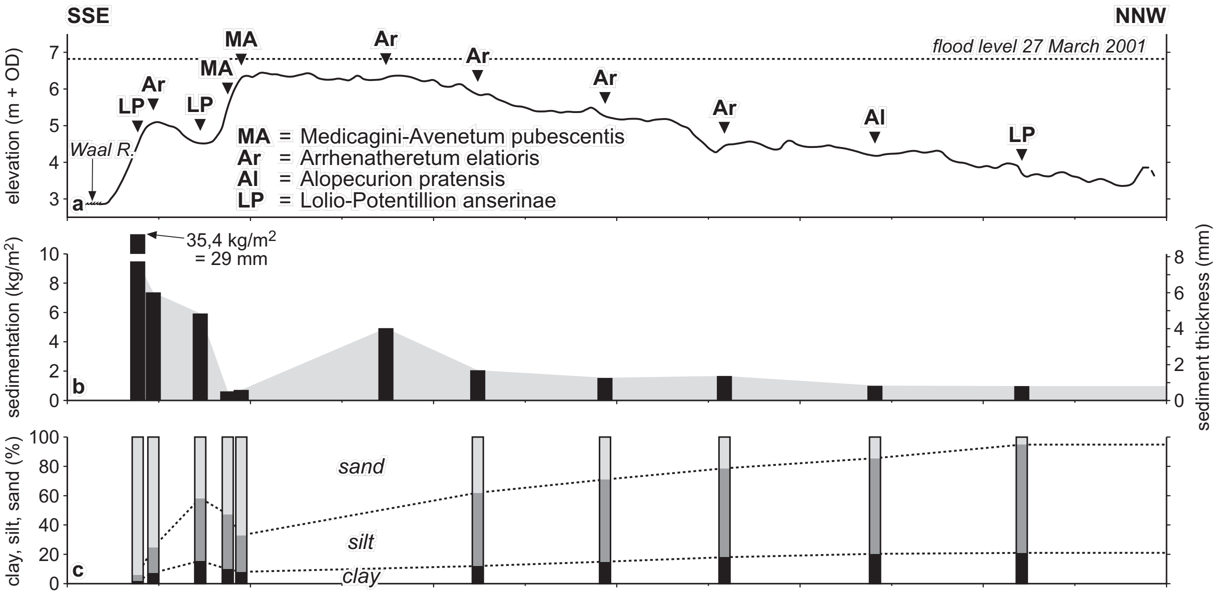


Figure 1. (a) Surface topography in a studied transect in the Rijswaaard study area on the Waal River, the Netherlands. Black triangles indicate locations of sediment traps. Grassland types at locations are also indicated. (b) Sedimentation in the transect during the flood season of 2001 measured with sediment traps. (c) Proportions of sand, silt and clay of the samples from the sediment traps.

References

Maas, G.J., & Makaske, B. (2003). Sedimentation on embanked floodplains of the rivers Waal and IJssel. R.S.E.W. Leuven, A.G. van Os, & P.H. Nienhuis (Eds.). Proceedings NCR-days 2002; current themes in Dutch river research. NCR, Delft, pp. 122-124.

Maas, G.J., Makaske, B., Hommel, P.W.F.M., Nijhof, B.S.J. & Wolfert, H.P. (2003). Verstoring en successie; rivierdynamiek en stroomdalvegetaties in de uiterwaarden van de Rijntakken. Alterra-rapport 759, Alterra, Wageningen.

Nijhof, B.S.J., & Hommel, P.W.F.M. (2003). The relation between the Medicagini-Avenetum vegetation and sedimentation. R.S.E.W. Leuven, A.G. van Os, & P.H. Nienhuis (Eds.). Proceedings NCR-days 2002; current themes in Dutch river research. NCR, Delft, pp. 130-134.

Wolfert, H.P., Hommel, P.W.F.M., Prins, A.H. & Stam, M.H. (2002). The formation of natural levees as a disturbance process significant to the conservation of riverine pastures. Landscape Ecology 17, Supplement 1, pp. 47-57.

The spatial organisation of savanna landscapes within drainage networks

C.J. Cullum

School of Animal, Plant & Environmental Sciences, University of the Witwatersrand,
Private Bag 3, Wits 2050, Johannesburg, South Africa.
e-mail: Cullum@gecko.wits.ac.za

In water-controlled ecosystems, spatial and temporal patterns of soil moisture not only constrain the distribution of vegetation, but are also implicated in system productivity and the provision of habitat (Scholes and Walker, 1993; Rodríguez-Iturbe and Porporato, 2004). Landscape patches defined in terms of their soil moisture regime are therefore likely to reflect fundamental ecosystem units, providing a powerful basis for a land classification that meets diverse management needs.

However, processes controlling the spatial and temporal distribution of water, soil and vegetation are interdependent, such that patch character and behaviour cannot be described, explained or foresighted by considering any of these three factors in isolation (Rodríguez-Iturbe and Porporato, 2004). Furthermore, interactions between water, soil and vegetation are scale-dependent, notoriously variable in time and space and are modified by a wide range of other factors (e.g. humans, fire, herbivory, biological engineering) that also vary across multiple spatial and temporal scales (O'Connell*, et al.*, 2000).

This paper focuses on network geometry as a control on the spatial distribution of Vegetation/ Soil/ Hydrology (VSH) patches in the semi-arid savannas of Kruger National Park, South Africa. Network geometry describes the intensity and direction of flow paths for water, sediment and associated nutrients. Thus, in water-controlled ecosystems, drainage network configuration can be viewed as an organising template for the ecohydrological and biogeochemical processes that determine vegetation patterns and dynamics (Caylor*, et al.*, 2005).

In an idealised river basin, consistent climate and geology produce a consistent fluvial erosion regime that generates fractal patterns of landscape dissection. Geometric relationships between area drained, stream length, stream density, bifurcation ratios, channel gradient and hillslope length elegantly describe basin structure at multiple scales using a limited number of parameters (Hack, 1957; Horton, 1945). For example, just two exponential components, d and h, effectively describe basin morphology and shape (Equations 1 and 2) for an idealised network (Dodds and Rothman, 2000).

$L \propto A^h$	where L = mean length of main stream channel A = mean area of watershed (from any point along a channel)	Equation 1
$L \propto L_l^{\,d}$	where L_l = mean longitudinal diameter of a watershed	Equation 2

Allometric relationships will be calculated for the Sabie river network within Kruger National Park and the spatial variance in exponential components examined at various resolutions. Since the Sabie traverses areas with different geologies and with a West-East rainfall gradient, it is expected that the exponential components should vary significantly within the network. However, patches with relatively similar exponential components should indicate areas with similar climate and geology, reflected in distinct vegetation, soil and hydrological characteristics. Variability within each group of VSH patches defined in this way may be accounted for by local conditions and the history of disturbance.

The ecological implications of contrasting network geometry are explored at catchment and reach scales. At the catchment scale, for example, drainage density is much lower on the relatively permeable basalts in the East than on the less permeable granites in the West of the catchment. On the basalts, water falling on hillslopes tends to infiltrate vertically, with relatively little (or very slow) lateral surface movement of water and sediment. By contrast, higher levels of runoff in the granites generate a higher stream density and more lateral surface movement of water and sediment. Differences in the lateral fluxes of water and sediment into the river channels result in comparatively sandy/gravelly beds in rivers fed from the granites, compared with frequent bedrock or cobbles in streams flowing from and over the basalts. The lateral movement of water and sediments on the granites also favours the formation of soil catenas (Milne, 1935), where fine clays and water-soluble nutrients are progressively leached out and transported downhill over long geological time scales. Distinct bands of soil, parallel to the contours, support different vegetation and in turn favour 0.different fauna. In the basalts, there is far less downslope variation in soil, with large areas of relatively homogenous vegetation. The relatively low stream density in the basalts also means that a smaller percentage area is occupied by channels, tributary junctions and fertile riverine vegetation, with larger distances between rivers.

At the reach scale, the area drained, the length and gradient of hillslopes (which are all associated with network position) are important controls both on the distribution of soil moisture (and hence on vegetation) and on the discharge of water and sediment. Thus, in an idealised catchment, the flow/sediment regime varies with network position to produce the longitudinal patterns of channel morphology that have long been observed in river systems (Schumm, 1977; Petts and Amoros, 1996).

Such examples illustrate the wide-ranging implications of network geometry and hence the potential descriptive and explanatory power of differences in the fractal dimensions of landscapes. Within-catchment variations in geology and climate that lead to breaks in the theoretical river 'continuum' (Vannote*, et al.*, 1980; Minshall*, et al.*, 1983) should be reflected in differences in the exponential components that succinctly describe river network structure. Further research is needed to establish the scales at which such an approach can effectively delineate distinct VSH patches that can inform landscape classifications for conservation management in savannas.

References

Caylor, K. K., Manfreda, S. & Rodriguez-Iturbe, I. (2005) On the coupled geomorphological and ecohydrological organization of river basins *Advances in Water Resources* **28:** 69-86.

Dodds, P. S. & Rothman, D. H. (2000) Scaling, universality and geomorphology *Annual Review of Earth and Planetary Sciences* **28:** 571-610.

Hack, J. T. (1957) Studies of longitudinal stream profiles in Virginia and Maryland *US Geological Survey Professional Paper* 45-97.

Horton, R. E. (1945) Erosional development of streams and their drainage basins; hydrophysical approach to quantitative morphology *Bulletin of the Geological Society of America* **56:**

Milne, G. (1935) Some suggested units for classification and mapping, particularly for East African soils *Soil Research* **4:** 183-198.

Minshall, G. W., Petersen, R. C., Cummins, K. W., Bott, T. L., Sedell, J. R., Cushing, C. E. & Vannote, R. L. (1983) Interbiome Comparison of Stream Ecosystem Dynamics *Ecological Monographs* **53:** 1-25.

O'Connell, D. A., Ryan, P. J., McKenzie, N. J. & Ringrose-Voase, A. J. (2000) Quantitative site and soil descriptors to improve the utility of forest soil surveys *Forest Ecology and Management* **138:** 107-122.

Petts, G. E. & Amoros, C. (1996) *Fluvial hydrosystems*. Chapman & Hall, London.

Rodríguez-Iturbe, I. & Porporato, A. (2004) *Ecohydrology of water-controlled ecosystems: soil moisture and plant dynamics*. Cambridge University Press, Cambridge.

Scholes, R. J. & Walker, B. H. (1993) *An African savanna: synthesis of the Nylsvley study*. Cambridge University Press, Cambridge.

Schumm, S. A. (1977) *The Fluvial System*. Wiley, New York.

Vannote, R. L., Minshall, G. W., Cummins, K. W., Sedell, J. R. & Cushing, C. E. (1980) River Continuum Concept *Canadian Journal of Fisheries and Aquatic Sciences* **37:** 130-137.

Influences of changing scale of modelling land use on simulating hydrological components in watershed land use planning assessments

Y.P. Lin [1], P.J. Wu[1], N.M. Hong[2]

[1]Department of Bioenvironmental Systems Engineering, National Taiwan University, No.1 Sec. 4 Roosevelt Rd. Taipei 106 Taiwan.
e-mail: yplin@ntu.edu.tw
[2] Department of Environmental Resources Management, The Overseas Chinese Institute of Technology, No. 100, Chiao Kwang Rd., Taichung 407, Taiwan

Introduction

Land-use changes can influence hydrological processes including infiltration, groundwater recharge, base flow and runoff. The dynamic of these hydrological processes even influence most of the abiotic and biotic processes in a watershed. Integrated land-use and hydrological simulation models are useful to evaluating watershed land-use planning strategies. However, scale can influence the measurement and quantitative description of land-use patterns. Therefore, the scale effects of simulating land-use on modelling hydrological components are important to impact analyses of land-use changes on hydrology for assessing watershed planning strategies.

Method

<u>Study area and data</u>

The Wu-Tu watershed is located in east of Keelung River Basin in the northern Taiwan. This watershed was urbanized by extensions of Taipei and Keelung Cities. Following land-use modelling in Lin *et. al* (2006), the driving factors were demography, social, infrastructure, geomorphology and soil-related variables, including altitude, slope, distance to river, , distance to major roads, distance to built-up area, distance to urban planning areas, soil erosion coefficient, soil drainage and population density for land-use modelling. Data for land-use and driving factors were generated and digitized by the Soil and Water Conservation Bureau using 1:5000 aerial photographs taken in 1999. Grain size in maps of land-use and driving factors were aggregated from 50×50 m to 75×75 m, 100×100 m, 125×125 m and 150×150 m resolutions.

<u>Land use change model</u>

In the CLUE-S model, the non-spatial module calculates the area of change for all land-use types at the aggregate level, while the spatial module translates demands into land-use changes at various locations within the study region (Verburg *et al.*, 2002). Empirical analysis results are used within the model when simulating the competition between land-use types specified by the user to restrict conversion of each land use that can take place based on actual land-use patterns (Verburg *et al.*, 2002). Probability maps for all land-use types are calculated using logistic regression models. The relationships between land uses and driving factors are then obtained using stepwise logistic regression as follows:

$$\mathrm{Log}\left(\frac{P_i}{1-P_i}\right)=\beta_0+\sum_{i=1}^{m}\beta_j X_{ij}$$

where i is the i-th grid cell, P_i is the probability of a land-use type occurring in a grid cell, j is the j-th driving factors, X_{ij} is the driving factor, m is the number of driving factors, β_0 is the intercept of the regression model and β_j is the coefficient for each driving factor in the model.

Landscape Metrics

To identify the effects of changing the resolution of spatial patterns for simulated land-use, landscape metrics—Number of Patches (NP), Mean Patch Size (MPS), Total Edge (TE), Mean Shape Index (MSI), Area Weight Mean Shape Index (AWMSI), Mean Patch Fractal Dimension (MPFD), Area Weight Mean Fractal Dimension (AWMPFD), Mean Nearest Neighbor (MNN) and Interspersion and Juxtaposition Index (IJI)—at landscape and class levels are calculated using the Patch Analyst in the GIS software ArcView (McGarigal and Marks, 1995).

Hydrological Model

In this study, the Generalized Watershed Loading Functions (GWLF) model was used to simulate hydrological components. This model is a combined distributed/lumped parameter watershed model for simulating runoff, sediment, and nutrient loadings in watersheds. Daily water balances are calculated for unsaturated and saturated sub-surface zones (Haith and Shoemaker, 1987).

Results and discussion

The results of landscape metrics indicated that compositions of simulated land-use changed when grain size changed. The results of hydrological modelling with various land-use planning strategies indicated that the hydrological components (streamflow, surface runoff and groundwater discharge) were impacted by land-use planning strategies in all cases of grain size, especially streamflow was. Nevertheless, the purposed integrated approach systematically provides useful information in effective scales to assess watershed land-use planning strategies.

The information provided by integrating models using an appropriate scale are more effective than that when using inappropriate scales for land-use planers. Moreover, the scale effects and selections for simulating land-use on modelling hydrological components are also important to impact analyses of land-use change on hydrology when assessing watershed strategies. This study integrates an empirical land-use change model, landscape metrics and a hydrological model to simulate and assess future land-use, land-use patterns and hydrological processes under various land-use planning strategies in various scales (grain sizes).

References

Haith, D.A. & Shoemaker, I.L. (1987) Generalized watershed loading functions for stream flow nutrients. *Water Resources Bull.* 107: 121-137.

Lin, Y.P.; Hong, N.M.; Wu, P.J.; Wu, C.F. & Verburg, P.H. (2006) Impacts of land use change scenarios on hydrology and land use patterns in the Wu-Tu watershed in Northern Taiwan. *Landscape and Urban Planning.* In Press.

McGarigal, K. & Marks, B.J. (1995) *FRAGSTATS: spatial pattern analysis program for quantifying landscape structure.* USDA For. Serv. Gen. Tec. Rep. PNW-351.

Verburg, P.H.; Soepboer, W.; Veldkamp, A.; Limpiada, R. & Espaldon, V. (2002) Modeling the spatial dynamics of regional land use: The CLUE-s model. *Environ. Manage.* **30:** 391-405.

Simulated annealing with landscape metrics to optimally simulate landscapes in watershed landscape planning and management

Y.P. Lin, M.H. Chen

Department of Bioenvironmental Systems Engineering, National Taiwan University, No.1 Sec. 4 Roosevelt Rd. Taipei 106 Taiwan. e-mail: yplin@ntu.edu.tw

Introduction

One of the major land-use changes that have an impact on the hydrological cycle and regulation are changes in the spatial patterns caused by deforestation and forest fragmentation by human development within a watershed. Optimizing landscape or land use aims to obtain landscape or land use patterns which well sustain landscape functions and processes. Landscape models simulate alternative landscape dynamics which provide information to evaluate and test hypotheses or scenarios of landscape or land use management. Landscape or land use composition, configuration, and connectivity are primary descriptors of the landscape pattern which can be quantified using spatial landscape indices or metrics to characterize and quantify landscape composition and configuration. This study developed an optimal landscape simulation model by optimizing (maximizing or minimizing) the landscape metrics using simulated annealing for alternative land use management strategies in Wu-Tu watershed in Northern Taiwan at the forest class level.

Method

The Wu-Tu watershed is an urbanizing watershed in the Keelung River Basin, located between the Taipei metropolitan area and Keelung Harbor in northern Taiwan. The Wu-Tu watershed has an area of approximately 204.41 km^2, with a mean elevation and mean slope of 242.00 m and 0.005°, respectively. The population in this watershed has increased owing to the expansion of the Taipei metropolitan area, Keeling city and the need for labor in Keelung Harbor during 1987-1997. In this study, an optimal technique, Simulated Annealing (SA), was used to solve a single-objective Spatial Pattern Optimization Problem. Optimal objectives were to identify the landscape patterns with the largest mean forest patches by maximizing a landscape metric Mean Patch Size (MPS), the most compact forest patterns by minimizing a landscape metric Mean Shape Index (MSI), and the most connected forest patches by minimizing a landscape metric Mean Nearest Neighbor (MNN) under various deforested scenarios that are removed 5%, 10%, 15%, 20%, 30%, 35%, 40%, 45% and 50% forest to be replaced by built-up area, agricultural land and grassland within the study watershed.

Results and Discussions

Mean patch sizes of forest patches ranged between 400 and 500 ha by optimal removal of 5 to 20% forest in the study area. Patch number increased significantly when 50% of forest was removed in the case of maximizing mean forest patch size. However, optimal mean patch size of forest decreased when the removed forest percentage was greater than 20% of the forest cover of the study watershed. Moreover, patch shapes tended to complex by optimal removing 5-35 % forest under the optimal mean patch size objective. In the objective of minimizing mean patch shapes of forest patches mean patch sizes decreased by removing 5 to 50% of forest in the study area. Optimal mean patch shapes tended to regular when the removed forest percentage increased in the study watershed in the case of minimizing mean shape indices of forest patches. Moreover, patch number increased by an optimal removal of 5-50 % of forest cover under the optimal Mean Patch Shape objective. In the case of minimizing mean nearest neighbor of forest patches Mean Patch Sizes decreased significantly by removing 5 to 50% of forest in the study area. Moreover, patch number increased significantly by optimal removal of 5-50 % of forest under the optimal Mean Nearest Neighbor objective.

Conclusions

The optimal landscape simulation model was developed optimizing (maximizing or minimizing) the landscape metrics using simulated annealing which are capable for simulating alternative land use management strategies. Various optimal objectives such as maximizing Mean Patch Size, minimizing Mean Patch Shape index and minimizing Nearest Neighbor Distance obtained various forest compositions and configurations in the study area. The optimal simulation approach can be integrated with environmental models, such as a hydrological model, in future land use planning assessments.

References

McGarigal, K. & Marks, B.J. (1995) *FRAGSTATS: spatial pattern analysis program for quantifying landscape structure.* USDA For. Serv. Gen. Tec. Rep. PNW-351.

A recent landscape evolution of the Shiyang river basin---patterns, changes and causative factors

L. Lu, X. Li, E.S. Kang, T. Wang

Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou 730000, P. R. China.
e-mail: luling@lzb.ac.cn

Introduction

Many investigations have shown that most arid inland basins of northwest China are experiencing ecosystem degradation (Wang and Cheng, 1999; Kang *et al.*, 2004). The Shiyang river basin (SRB), which is located between 37°07'-39°28'N and 101°22'-104°05'E and covers the area of 41600km^2 with a population of 2.37 million, is the one under greatest threat from desertification and the one with the greatest degree of poverty and environmental stress (ADB, 2003). Landscape theory with remote sensing technology facilitates our understanding of the changing environment over a broad range of spatial and temporal scales (Lu *et al.*, 2003).

Data and method

In this study, two landscape maps of SRB with 30m resolution in 1986 and 2000 were compiled from several Landsat TM/ETM+ images through interactively manual interpretation. The interpretation accuracy of the landscape classification for the 14 types (Table 1) was more than 80% compared to intensive field surveys. The landscape changes of SRB between 1986 and 2000 were then derived from the two maps via GIS platform. Some major and important transitions were generalized from the variety of possible transitions (Figure 1).

Results and analysis

The recent landscape pattern of SRB displayed a significant process of expanding the existing oases into the surrounding grasslands and desert (Figure.1). As shown in Table 1, the most pronounced changes occurred in the increased area of farmland (over 38,000 ha increased in the 15-year period). Most of them were converted from grasslands, woodlands, gobi, sandy and salinized lands. The loss of a large area of grasslands and woodlands is suggested to be irrational because the grasslands and woodlands are important buffers to the oasis and provide water preserve in the upper reaches. In addition, much of the new cultivation which was suspected to be illegal was at the margins of the oases or outside the boundaries of protected woodlands. The landscape changes in these marginal areas displayed complex shapes and were remarkably fragmentary and disturbed. In any case because of its low productivity, this temporary cultivation is likely to be abandoned within a short time as commodity prices continue to fall or groundwater becomes too costly to pump. The results of abandoned farmlands existed in the whole basin are a legacy of irreparably damaged soil on which nothing will grow and follows in sandy desertification and dust storms.

Conclusion and discussion

The recent landscape pattern and change in SRB are strongly controlled by local human activities in terms of overextended reclamations and poor water management. The natural resources of land and water in the basin are being used beyond their sustainable limit. Therefore, it is necessary to carry out a comprehensive authorized management strategy of land use development and water resource allocation among different sectors and stakeholders in the whole basin.

Table 1. Total areas of changes in different landscape types in SRB between1986-2000

Landscape type	Total area in 2000 (Ha)	Change 2000-1986 (Ha)	Total % Change (2000-1986) /2000
Farmland	679,653	38,986	5.74
Woodland	263,115	-4618	-1.76
Grassland	1,117,917	-19,403	-1.74
Water area	4989	-26	-0.52
Occasional flooding	9916	247	2.49
Glacier & perpetual snow	64	0	0.00
Residential area	38,609	2289	5.93
Sandy desert	922,809	-7536	-0.82
Gobi	446,555	-2799	-0.63
Salinized land	200,635	-5871	-2.93
Marsh	30,501	0	0.00
Bare soil	18,763	-1346	-7.17
Bare rock	261,010	26	0.01
cold desert	72,788	51	0.07

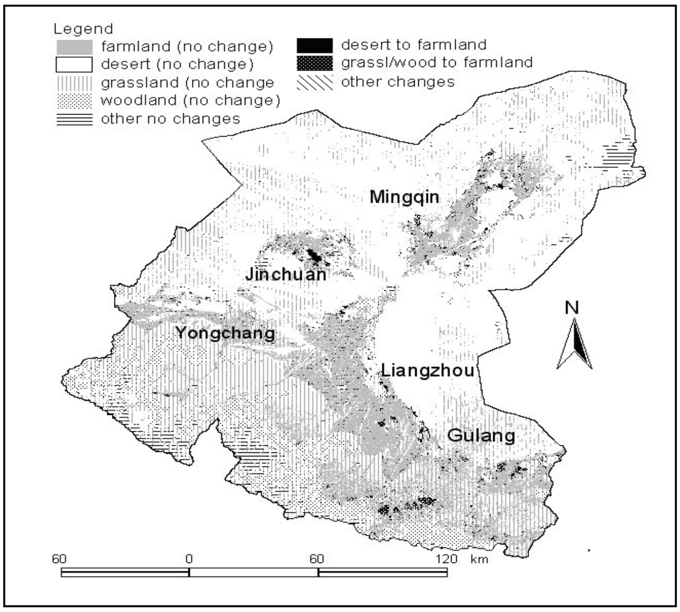


Figure 1. Landscape changes in SRB between1986-2000

References

ADB. (2003) *The Project of ADB Technical Assistance to the People's Republic of China for Optimizing Initiatives to Combat Desertification in Gansu Province.* **T.A.No.3663-PRC**

Kang, E.S; Li, X.; Zhang, J.S. & Hu, X.L. (2004) Water resources relating to desertification in the Hexi area of Gansu province, China. *Journal of Glaciology and Geocryology.* **26(6):** 657-667.

Lu, L.; Li, X. & Cheng, G.D. (2003) Landscape Evolution in the Middle Heihe River Gasin of Northwest China during the Last Decade. *Journal of Arid Environments.* **53(3):** 395-408.

Wang, G.X. & Cheng, G.D. (1999) Water resource use and its eco-environmental problems in arid zone of northwest China. *Journal of Natural Resources.* **14:** 109-116.

Response of ecological process after water deliveries to dry watercourse of lower reaches of the Tarim River Basin

Chen Y.N, W.H. Li, Y.P. Chen, C.C. Xu, X.M. Hao

Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences,40-3 South Beijing Road, Urumqi 830011, Xinjiang, China.
e-mail: chenyn@ms.xjb.ac.cn

Introduction

The recent fast growth of population and economic activities in the Tarim River Basin has dramatically changed the temporal and spatial distributions of water resources in the area, and has made the existing problem of scarcity of water resources even more striking. Even worse, more than 321 km river is dried up in the lower reaches of the Tarim river so that the groundwater depth in the vicinity of the lower reaches has dropped from 1-3m to 5-12m. The groundwater is also salinized and the ecosystems have been suffering serious damage. Vegetation relying on the groundwater has seriously degenerated, the “Green Corridor” between Kuluke desert and Taklimakan desert is shrinking continuously. Since 2000, the local government has conducted ecological water deliveries four-times to the lower reaches in order to lift the groundwater level for rehabilitating the damaged ecosystems, and protecting the “Green Corridor”. The paper discusses the response effect in the groundwater depth, NDVI, growth and physiology of natural vegetation in order to provide a scientific basis for protecting the environment.

Response of ecological process to water delivery

<u>Change of groundwater depth</u>

According to the investigation of monitoring well in sections, the change of groundwater is sensitive (Chen, 2004; Xu, 2003). The depth of groundwater was raised from 9.87m before water delivery to 2.66m after the fourth stage of water delivery (Table 1). The increasing height of the water table at each time of water delivery is 21.6%□66.4%□42.3% and 55.74%, respectively. The scope of response in transverse section is from 250 m after the first stage to 1050 m after the fourth stage of water delivery.

Response of growth and physiology of natural vegetation to water delivery (NDVI)

Spatial distribution change of vegetation to water delivery can be fully reflected by NDVI. With water deliveries being carried out, the NDVI of all sections in the lower reaches have increased, that is, vegetation growth improved. In a lengthways direction, vegetation of upper excelled that of lower. In transverse direction, the NDVI decreased with the increasing distance away from the river, indicating that the water delivery had a regressive effect in distance. The NDVI was highly correlated with groundwater depth. With the groundwater depth increasing, the NDVI decreased.

<u>Vegetation cover and growth</u>

According to the investigation from both transverse and lengthways directions, the vegetation cover and growth were improved along the river course after water delivery. Owing to the different depths of groundwater needed for vegetation to grow, the degree and response to less water are different with diverse vegetation (Li, 2004). The sensitive area of *Phragmites communis* is about 100-150m by measuring the characters of the leaves. The sensitive area of *Populus euphratica* was about 200-250m after the first stage of water delivery and extended to 800m after the fourth stage of water delivering by testing new branch's length and the quantity of leaves. The average quantity of leaves increase by 57%, 22.2% and 9.2% respectively comparing with the end section from the upper reaches to the lower reaches in lengthways.

Floral physiology

According to the index test of floral physiology, the physiological index of *Chinese Tamarix* such as PRO, POD, SOD does not change very much as the depth of groundwater changed from 2 to 5 meters, which indicates that this enables to *Chinese Tamarix* to survive.

The content of PRO of *Phragmites communis* will increase as the ground water level goes down, while its POD will reduce as the ground water level brings down. The scope of response is 150-200m in transverse section.

Populus euphratica is the only tree in the lower reaches of the river. The index of *Populus euphratica*'s SOD takes on the change processes of water gradient in both lengthways and transverse direction. The average SOD activity of *Populus euphratica* is from 60.66, 54.96, 53.77 to 51.15 activity unit as the depth of groundwater depth changed from 9.16, 8.41, 8.34 to 7.65 meters from upper to the lower reach area respectively, inosculating with the change of water gradient. The influence range in transverse can amount to 250-300 metres, which is accordant with the result by the testing on the new branch's length, and the quantity of leaves mentioned above.

In summary, the necessary groundwater depth for *Chinese Tamarix* survival is from 5 to 6 metres, *Populus euphratica* is 4-5metres and *Phragmites communis* is about 3 metres.

Table 1. The fluctuation of groundwater depth in each time of water delivery in lower reaches of Tarim River.

Water delivering	First time	Second time	Third time	Fourth time
Groundwater depth (m)	7.74	3.79	3.16	2.66
Uplift extent (%)	21.6	66.4	42.3	55.4
Duration of water delivering (days)	61	104	67	110
Amount of water delivering per day ($\times 10^4 m^3$)	162.02	211.54	294.03	266.37

References

Chen Y.N.; Zhang X.L.; Zhu X.M.; Li W.H.; Zhang Y.M.; Xu H.L.; Zhang H.F. & Chen Y.P. (2004) Ecological effect of water delivery in dried-up watercourse in lower reaches of Tarim River, Xinjiang. *Sciences in China (D)* **34(5):** 475-482.

Xu H.L.; Song Y.D. & Chen Y.N. (2003) Dynamic change of groundwater after ecological water transport at the lower reaches of Tarim River. *China Environmental Science* **23(3):** 327-331.

Li W.H.; Chen Y.P.; Zhang H.F. & Hou P. (2004) Response of vegetation to water input at lower dry Tarim River. *Journal of Desert Research* **24(3):** 301-305.

Site selection in dynamic landscapes: a probabilistic model to protect hydroseres in the Pantanal wetland

M.Drechsler [1], R.Lourival [2,3], H.P. Possingham [3]

[1] University of Leipzig - Germany, e-mail: martin.drechsler@ufz.de
[2] The Capes Foundation – Ministry of Education Brasilia - Brazil
[3] The Ecology Centre - The University of Queensland – Brisbane 4072 - Australia,

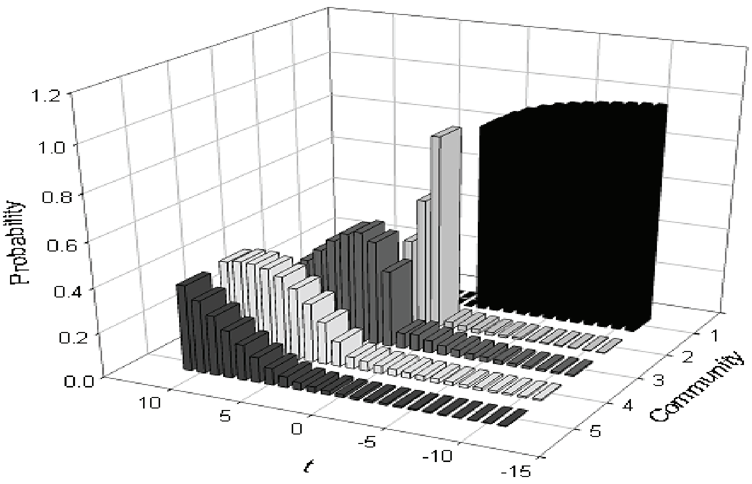
The great majority of conservation planning algorithms ignores an important feature of the real world: ecosystem dynamics. These algorithms have been a support tool for decision makers in terrestrial, marine and freshwater ecosystems. They offer a spatially explicit optimization mechanism capable of reducing most common bias from *ad hoc* reserve selection, through a transparent, target oriented and defensible arguments for negotiation (Pressey and Cowling 2001).

Incorporating ecosystem dynamics is currently regarded as one of the major challenges in reserve design (Cabeza and Moilanen 2003). Broadly speaking, ecosystem dynamics are driven by two processes: disturbance (Sousa 1984), through events like fire of flooding, and succession. There have been many attempts to classify disturbance regimes based on the extent, intensity and frequency of disturbance (Tutin 1941). Usually, for catastrophic events, subsequent succession is regarded as a unidirectional process (Platt and Connell 2003), where a disturbance event sets back the system to the earliest state, from which it evolves to later states. A less frequently considered type of succession is what might be termed "bidirectional succession". An important type of system that exhibits this type of dynamics are wetlands (Ward 1998; Junk 1999). In a wetland a flood is not an event that destroys everything and sets the system "back to zero". Instead, there is only movement back and forth on a terrestrialization-paludification gradient (Klinger 1996). Hence in our site selection framework we combine succession and disturbance into one process – bidirectional succession.

We consider two different levels of state variables: an abiotic and a biotic one. At the abiotic level we simply define a site by the time since the last disturbance event ("site age"). From a biotic perspective a stage is defined by the presence of a particular seral community. After integrating the biotic to the abiotic models we investigate the performance of various site selection strategies for a given target where the target is the probability of having a particular abiotic or biotic state protected. We describe the transition probabilities as a Markov process and we use simulated annealing to optimize the selection of sites for conservation.

Our result shows that the relationship between site age and the observed species community is not deterministic (Figure-1), such that for a given site age several species communities can be observed with some likelihood. This is plausible, since communities that that survive in such fluctuating environments do not simply disappear; they expand and contract their distribution responding to the disturbance history of the site (Junk 1999). Another important issue is the spatial correlation between sites, which play an important role in selection, since neighbouring sites are assumed be equally affected by disturbance. Our results do not support such view, and sites showed independency regarding the communities they sustain. This is also plausible because differences in micro-topography and flood frequencies seem to counterbalance those deterministic forces.

Figure 1: Probability of observing a community (1-5) on a site if the last flood was t years ago. Negative time intervals, $t<0$, mean floods in every of the previous $|t|+1$ years. The probability of flooding is $q=0.5$.



References

Cabeza, M. and A. Moilanen (2003). "Site-selection algorithms and habitat loss." Conservation Biology **17**(5): 1402-1413.

Junk, W. J. (1999). "The flood pulse concept of large rivers: learning from the tropics." Archiv Fur Hydrobiologie(3): 261-280.

Klinger, L. F. (1996). "The myth of the classic hydrosere model of bog succession." Arctic and Alpine Research **28**(1): 1-9.

Platt, W. J. and J. H. Connell (2003). "Natural disturbances and directional replacement of species." Ecological Monographs **73**(4): 507-522.

Pressey, R. L. and R. M. Cowling (2001). "Reserve selection algorithms and the real world." Conservation Biology **15**(1): 275-277.

Sousa, W. P. (1984). "The Role of Disturbance in Natural Communities." Annual Review of Ecology and Systematics **15**: 353-391.

Tutin, T. G. (1941). "The hydrosere and current concepts of the climax." Journal of Ecology **29**: 268-279.

Ward, J. V. (1998). "Riverine landscapes: Biodiversity patterns, disturbance regimes, and aquatic conservation." Biological Conservation **83**(3): 269-278.

Indicators for the linkage of forest, river, village and ocean ecosystems

Y. Natuhara, A. Imanishi, K. Imai

Graduate School of Global Environmental Studies, Kyoto UniversityYoshida-Honmachi, Sakyo, Kyoto 606-8501 JAPAN.
e-mail: natuhara@ges.mbox.media.kyoto-u.ac.jp

Introduction

Landscape ecology focuses on interacting ecosystems. Linkage of different ecosystems produces unique ecosystem services that are not produced by a single ecosystem. For example, gravel riverbeds provide spawning sites for salmon that grow up in the ocean. Then the salmon migrate upstream from the ocean to eventually provide nutrients for forests (Helfield & Naiman 2001). However, the linkages between ecosystems have been interrupted by urban development, road construction, dam, land reform in paddy field, etc. Some ecosystems deteriorate by the interruption of the linkage. We reviewed studies on the ecosystem linkages in landscapes. We explore indicators of the linkages to find the priority sites for restoration.

Function of the linkage and problems identified in Japan

<u>Catchments</u>

Many studies have reported that the increased agricultural land within catchments leads to declines in water quality, habitat, and biological assemblages (e.g. Richards *et a*l. 1993). Fine sediment increases by decreasing flow resulted from dam construction and river improvement, and by increasing sediment production resulted from deforestation. The density of macroinvertebrates in agricultural catchments was only 10-20% of that in the forested catchments (Nagasaka *et al*. 2000).

<u>Riparian forest</u>

Riparian forests have diverse functions. Approximately 30 m is required for maintaining shading effects and the provision of organic litter and woody debris. But 100-200 m is needed for the habitat of animals (Takahashi *et al.* 2003). Riparian forests decreased in the middle and lower reaches in Japan.

<u>Dam</u>

Interruption of the continuity of sediment transport by dams causes sediment-starved and prone to erode the channel bed and banks, producing channel incision, coarsening of bed material, and loss of spawning gravels for salmon and trout (Kondolf 1997). Dams change down stream ecosystems and the effect reach ocean ecosystem (Humborg *et al.* 1997).

<u>Floodplain</u>

Floodplains provide spawning and nursery sites for fish (Halyk & Balon 1983) and habitats for aquatic plants (Tremolieres 2004). But floodplains have decreased because of modification of the channel and dredging, flow control by dams and bank construction in Japan. The results of experimental flooding suggest that diversity of floodplain morphology should be preserved to maintain larval habitats (Sagawa *et al*. 2005). Paddy fields also have functioned as floodplains for fishes and plants for 2000 years. Catfish and loach move into paddy fields from rivers after irrigation, and spawn (Naruse & Oishi 1996). However, implementation of land consolidation projects in the paddy fields interrupts this linkage between rivers and paddy fields (Suzuki et al. 2001).

<u>Shore erosion</u>

Sandy shore area decreased by 5059 ha in the 70 years until 1978 and by 2395 ha from 1978 to 1992 due to shore erosion. The forest area in the basins has increased and the sediment load in the river channel had decreased. Tsutsumi (2005) suggested that supply of sand from river to shore increased mangan concentration of sediment that causes negative impact on clam production.

References

Halyk, L. C. & Balon, E. K. (1983) Structure and ecological production of the fish taxocene of a small floodplain system. *Canadian Journal of Zoology* **61:** 2446-2464.

Helfield, J. M. & Naiman, R. J. (2001) Effects of salmon-derived nitrogen on riparian forest growth and implication for stream productivity. *Ecology* **82:** 2403-2409.

Humborg, C; Ittekkot, V; Cociasu, A. & Bodungen, B. V. (1997) Effect of Danube River dam on Black Sea biogeochemistry and ecosystem structure. *Nature* **386:** 385-388.

Kondolf, G. M. (1997) Hungry Water: Effects of Dams and Gravel Mining on River Channels. *Environmental Management* **21:** 533–551

Nagasaka, A; Nakajima, M; Yanai, S. & Nagasaka, Y. (2000) Influences of substrate composition on stream habitat and macroinvertebrate communities: a comprehensive experiment in a forested and an agricultural catchment. *Ecology and Civil Engineering* **3:** 243-254

Naruse, M. & Oishi, T. (1996) Annual and daily activity rhythms of loaches in an irrigation creek and ditches around paddy fields. *Environmental Biology of Fishes* **47:** 93-99.

Richards, C; Host, G. & Arther, J. W. (1993) Identification of predominant environmental factors structuring stream macroinvertebrate communities within a large agricultural catchment. *Freshwter Biology* **29:** 285-294.

Sagawa, S; Kayaba, Y; Arai, H. & Amano, K. (2005) Habitat selection by larval cyprinid fishes: relationship between larval habitats and experimental flooding. *Ecology and Civil Engineering* **7:** 129-138

Suzuki, M; Mizutani, M. & Goto, A. (2001) Trial manufactures and experiments of small-scale fishways to ensure both upward and downward migration of freshwater fishes in the aquatic area with paddy fields. *Ecology and Civil Engineering* **4:** 163-178

Takahashi, K; Hayashi, S; Nakamura, F; Tsuji, T; Tsuchiya, S. & Imaizumi, H. (2003) A review on buffer width required for ecological functions of riparian forests. *Ecology and Civil Engineering* **5:** 139-168

Tsutsumi, H. (2005) Marked decline of clam harvesting fisheries and environmental changes on the tidal flats facing the Ariake Sea in Kumamoto Prefecture. *Ecology and Civil Engineering* **8:** 83-102

Tremolieres, M. (2004) Plant response strategies to stress and disturbance: the case of aquatic plants. *Journal of Biosciences* **29:** 461-470.

4.4 Posters

Landscape models predict distribution and assess protective status of freshwater fishes

K. M. Mattson[1], P. L. Angermeier[2] , S. D. Klopfer[3]

[1]Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0321, USA,
e-mail: mattsonh@vt.edu.
[2]United States Geological Survey, Virginia Cooperative Fish and Wildlife Research Unit, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0321, USA.
[3] Conservation Management Institute, 1900 Kraft Drive, Blacksburg, Virginia 24061, USA.

Introduction

Freshwater biota are highly imperiled worldwide due to intensive human land and water uses, which impact the flow regime, water quality, physical habitat, biotic interactions, and energy dynamics of aquatic ecosystems. Protecting freshwater biodiversity requires innovative approaches that enable conservationists to retain and restore valued biotic components and use a landscape perspective to model ecological conditions. Such approaches would inform decision-makers about the spatial relations among biodiversity targets, human uses of land and water, and the biotic risks associated with those uses. We employed a geographic information system framework to integrate maps of the type, extent, and severity of anthropogenic stressors with maps of fish distributions, and to assess the long-term sustainability of species within catchments. We applied our approach to 107 catchments in the upper Tennessee River basin (UTRB),

Methods

We combined projected occurrences of fish species, based on habitat descriptors, with projections of threats to the major drivers of biological integrity, then assessed the extent to which current land/water uses impair the long-term persistence of each species. We derived habitat associations from relations between known occurrences and landscape descriptors such as river drainage, physiography, stream size, and elevation, then used them in logistic regression models to predict reach-specific occurrences for 118 species. Readily available data on mining, impoundments, urbanization, agriculture, road density, and other human activities were used to rank the extent and severity of threats within catchments according to their expected impact on stream integrity (1). Each catchment was assigned a protective status (highly vulnerable, somewhat vulnerable, not vulnerable) based on catchment-level risk (low, moderate, high) and occurrences of conservation targets.

Results and Conclusions

Although most (76%) of the fish species we modeled are not imperiled overall, many, including some ubiquitous species, are at risk in the UTRB. Several species are highly vulnerable due to their limited distributions. Of the remaining species, 42% were under-represented in low-risk catchments and considered somewhat vulnerable. The human land/water uses posing the most risk to biota are manufacturing and effluent sites, bridges, and mining activity. Our approach integrates natural and anthropogenic landscape features with catchment-specific risks and ranks protective status of catchments based on the juxtaposition of anthropogenic stressors with valued freshwater biota.

References

Mattson, K. M., and P. L. Angermeier. 2007. Integrating human impacts and ecological integrity into a risk-based protocol for conservation planning. Environmental Management **39**:125-138.

Landscape Ecology in the Pantanal, integrating science and society

R.H.G. Jongman[1], M. van Eupen[1], B. Makaske[1], C.R. Padovani [2]

[1] Alterra Wageningen UR, PO Box 47, Wageningen, The Netherlands, e-mail: rob.jongman@wur.nl
[2] Embrapa CPAC, Caixa Postal 109, 79320-900 Corumbá, Mato Grosso do Sul Brazil

The Pantanal in Brazil measures about 250.000 km^2 and consists of a number of large rivers in a joint wetland area. The economy is based on cattle breeding, fishing and ecotourism. Large areas are dominated by the river regime of the Paraguay and its tributaries. In the wet season large areas of the savannah are flooded. At present erosion and silting up make the one of its rivers, the Taquari into an unstable braided system. This is at the moment a major problem causing a more or less permanent inundation of 5.000 to 8.000 km^2 in the subregion Paiaguas in stead of periodic inundation. The result is a decline of the fish populations and a decline of the area for cattle breeding.
The important added value of the project is that knowledge has been set into context of the river as an ecosystem and a socio-economic unit. Within that context the links between science fields of hydrology, ecology and economics have been made. It has been concluded, that biodiversity can be important for regional economy: Less aquatic biodiversity means less fish, less fishing tourism, less ecotourism, less income and more isolation. The relationship of the hydrological behaviour of a river system and its ecological functioning (the flood pulse) can also be an important lesson to be learned for river management in Europe.
In a situation where politics is important, it is essential that all are involved and discuss matters using political and scientific arguments and the right economic and hydrological models to explain the situation. Proper knowledge appeared the only convincing argument for taking decisions as it is important that the results of the project will be accepted both in the region and by authorities that supervise the region.
We concluded that technical solutions are not always the best solutions. Building a dam have been proposed by different stakeholders and the project was capable of showing the consequences, both positive and negative especially the negative ecological consequences and the long term problems that they cause. The detailed conclusions were:

- The important added value of the project is that knowledge has been set into context of the river as an ecosystem and a socio-economic unit.
- Biodiversity can be important for regional economy: Less aquatic biodiversity means less fish, less fishing tourism, less ecotourism, less income and more isolation. The relationship of the hydrological behaviour of a river system and its ecological functioning (the flood pulse) can also be an important lesson to be learned for river management in Europe.
- It is essential that all are involved and discuss matters using political and scientific arguments and the correct economic and hydrological models to explain the situation. Knowledge appeared the only convincing argument for taking decisions.
- It is important that the results of the project will be accepted both in the region and by authorities that supervise the region.
- Technical solutions are not always the best solutions: Technical solutions such as building a dam have been proposed by different stakeholders and the project was capable of showing the consequences, both positive and negative.

In general, understanding the hydrological dynamics and related ecology of rivers at the basin scale and communicating this with the organisations and people involved is the basis of economically and ecologically sustainable river management.

Channel and vegetation changes in the Sharda River - conservation implications for swamp deer in Kishanpur Wildlife Sanctuary, Uttar Pradesh, India

N. Midha[1], P.K. Mathur[2]

[1]WII-MoEF-NNRMS Project, Wildlife Institute of India, Post Box #18, Chandrabani, Dehra Dun - 248 001, India.
e-mail: n_midha@rediffmail.com
[2]Department of Landscape Level Planning and Management, Wildlife Institute of India, Post Box #18, Chandrabani, Dehra Dun - 248 001, India.

Introduction

Jhadi *taal,* an important swamp in Kishanpur Wildlife Sanctuary (KWLS) on the floodplains of Sharda River is one of the few surviving strongholds of a key species of *Terai* ecosystem i.e. Northern swamp deer (*Cervus duvauceli duvauceli*). Changes in the river course during recent decades have brought the channel dangerously close to it. Jhadi *taal* and eventually swamp deer future is considered precarious owing to potential flooding, siltation or loss of habitat. Present study assessed channel changes in *ca.* 10 km stretch of Sharda River and its likely implications on conservation of swamp deer.

Methodology

Changes in bank line position, length, area, sinuosity and land use/cover were documented using toposheets (1948 and 1965) and satellite imageries of Landsat (MS - 1977, TM -1990 and 1999) and IRS ID (LISS III - 2001). Visual interpretation was carried out to prepare river channel and land use/cover maps. Generated maps were overlaid. Locational Probability Model was also developed (Wasklewicz *et al.*, 2004).

Results

Analyses revealed channel shift by 3.1 km from 1948 to 2001 towards Jhadi *taal* and distance in 2001 remained just 100 m. Channel length, area and sinuosity oscillated considerably with a net increase in sinuosity by 15% and area by 96%. Loss of Sal (*Shorea robusta*) forest and grassland habitats by 12% and 3% respectively was also registered. Net gain of 5% was documented in agriculture area. Locational Probability Model predicted that 51% area of the studied channel as 'unstable', 45% 'moderately stable' whereas only 4% area as 'stable'.

Conclusions

Study revealed noticeable fluctuation in channel characteristics in short span of 53–year of assessment period. The probable reasons for such behavior could be attributed to rapid land use changes particularly deforestation on Nepalese side during 1960s-70s and channelization of Sharda River in upper reaches. Enchanced dynamism of river has definitely imperiled one of the strongholds of already endangered deer.

References

Wasklewicz, T.A.; Anderson, S. & Liu, Pin-Shou (2004) Geomorphic context of channel locational probabilities along the Lower Mississippi River, USA. *Geomorphology* **63**: 145-158.

From catastrophe to conservation: Protecting the pond complex of Tommelen, Belgium

J. Hollinshead[1], T. de Bie[2], A.Hul[l1]

[1] Ponds Research Unit, Liverpool John Moores University, UK.
e-mail: j.m.hollinshead@ljmu.ac.uk
[2] University of Leuven, Belgium

At Tommellen, near Hasselt, Belgium an important wildlife site consists of over 117 ponds, plantation woodland and grassland. The ponds are fairly uniform morphologically, being in the main circular, and occurring in two basic sizes, the smaller around 5m in diameter, and the larger around 8m in diameter, with depth 2 – 4m respectively. Age structure is completely uniform, being created more or less simultaneously during an air raid, which took place on April 8th. 1944. One hundred and ninety eight B-26 Marauder bombers, and 32 P-47 Thunderbolt fighter-bombers of the 9th USAAF attacked rail installations at Hasselt, Belgium, in preparation for the Normandy landings, creating a substantial crater field, some of which has survived as the pond complex. Despite the uniformity of morphology and age, ecologically these ponds display extreme variation across the site and between neighbouring ponds, in both floral and faunal communities, which can only partially be explained by differences in size and hydroperiod. The site as a whole is notable for invertebrate species, particularly *Odonata*, and amphibian species richness and abundance. The local community appreciate the value of the site, which is now almost completely isolated by road and rail corridors, industrial and housing development. Older members of the community, and American veterans who participated, recognise the site as a link to their past and the experiences of the 1940's. The importance of the historic and social dimension of pond conservation is emphasized by the role explanation of these aspects is playing in the campaign for statutory protection for the site, which is being carried out by local conservationists, researchers at LJMU and KU Leuven and supported by the European Ponds Conservation Network.

A research agenda for the Pantanal and the Upper Paraguay River basin

R.H.G. Jongman[1], J.M. Leeuwestein[2], P. Girard [3]

[1] Alterra Wageningen UR, PO Box 47, 6700AA Wageningen, The Netherlands
e-mail: rob.jongman@wur.nl
[2] Ecobusiness, SHIN 08, Conj 11, C18, Brasilia, Brazil; [3] CPP, Av. Fernando da Costa s/n
Cuiaba, 78060-900, Brazil.

The Pantanal is the largest wetland of the world except for rain forests. It measures about 250.000 km^2 and is one of the biodiversity hotspots in the world. The main objective of INREP is to strengthen the cooperation between policy makers, stakeholders and scientific institutions in Brazil, Bolivia and Paraguay and the European science community and NGOs working in the region for sustainable water management at river-basin scale and efficiency in water use in the Pantanal.

To achieve this goal, two preparatory workshops were held which counted on a participation of about 80 people, as well as a Bi-regional Symposium in Campo Grande, where 76 persons – representing the three countries of the UPRB and the international community – worked on an international research agenda for the watershed (see http://www.inrep.nl and http://www.ec.europa.eu/research/water-initiative).

The approach that has been chosen was the participatory methodology analysing Strengths, Weaknesses, Opportunities and Threats (SWOT), focusing on the potentials for both sustainable management and development. The analysis was based on a country document for each country. The result was an number of priorities for action This information was the basis for the Bi-regional Symposium of Campo Grande. The documents where discussed during the Symposium, which resulted in a final SWOT for the region as a whole and over 70 priority actions resulting in a in a Research Agenda for the region.

On the initiative of the Bolivian participants of the Symposium, an extra workshop was realized in Santa Cruz, Bolivia, on the 7th of November of 2006, providing the opportunity to include more stakeholders from this country to define the research activities. At this event, 22 persons participated.

The outcomes of the Symposium, the following major issues are identified for the UPRB:

1. Environmental change: diagnosis and remediation
   1.1. The Paraguay Hidrovia
   1.2. The climate functions and land use of the Pantanal
2. Assessment and mapping
3. Natural resources management
4. Governance, laws, institutions and policy
   4.1 Social organizations in the Pantanal
   4.2 Research organizations in the Pantanal
   4.3 Governmental organisations and legislation in the Pantanal
5. Sustainable development: diagnosis and solutions;
6. Capacity building and education.

For these major topics, 32 main research activities have been identified. This Research Agenda is the result of a participative effort involving the main stakeholders from the three countries, European research institutions and NGOs working in the region. It is a planning document for governmental, social and research institutions to elaborate future projects. In being a joint action it establishes the key-elements of knowledge required for sustainable development in this region. Research projects that have been integrated within the scope of this Agenda do have a conscientious basis in the region and are supported by governmental agencies, NGOs and civil society.

Acknowedgement: This project is carried out in the framework of EU FP6

Landscape scale influences on the streams habitats and biota: the riverine system of Natisone (Italy)

R. Zorza [1], M. Sigura [2], G. Oriolo [3], P. Bonfanti [2], G. Honsell [1]

[1] University of Udine, Department of Agro-Industrial Economics and Biology: Plant Biology Section, via Cotonificio 108, 33100 Udine, Italy. e-mail: zorza.raffaella@uniud.it
[2] University of Udine. Department of Agricultural and Environmental Sciences, via delle Scienze 208, 33100 Udine, Italy.
[3] University of Trieste, Department of Biology, via Giorgieri 9/10, 34127 Trieste, Italy.

Introduction

Landscape ecology emphasizes the interaction between spatial pattern and ecological processes and has conceptual and technical tools relevant to monitoring rivers. Quantifying landscape structure is a prerequisite to the study of landscape function and change. A new trend in the calculation of landscape metrics is to integrate the traditional calculation program into the geographic information system (GIS) so that data models and spatial analysis tools can be utilized effectively. Our objectives were to analyse the characteristics of landscape structure and its influences on the stream habitats and biota of the riverine system of Natisone. To understand the spatial complexity of the river we have used physical habitat measure, a number of bioindicators following the Water Framework Directive (WFD 2000/60/CE), vegetation and landscape indicators.

Methods and Results

The Natisone is a torrential prealpine river in the province of Udine (Friuli Venezia-Giulia, Italy) with a bed characterized by gravel and stones.

A vegetation map (1:5000) was prepared to analyze the habitat of each vegetation type and to define six homogeneous vegetal landscape units along the river using 75 transects perpendicular to the broken line of the stream (40 Km).These transects described the relative presence of 34 mapped classes. We used landscape metrics calculated by FRAGSTATS on the vegetation and land use map (1:25000) to evaluate the influence of human pressure and to confirm the status of riverine system.

Upstream we found units characterized by high connectivity and low diversity, due to the dominance of woods, large and species-rich patches types that reflect the high biodiversity of this area. Downstream there are units with a lower naturality and a decrease in quality of water as effect of a higher human pressure by intensive agriculture and urban development. The downstream landscape pattern is an heterogeneous mosaic of fragmented patches characterized by a small number of natural patches strictly connected with the bed river that underline the decrease of naturality along it and that the gradient of the naturality is confirmed in the integrated reading of the data. A good-acceptable water quality was assessed in ten sampling stations by the Diatom Eutrophication/Pollution Index (EPI-D) (Dell'Uomo, 2004). In this study we have noticed that Natisone has a Good Ecological State in the sense of WFD with a lot of natural habitats. Attempts have been made to understand disturbance factors in the landscape and to underline the impact of land uses on spatial habitats modifications along Natisone river.

References

Dell'Uomo, A. (2004) *L'indice diatomico di Eutrofizzazione/Polluzione (EPI-D) nel monitoraggio delle acque correnti.* Linee guida, APAT, Roma, 102 pp.

Corridor effect of the spatial changes of landscape patterns in arid areas: a case of the river corridor areas in the middle and lower reaches of Tarim River

H. Zhou[,2], D. Xiao[,2] & K. Zhou

1. Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi 830011, China (e-mail: zhouhr@ms.xjb.ac.cn);
2. Shenyang Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110016, China

Introduction

The radiative effect and the characteristics of the river corridors on landscape and patch levels were analysed in the middle and lower reaches of the Tarim River.

Study area

This river corridor areas (38°47′52″~41°38′30″N, 85°33′38″~88°40′30″E) are dominated by the traditional green corridors along the river section from the Qara Reservoir in Yuli County to the Taitema Lake in Ruoqiang County and is bounded by the piedmont and the large-area dunes. The study area has a length of 413 km and width of 87 km with a total area of 34526 km^2.

Study Method

The buffer zones perpendicular to the watercourse were divided in a 5-km interval away from the watercourse along both riversides□10 km wider□using the method of the buffer zone analysis.The landscape pattern indexes of each buffer zone were calculated, and the indexes of the main landscape patterns were analyzed so as to reveal.

Results

(1) The radiative width is generally a 30-km buffer zone in the study area, and can be up to 50~70 km in some areas. (2) The landscapes of woodlands and wetlands are generally distributed within the 10 km buffer zone along both riversides.(3) The closer the buffer zone to the watercourse, the higher the patch density and the largest patch index are. (4)In the ecological and environmental regeneration for the study area, the extent of ecological effect of the river corridors must fully be considered.

References

Ward J.V., Maland F. & Tockner K., Landscape ecology integrates pattern and process in river corridors, Issues in Landscape Ecology (ed. Jon A. Wiens & Michael Moss R.), International Association for Landscape Ecology Fifth World Congress, Snowmass Village, Colorado, USA, 1999, 97-102.

Xiao D., Hu Y., Li X., et al., Study on Landscape Ecology in the Bohai Delta (in Chinese), Beijing: Science Press, 2001.

Zhou Huarong□Study on landscape ecology for the river corridor of the middle and lower reaches of Tarim River, Xinjiang, China, PhD thesis, Shenyang Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang , 2004, 156.

A landscape ecological study of the Ganges-Brahmaputra-Meghna delta basin, Bangladesh

T. Byomkesh[1], N. Nakagoshi[1], M.S. Rashid[2]

[1]Graduate School for International Development and Cooperation, Hiroshima University, Japan.
e-mail: bbyomkesh@yahoo.com
[2]Department of Geography and Environment, Jahangirnagar University, Dhaka, Bangladesh.

Bangladesh is a land of extremes and home to an estimated 140-plus million people in 144,000 sq. km. Continuous severely degradation of terrestrial, aquatic and floodplain ecosystems, land covers change, deforestation, land degradation, water and air pollution, salinity, affect of global climate change and frequent natural calamities (e.g. flood and cyclone) are some of the environmental issues of Bangladesh. Estimates in 1990 revealed that Bangladesh had less than 0.02 ha of forestland per person. The rapidly increasing Bangladesh population has dramatically amplified the demands for natural resources and has caused significant changes in the quantity and quality of natural resource. To solve these problems well thought out strategies are needed. Presently Environmental management practices are trending away from simple, local-scale assessments toward complex, multiple-stress or regional assessments. Landscape ecology provides the theory behind these assessments while GIS with Remote Sensing supply the tools to implement them. As changes throughout landscapes occur, the overall structure of ecological communities is affected. In order to understand landscapes, it is important to recognize the patterns that are created along both spatial and temporal scales. On the basis of the above background the objectives of this study is to (i) Finding land use pattern through time and space in the delta (ii) Characterized the types, rates and temporal variability of land use and land cover changes over time and (iii) Identify the driving forces and consequences of changes. This study will make use of remotely sensed data and GIS technologies to evaluate qualitatively and quantitatively outcome of Bangladesh land cover/use distribution. Through the data analysis the land use pattern model of Bangladesh will be established. It is understood that this study will be useful for future environmental planning and management that conserves and sustains the ecosystem support needed for the livelihood of Bangladesh's poor dense population's livelihoods.

References

Loveland T., (2001). Strategic plan for the U.S. climate Change, Science Programme. Chapter 6, Land-Use/Land-Cover Change, U.S.A. pp 63-70.

National Adaptation Programe of Action (NAPA). (2005). Final report. Ministry of Environment and Forest, Government of the People's Republic of Bangladesh.

State of Environment, Bangladesh (2001). Report. UNEP. ISBN: 92-807-2017-1.

http://landcover.usgs.gov/pdf/anderson.pdf

http://www.epa.gov/esd/land-sci/pdf/overview-fs.pdf

http://www.epa.gov/esd/land-sci/region-assess.htm#project-summary

Quick scan system analysis as a basis for ecological restoration measures

J.C.J de Hoog[1], M.H. Jalink[2]

[1] Water board De Dommel, Postbus 10001, 5280 DA Boxtel, The Netherlands,
email: jdhoog@dommel.nl
[2] Kiwa Water Research, Postbus 1072, 3430 BB Nieuwegein, The Netherlands.

Introduction

In the convention of Cork (2004) the water boards, provincial authorities and other organizations in the province of Noord-Brabant (the Netherlands) have stated that they will prioritize the ecological restoration of the most important and critical nature reserves, the so-called *nature pearls*. The water boards have taken the responsibility to realize the required ground water levels and surface water levels for restoration of wetland plant communities.

Before starting detailed research and ground water modeling in about 40 nature pearls, Water board De Dommel wanted to know which restoration measures are likely to be successful, and what characteristics of the hydro-ecological system should be incorporated in the ground water models. Kiwa Water Research and Water board De Dommel developed a method for a quick scan ecosystem analysis that requires only a few days per nature pearl.

Method

General knowledge of hydrological, hydrochemical, ecological processes and indicators, and a framework of hydro-ecological system types in Noord-Brabant is used to identify the local hydro-ecological system types of each nature pearl, the causes of non-optimal functioning and promising restoration measures. The information used consists of soil type, elevation, depth of drainage, hydrolic head, groundwater quality data and the presence of certain plant communities or species. Additionally, a field excursion is necessary to acquire specific information of the location such as soil structure. The findings are presented in hydro-ecological cross-sections showing the most important gradients and underlying processes. This information forms a basis for further, detailed modeling

Case study

The quick scan ecosystem analysis was tested in the area Bossche Broek-south (near 's-Hertogenbosch). In this area, results of an earlier hydrologic model indicate seepage from a deep aquifer, so it was assumed this would support base rich hay meadows. However, the groundwater quality data show the dominance of local groundwater systems, rich in sulfate and potassium, in the upper four meters. No signs of groundwater from the deeper aquifer were found. Additionally the thick layers of clayey peat and clay show the former influence of flooding and the Carex acuta vegetation is typical of (formerly) flooded wet meadows. It was concluded that the thick peat and clay layers and loam layers in the subsoil may prevent the seepage from the deep aquifer. These layers should be incorporated in the model. Nature goals should be adapted to this (formerly) flooded system instead of being dependent on seepage from the deeper aquifer.

Perspectives

In the Bossche Brook south the quick scan appeared to be an effective tool to gain insight in the hydro-ecological system and the possibilities for ecological restoration. The method is now being carried out for 17 of the 40 nature pearls of Water Board De Dommel. The poster depicts the main goals, the main principles and the method of the quick scan. With the case study of Bossche Broek-south we will illustrate the method and focus on the implications for further actions and research.

Changing Landscape Mosaic of the Mid-Paraíba do Sul River Valley: Geo-Hydroecological Responses to *Eucalyptus* Growth [1]

A.M. Sato, L.G.G. Vianna, R.C.G. Almeida, A.S. Avelar, A.L. Coelho Netto

GEOHECO/Geo-Hydroecology Laboratory, Geography Department, Institute of Geosciences, Federal University of Rio de Janeiro, 21941-590, Brazil.
e-mail:sato@ufrj.br

Introduction

Since 2000 the landscape mosaic of Middle Paraíba do Sul river valley has been rapidly modifying by the spreading of *Eucalyptus* patches in substitution to cattle grazing grasslands. Evidences of landscape instability are given by the occurrence of deep gullies which are eroded by the action of groundwater flows and landslide scars as previously shown by Coelho Netto (1999). Our current research interests are driven to understand the role played by *Eucalyptus* controlling the hillslope hydrology and erosion and explain how these changes may affect the regional landscape system. This paper presents the initial studies with special attention to the effects on the biota-soil-water interactions.

Study Area and Methods

Field work has been conducted in the Sesmarias river basin (149 km^2), a tributary of Paraíba do Sul river (SE Brazil), at the *Eucalyptus* Farm Monte Alegre (hybrids *E. urophylla* x *grandis*, 3x2 m spacing, planted in April 2004). Average annual precipitation is 1700 mm and rainfall concentrates from October to March. A land use map of the basin (rainforest, grassland, *Eucalyptus* and urban zones) was generated via CYBERS images (August 2006) and geo-referenced with LANDSAT. A representative hillslope was selected within a first order basin to examine litter production, storage and water retention (WR) and to ascertain the physical characteristics of soil and hydrological measurements (gross rainfall, interception and overland flow production) at both the hillslope divide (8^{o}) and side-slopes (24^{o}). Sampling sites followed the spatial pattern of tree planting and included samples under tree canopies (UC) and between tree trunks (BT). Hydrologic records refer to the period from October to December 2006, while the litter records refer from October 2006 to January 2007.

Results and Discussion

Grasslands predominate in 63.5% of the basin area; *Eucalyptus* concentrates in the hilly lowlands and occupies 3.1% of total area; rainforest remnants (31.7%) occur only in the mountainous domain; and a small urban zone (1.6%) is adjacent to Paraíba do Sul river. *Eucalyptus* litter storage is spatially non-uniform: at BT (8.925 Mg.ha^{-1}) is greater than UC (7.421 Mg.ha^{-1}). Average side-slope WR is greater (342%) than at hillslope divide (183%) explained by greater presence of dry grass remnants on the side-slope. Deus (1991) found that grass WR may attain 500% in the dry period. Throughfall UC is frequently higher than in the open area due to convergent flows from branches and leaves: mean throughfall at UC sites is 140% ranging from 567% to 55%; at BT sites the average value is 84% ranging from 176% to 51%. Overlandflow production is very low on steep side-slopes; it can be neglected in the hillslope divides. So the *Eucalyptus* growth is highly favorable to infiltration.

[1] Financial support: CNPq & FAPERJ

References

Coelho Netto, A.L. (1999) Catastrophic Landscape Evolution in a Humid Region (SE Brazil): inheritances from tectonic, climatic and land use induced changes. *Supplementi di Geografia Fisica e Dinamica Quaternária III*. **3**: 21-48.

Deus, E. (1991) The Role of Ant (*Atta spp.)* Excavation in Pasture Area Slope Hydrology – Bananal (SP). *Master's Thesis, PPGG/IGEO/UFRJ*. 135p.

Analysis of the quality of the riparian forest as a bioindicator in mediterranean river basins monitoring

S. Sànchez Mateo, M. Boada Juncà

Environmental Science and Technologies Institute. Autonomous University of Barcelona (UAB). Campus de la UAB. Edifici Cn. Torre 5 (parells). 08193 Bellaterra (Cerdanyola del Vallès). Barcelona. Spain.
e-mail: sonia.sanchez.mateo@uab.cat

The ecological study of the riparian communities has become in one of the main keys to understand the dynamics of the fluvial systems. In this context, the European Water Framework Directive (Directive 2000/60/EC) defines new sustainability approaches to protect the hydric resources through river basin analysis, in terms of ecosystems and anthropic activities repercussions, in order to assess the ecological state by monitoring indicators.

And this is the framework in which L'Observatori project is submitted; a regional pioneer initiative started up in 1996 that aims to develop and monitoring sustainability indicators on a river basin scale in Catalonia (Spain). L'Observatori proposes a holistic approach towards both the global comprehension of the fluvial ecosystem functioning and the dynamic transformation at which Tordera river basin is subjected. It aims a continued and integrated evaluation of the ecological, hydrological and social status of the basin. One of the research lines that L'Observatori includes, referring to the ecological aspect, is the analysis of the quality of the riparian forest as a measure of sustainability, which defines the status of riverine resources.

The role of the riparian forest in the fluvial ecosystem dynamics can be defined in a multifunctional scope since its hydrological, ecosystemical and economical implications. Taking into account these aspects, the main goal of this study is the proposal of a methodology for the monitoring of the mediterranean riparian forests at the Tordera river basin, based in the evaluation of its quality by applying the QBR index (Riparian Forest Quality Index) in serial transects throughout the area of study.

Anthropogenic interference on fish assemblages, Meia Ponte River, Goiás, Brazil

M. Pazete de Oliveira, F.L. Tejerina-Garro

Centro de Biologia Aquática, Universidade Católica de Goiás, Av. Engler s/n, Jardim Mariliza, CEP 74650-010, Goiânia, Goiás, Brazil.
mpazete@gmail.com

The Meia Ponte River basin (Upper Paraná River) occupies an area of 12180 km², supplying water for industrial and agricultural activities (Fialho and Tejerina-Garro, 2004), but also receiving domestic seweage. This work aims to compare the fish assemblage composition and structure of five river stretches (each one of 1000 m) Considering four ecological descriptors (abundance, richness, Shannon-Wiener diversity, equitability) and similarity.

Fish were collected each two months between March and November/2006 using four set of nets (meshes 12, 15, 20, 25, 30, 35, 50 and 70 mm) following the protocol suggested by Tejerina-Garro and Mérona (2001). Ecological descriptors and fish assemblages similarity (cluster analysis using the Ward method followed by a Monte Carlo test, 1000 interactions) were calculated using the software ADE-4 (Thiolouse et al., 2001).

They were collected 2454 individuals distributed in 71 species, including eight exotic ones. Only richness display significant differences among stretches ($p=0.006$), but this descriptor does not increase in the headwaters-rivers' mouth sense. The comparison of the similarity indicates that the three river stretches upstream the Rochedo dam are different from downstream ones.

Despite the presence of important tributaries of the Amazon and Paraná basin in Goiás State and aquatic landscape modifications, systematized information about its ichthyofauna or the influences of anthropogenic activities on fish assemblages are poor. This kind of information can contribute to the conservation planning of the local aquatic environment, which represents goods and services for the society (Richter et al., 2003).

References

Fialho, A. & Tejerina-Garro, F. L. 2004. *Peixes do Rio Meia Ponte, GO***.** Série didática 12. Editora da Universidade Católica de Goiás, Goiânia.

Richter, B. D.; Mathews, R.; Harrison, D. L. & Wigington, R. (2003) Ecologically sustainable water management: managing river flows for ecological integrity**.** *Ecological Applications,* **13(1)**: 206–224.

Tejerina-Garro, F. L. & Mérona, B. (2001) Gill net sampling standardisation in large rivers of French Guiana (South America). *Bulletin Français de la Pêche et de La Pisciculture,* **357/360**: 227–240.

Thioulouse, J.; Chessel, D.; Doledec, S. Oliver, J.M.; Goreaud, F. & Pelessier, R. (2001). *Ecological data analysis: exploratory and Euclidian in Environmental Sciences*. Version 2001 ©CNRS 1995 – 2001.

Interaction between land use and fish assemblage in the River João Leite basin, Goiás, Brazil

A.M. Dias[1], F.L. Tejerina-Garro[1]

[1] Aquatic Center Biology, University Catholic of Goiás, Campus II, Av. Engler s/n, Mariliza Garden, CEP 74650-010, Goiânia, Goiás, Brazil.
e-mail: alesandradias@gmail.com

This study aims to compare the fish assemblages of creeks located into the Altamiro of Moura Pacheco State Park and those draining regions where dominated cattle raise and agriculture activities (Novaes-Pinto, 1993). All creeks are tributaries of the João Leite River, high Paraná River basin (GALINKIN, 2003).. Fish was sampled each two month between August/2004 and July/2005 using electric fishing in twelve creeks in a stretch 50m. Each creeks was grouped by and region similarity, a group considered preserved, a group in the average region, a group in the intermediate region and a group in the inferior region. The evaluation of the communities was given through analysis of correspondence of program AD-4 where it presented differences enters the communities of fish in the different regions (conserved, average, intermediate and inferior). Mount Carlo's test identified significant difference, $p<0,005$. The ecological describers (Abundance, Shannon, uniformity and Richness) had been different for each region, reflecting in differences between the communities of fish of the sub-basin of the River João Leite. The analysis shown abundance of 10.838 individuals, being bigger in the average region, 4509 individuals collected and lesser region in the intermediate region, 1687 individuals. The average of the wealth was bigger in the medium region 22,58 species and minor in the inferior, 14,33 species. The index of Shannon presented a average diversity of 3,13 in the medium region, and minor in the preserved region 2,8 bits. The uniformity showed a minimum average of 0,69 in preserved region and 0.81 in the medium region. The results show significant differences between conserved areas and not conserved however the richness, the abundance, diversity and the uniformity it is not bigger in the areas conserved. Moreover, one observed that it has an influence of the position of the creeks in the groups not conserved (direction headboard-estuary), however the ecological describers do not follow the standard predicted for the concept of the continuous river (Vannot, *et al*.; 1980), or either, these do not increase in the direction headboard-estuary, what it suggests an influence of the anthropics activities in the inferior intermediate region and inferior region.

References

Galinkin, M. (2003). *GeoGoiás* 2002. M. Galinkin (ed). Agência Ambiental do Estado de Goiás, Fundação CEBRAC, PNUMA, SEMARH. Brasília, 272 p.

Novaes-Pinto, M. (1993) Caracterização geomorfológica do Distrito Federal. 285-320. In NOVAES-PINTO, M. (Org). *Cerrado: caracterização, ocupação e perspectivas*. 2ª ed., Editora UnB, Brasília.

Vannote, R. L.; Minshall, G.W.; Cummins, K. W; Sedell, J. R.; Cushing, C. E. (1980) The river continnun concept. Can J. *Fish Aquatic. Sci., 37*: 130-137.

Composition and spatial distribution of the fish assemblage in the tributaries of the Ribeirão João Leite sub-basin, Goiás, Brazil

A.P. Fialho[1], L.C. Gomes[2], F.L. Tejerina-Garro[1].

[1] Universidade Católica de Goiás, Centro de Biologia Aquática, Campus II Av. Engler s/n, Jardim Mariliza, Cx. Postal 86 CEP 74605-010 Goiânia, GO, Brazil.
e-mail: afonso@ucg.br
[2] Universidade Estadual de Maringá, DBI/Nupélia. Av. Colombo, 5790, Maringá, PR.

The present study was conducted in the Ribeirão João Leite sub-basin, Center-West Region, Brazil. It aims to describe the composition and spatial distribution of fish assemblages in nine tributaries distributed along the mentioned sub-basin.

Five samples were conducted between August/2004 and September/2005. Fish were collected using electrofishing along a 50 m stretch. A Detrended Correspondence Analysis (DCA) was applied on transformed abundance data (square root) as suggested by Gauch Jr (1982). Spatial distribution of species was tested using a two-way ANOVA.

The 5277 individuals collected are distributed in 49 species, 14 families, and 6 Orders. Two axes from DCA with eigenvalues above 0.20 (Matthews, 1998) were retained for interpretation (eigenvalues 0.35 and 0.24, respectively). The bifactorial ANOVA (position) was significant ($p < 0.05$) demonstrating difference in the composition and space distribution of fish assemblages along the sub-basin (upper section - 23.15% of abundance, middle section - 48.95% and low section - 27.80%)

Although the small space scale of the sub-basin sampled, the results demonstrate a great heterogeneity in fish assemblage composition among sections. This result can contributes to planning conservation of this sub-basin, which is used for water supply of the metropolitan area of Goiânia city.

References

Gauch Jr., H. G. (1982). Multivariate analysis in community ecology. Cambridge University, USA.
Matthews, W. J., (1998). Patterns in freshwater fish ecology. International Thomson Editors, USA.

Reconstruction of paleoenvironment to understand involved processes on landscape development; an important tool for long term research and management at the Valdivian urban wetlands (Chile).

H. Rubilar[1,3]; B. Jessel[1]; G. Rojas[2]; C. Ramírez[3]

[1] Geoecology Institute - Landschaftsplanung. Universität Potsdam. PF 601553; Potsdam. Germany.
[2] Geoscience Institute - Universidad Austral de Chile. Casilla 567 Valdivia. Chile.
[3] Botany Institute - Universidad Austral de Chile. Casilla 567 Valdivia. Chile.
rubilarh@rz.uni-potsdam.de

Abstract

To know baseline conditions is a high need for nature management. Using basic geological studies, historical information, the testimonies of people and the knowledge of current vegetation situation entered into GIS, it was possible to create a picture of the Valdivian urban wetlands (Chile) development, and quantify the land use change. The results should be checked with future research, nevertheless is a concrete contribution as starting point. The processes involved in the landscape evolution were elucidated, giving guidelines for the wetlands management (Figure: 1).

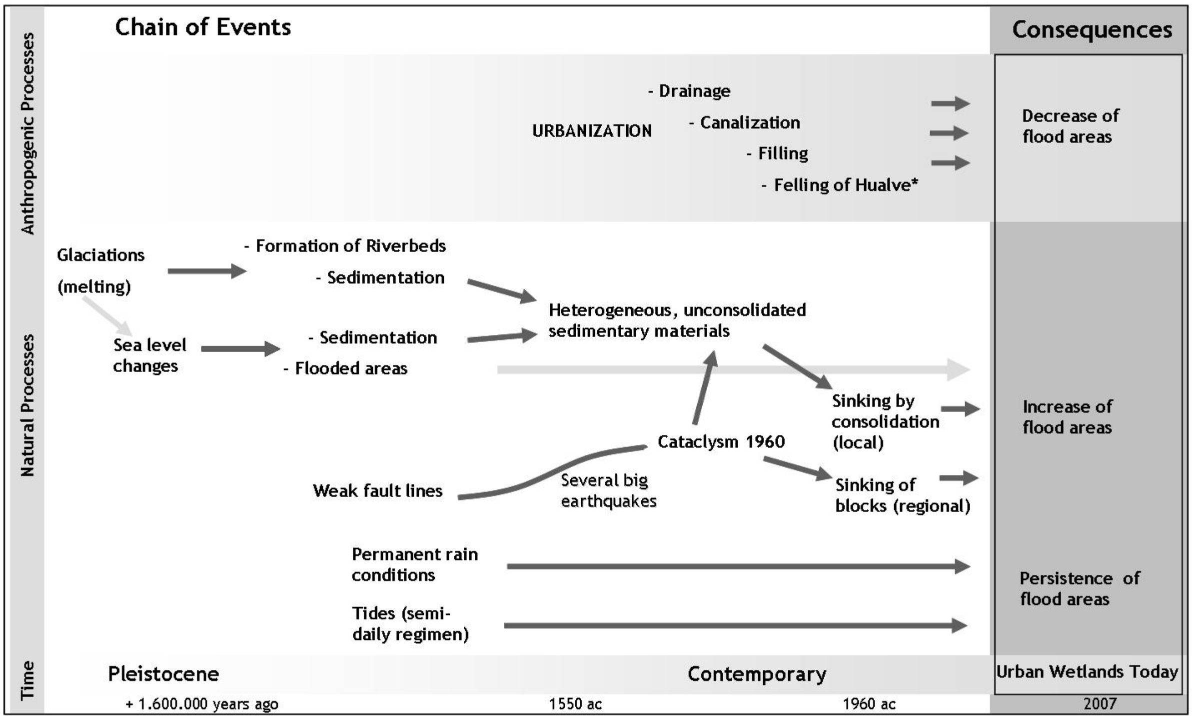


Figure 1: Natural and anthropogenic events that led to the current Valdivian urban wetland distribution. (*Hualve: wet-forest, *Blepharocalyo-Myrceugenietum exsuccae*).

Comments

The loss of wetlands is a fact and it will continue being a usual situation in Valdivia. Considering the important functions and values of these wetlands, we propose conservation management and soon deeper studies of the area. According with the social features of the region, an integrative approach is crucial, which takes into account environmental and social factors. Special emphasis should be given to educational and cognitive aspects of the wetlands.

The application of an artificial wetland on the treatment of river water

D.F. Juang[1], P.C. Chen[2], Y.C. Lee[2]

[1] Department of Healthcare Administration, Mei-Ho Institute of Technology, 24F, 230, Ming-Chuan Second Road, Kaohsiung 806, Taiwan, R.O.C. e-mail: x2060@ email.meiho.edu.tw
[2] DHV Planetek Co., LTD, 4F, 505, Chung Shan Second Road, Kaohsiung 801, Taiwan, R.O.C.

Introduction

In this study, we selected a new constructed free water surface (FWS) wetland located at the Chia Yi County of Taiwan and observed its treatment efficiency by periodically analyzing the water quality in the influent and effluent. The influent of this wetland was pumped from the Ho-Bou-Yu Drainage which is next to the wetland, and the treated water was then discharged to the downstream of Drainage by gravity. Table 1 showed the characteristics of this FWS wetland.

Table 1. Characteristics of FWS wetland.

Wetland Zone	Flow Rate between 3672 CMD and 5352 CMD					
Items	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Total
Water Depth (m)	1.2	0.6	1.2	1.2	1.2	
Area (m^2)	1800	1000	6300	4000	2400	15500
Effective Volume (m^3)	2160	600	7560	4800	2880	18000
Hydraulic Retention Time (day)	0.4-0.59	0.11-0.16	1.41-2.06	0.90-1.31	0.54-0.78	3.36-4.90
Covering Ratio of Macrophytes	70%	90%	20%	10%	<5%	

Treatment Efficiency of FWS Wetland

The results of this study showed that the FWS wetland could effectively treat the pollutants in the river water, and the relationships between the effluent concentration and the loading rate of pollutants were illustrated in Fig. 1-2.

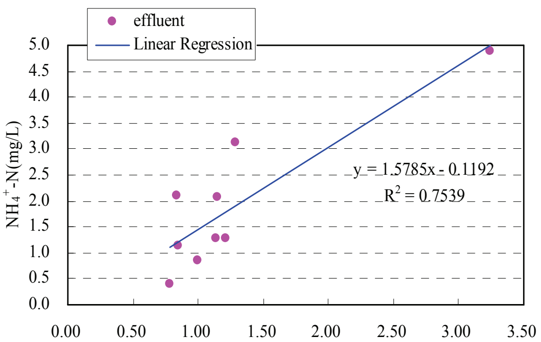


Fig. 1. Relationship between efflu. BOD conc.and BOD loading rate.

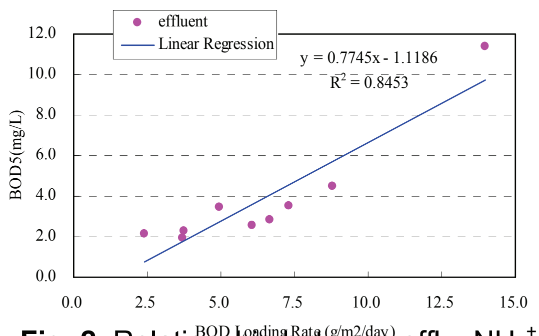


Fig. 2. Relationship between efflu. NH_4^+-N conc. and NH_4^+-N loading rate.

References

Jing, S.R., Lin, Y.F., Lee, D.Y., and Wang, T.W. (2002). Performance of constructed wetlands planted with various macrophytes and using high hydraulic loading. *Journal of Environmental Quality*, 31(2), 690-696.

USEPA (2000). *Constructed Wetlands Treatment of Municipal Wastewaters*, EPA Manual, EPA/625/R-99/010, USA.

A human-modified ecological hotspot: Jabbul salt lake (Syria)

F. Turkelboom [1], Z. Masri [1], A. Saeed [2], B. Kasmo [3]

[1] ICARDA, P.O. Box 5466, Aleppo, Syria.
e-mail: F.Turkelboom@cgiar.org
[2] Chamber of Industry, Aleppo, Syria.
[3] GOLD, Ministry of Irrigation, Aleppo, Syria.

Jabbul salt lake (or *sebkha*) is a hydrologically-closed agro-ecosystem in NW Syria, which includes a seasonal lake (28,000 ha), seasonal shorelines and surrounding agricultural villages. This place is rich in agricultural production, indigenous culture and biodiversity. However, over the last decades, many changes have taken place, which threaten the sustainability of both livelihoods and the environment. The objectives of this study were to assess the changes in the environment and the institutional setting, and to design a way forward for sustainable management of this valuable agro-ecosystem.

Sebkhat al-Jabbul experienced a lot of changes as a result of human interventions during the last 50 years. Historical records and maps indicate that *Sebkhat al-Jabbul* was a seasonal salt lake, which was fed mainly by *Al-Dahab* river, and which dried out for 90% during the hot summer season. Until the 1960's, the *sabkha* was surrounded by rainfed agriculture and rangeland. Beside salt extraction, there was no major human interference and the only institutions involved in the area were local village councils. During the 1970's, water extraction of the streams and overpumping from the groundwater around the lake resulted in a decline of the water level in the lake. A major turning point for the eco-system was the extension of the Euphrates irrigation scheme to the north and northeaster parts of the lake during the 1980's and 1990's. It resulted in a population explosion and expansion of intensive high-input irrigated agriculture. The inflow of drainage water from the irrigation schemes caused a more permanent presence of water in the lake, while the building of dykes resulted in several quasi-independent lakes with different salinity content. The new lake conditions attracted an extremely rich birdlife. Among them are the greater flamingo and the global threatened white-headed duck (Serra *et al*., 2006). On the other hand, growing rural towns, new factories and increased use of agricultural inputs resulted in a fast increase of inflow of polluted sewage water. For many villages around the lake, salt collection was and remains an important source of income, despite the pollution of the salt. Other side effects of this changing situation are the increasing water table, secondary salinisation of some agricultural land, decline of the halophyte vegetation along the shoreline, illegal hunting and unregulated fishing.

The institutional landscape has also changed dramatically over the last 3 decades. The major stakeholders now include 5 Ministries, 12 government institutions, 5 research centers, one NGO, the private sector and farmer organisations. A major challenge is that government agencies have overlapping and unclear mandates related to *Sebkhat al-Jabbul*. This resulted in a lack of common-agreed vision and integrated master plan, in single-disciplinary interventions, lack of coordination, legal vacuum and scattered knowledge of the lake. The key to get out of this impasse is to start-up a multi-stakeholder process (MSP), which provides leadership for envisioning and planning, while accommodating the diverse perceptions and aspirations of all involved, and taking into account the environmental limitations and opportunities of the ecosystem. This MSP approach is expected to lead to conservation of the rich biodiversity, while ensuring local livelihoods and strengthening the local environmental governance institutions.

Reference

Serra G., Murdoch D., Turkelboom F., Travert F., Mujawer Y. and Scott D., 2006. *Sabkhat al-Jabbul*, a threatened Ramsar wetland, Syria. Sandgrouse, 28(2): 127-141.

Influence of groundwater system on landscape ecology: a case study in Beijing, China

P. Yun[1], N. Nakagoshi [1], G. Huili [2,3], X. Zaiping[1]

[1] Graduate School for International Development and Cooperation, Hiroshima University, Higashi-Hiroshima, 739-8529, Japan.
e-mail: ysyk2997@hotmail.com
[2] Key Lab of 3-D Information Acquisition and Application, MOE, Beijing,100037,China.
[3] Key Lab of Resource Environment and GIS of Beijing, Capital Normal University, Beijing, 100037, China.

Introduction

Since groundwater has been greatly exploited as the primary water resource in Beijing, the influence of groundwater system on landscape ecology must be well understood to achieve a well urban ecosystem. GIS(Geographic Information System), RS(Remote Sensing)and some other space technologies now provide us with advanced tools to analyze the influence of groundwater on landscape ecology.

Methods

This study chose the plain of Beijing as the study area, shallow groundwater table and remote sensing images of this area in the time series from year 1990 to 2004 were collected as the basic data source. Firstly, water table distribution was interpolated, and then its spatial variation was analyzed with geostatistics methods. Then, NDVI (Normalized Difference Vegetation Index) and some landscape metrics were calculated from processed TM images, outputted to raster layers, and analyzed on heterogeneity with Kriging semi-variogram. After this, overlay, gradient analysis, and visual comparison were implemented to find the spatial and temporal relationship between groundwater and landscape ecology.

Results and discussion

Based on the spatial and temporal analysis, some relationship between groundwater and landscape ecology was established by this study for the first time. One is about spatial heterogeneity. Shallow groundwater table and landscape has the similar variation in orientations. Another is about temporal dynamics. By comparing the value of variogram formulation parameters, which are nugget, sill, and range of spatial dependence, it can be concluded that spatial structure of landscape metrics and NDVI changes following the groundwater table dynamics. This kind of spatial and temporal relationship is considered to be the result of interaction between groundwater and vegetation.

References

Bernaldez F.G., Rey Benayas J.M., Levassor C., etc.(1989). Landscape ecology of uncultivated lowlands in central Spain. *Landscape Ecology* **3**:3-18.

Caruso B.S.(1989). Temporal and spatial patterns of extreme low flows and effects on stream ecosystems in Otago, New Zealand. *Journal of Hydrology* **257**: 115-133.

Theme 5: Monitoring at the Landscape scale

5.1 Symposium 10: Monitoring at the landscape scale

Monitoring patterns of land cover change in cultural Irish landscapes using landscape metrics and SPOT 5 imagery

S.J.P. McKenzie, A. Cooper, T. McCann

School of Environmental Sciences, University of Ulster, Coleraine, Northern Ireland.
e-mail: sjp.mckenzie@ulster.ac.uk

Introduction

Early approaches in environmental Remote Sensing (RS) concentrated on low-resolution satellites that cannot satisfactorily detect fine-level variations inherent in cultural landscapes. Research focussed upon spectral responses rather than considering the role of spatial characteristics. Calibration between satellite image models and land cover was largely in the form of sparse ground truth samples. Our research investigates landscape metrics, RS and Geographic Information Systems (GIS), calibrated against field survey data from sample grid squares of the Northern Ireland Countryside Survey (Cooper *et al.*, 2003). This was a project which mapped and estimated changes in land cover in Northern Ireland over a ten year period between 1988 and 1998. Our current research considers how effectively landscape metrics add value to interpreting land cover change.

Methods

A baseline and resurvey sample of 35 quarter kilometre grid squares in a lowland agricultural landscape of County Down was selected for study from the Northern Ireland Countryside Survey (NICS). Land cover field maps from each survey date (*c.*1988 and 1998) were digitised then rasterized using ArcScan software. Landscape metrics were generated using Fragstats software to assess the patterns of change in the shape of mapped land cover. SPOT 5 satellite imagery, provided through the OASIS scheme, was used to create pan-sharpened images of the sample grid squares. Imagery was available from July 2004 and October 2005 in 2.5m panchromatic and 10m multispectral modes. Each scale was classified using a maximum likelihood classifier. Each image was divided into four main land cover types; agricultural grassland and crops, semi-natural vegetation, woodland and hard surfaces. Data was also available from the 2001 Landsat sensor. Aerial photography from 2004 was digitised to serve as a check on values generated from the satellite imagery.

Results

The landscape metrics applied included area, contagion, patch-per-unit area (PPU), number of patches, total edge (Zeng Wu, 2005), percentage land area (PLAND) and weighted mean patch fractal dimension. Contagion values suggested a highly aggregated landscape. When considered alongside metrics such as PLAND and absolute area they showed that agricultural grassland and crops predominated. Contagion values did not change significantly despite changes in the spatial configuration of land cover parcels. The PPU statistic suggested by Frohn (1998) was much more sensitive to changes in landscape structure showing that as the number of patches increased in a landscape, the level of fragmentation also increased. The Euclidean Nearest Neighbour (ENN) statistic was consistently low for agricultural land cover while the value was much higher for semi-natural and woodland land cover. Our research found that different types of land cover have unique spatial signatures. Agricultural land cover is characterised by high contagion and PLAND values while ENN and mean fractal dimension values are low. Semi-natural vegetation is characterised by high contagion values but low PLAND values while ENN and mean fractal dimension values are generally much higher. Patch-level statistics such as mean shape index and fractal dimension were able to distinguish between agricultural and non-agricultural land cover patches.

Spectral similarities between land cover parcels meant that it was difficult to maintain the separability of field-mapped land cover recorded by the NICS. However, there was a high level of correlation between SPOT imagery, aerial photography and NICS data.

Discussion

When applied to NICS field data, landscape metrics significantly aid the interpretation of land cover change. Interesting trends are apparent when applying metrics such as ENN, PPU and total edge. Investigation of metrics from satellite imagery suggests a high level of correlation between woodland, agricultural land cover and hard surfaces in terms of area. Other metrics such as contagion are less reliable as a number of misclassified pixels pepper the landscape. The level of correspondence between NICS data and classified satellite imagery was relatively high despite differences in typology and dates.

References

Cooper, A; McCann, T. & Meharg, M. J. (2003) Sampling Broad Habitat change to assess biodiversity conservation action in Northern Ireland. *Journal of Environmental Management* **67**: 283-290.

Frohn, R.C. (1998) *Remote Sensing for Landscape Ecology. New metric indicators for monitoring, modelling, and assessment of ecosystems.* Lewis Publishers, Boca Raton, Florida.

Zeng, H. & Wu, X.B. (2005) Utilities of edge-based metrics for studying landscape fragmentation. *Computers, Environment and Urban Systems* **29:** 159-178.

The NILS programme, monitoring the Swedish landscapes for biodiversity assessment

A. Allard,[1], P-A, Esseen[1], A. Glimskär[2], G. Ståhl[1], S. Sundquist[1], O. Inghe[3]

[1] Department of Forest Resource Management, SLU,SE-901 86 Umeå, Sweden
e-mail: anna.allard@resgeom.slu.se
[2] Department of Conservation Biology, SLU, SE-750 07 Uppsala, Sweden
[3] Swedish Environmental Protection Agency, SE-106 48 Stockholm, Sweden

Introduction

The National Inventory of Landscapes in Sweden, (NILS) is a programme for monitoring the Swedish landscapes and it has now run for some years. It was created to meet the increasing demands for information on national resources and environmental conditions. An example of such a demand is a set of 16 Environmental Quality Goals that the Swedish Environmental Protection Agency has decided upon as guidelines, and information is needed to assess if these objectives are being met. The awareness of environmental stresses has increased globally and international collaboration is needed in order to mitigate effects are on the rise. There are many and varied end-users of information and this places special demands on the type of data captured, both in terms of scales and variables.

Design

The NILS programme has chosen to capture data without pre-classification and at several scales, thus to be able to conform to, and constitute a platform for as many other programmes as possible. One inventory is made in the field and a parallel inventory is made using interpretation of colour infrared air photos, both using quantitative variables in a context-dependent flow that captures processes, habitats, structures as well as species, see Table 1. Data from the two inventories are then used for a two-phase estimation of conditions and quantities. The design is derived from a grid of landscape squares, statistically sound, which covers representative land and lake areas in the entire nation. Examples are given in Figure 1.

Collaborations and projects for development

NILS is pursuing many types of projects, from internal development projects to commissions and collaborations with research specialists and other environmental monitoring programs. Examples are to gather information about small biotopes and their management in rural landscapes for the follow-up made by the Swedish Board of Agriculture. Another example is the construction of inventories of the cultural heritage of the country. Collaboration is also being carried out to asses Fungi and the spread of disease from vector animals in an European perspective.

Always looking forward

A variety of techniques are being examined in the NILS programme involving end-users, mainly at the Remote Sensing Laboratory at SLU, for example to speed up the time used in the inventory based on aerial photography. Examples are to use laser scanned data for image matching to extract tree height and possibly get information of the floor of dense forests and thereby be able to obtain information on hydrology. Another example is automatic tree recognition, which seems promising for the northern half of Sweden, where there are few tree species.

Contact

More information is found at: http://nils.slu.se/

Table 1. The variable content in NILS (DPSIR-compatible).

Processes (***Pressure***)	Structures (***State***)
Ground disturbance	Vegetation structure
Hydrological changes	Dead wood and canopy structure
Grazing and mowing	Hydromorphological mire structures
Forestry	Linear and point features
Climate changes and air pollution	Soil properties
Habitats (***State***)	Species (***Impact***)
Forest	Vegetation-forming plants
Wetlands and shores	Epiphytes
Grassland and heath	Grasslands indicators (e.g. grazing impact)
Cliffs, rocks and other bare substrates	Game (droppings, etc.)
Man-made habitats (parks, etc.)	

Figure 1. Examples of Swedish habitat types monitored by the NILS programme.

References

Esseen, P-A; Glimskär, A; Ståhl, G. & Sundquist, S., (2006) *Fältinstruktion för nationell inventering av landskapet i Sverige, NILS*, (in Swedish), Department of Forest Resource Management, Swedish University of Agriculture, Umeå

Allard, A; Nilsson, B; Pramborg, K; Ståhl, G. & Sundquist, S., (2003) *Manual for aerial photo interpretation in the National Inventory of Landscapes in Sweden*, Department of Forest Resource Management, Swedish University of Agriculture, Umeå

Allard, A; Marklund, L; Glimskär, A. & Högström, M., (2006) *Utveckling av nationellt uppföljningssystem för småbiotoper vid åkermark*, (in Swedish), Report 158, Department of Forest Resource Management, Swedish University of Agriculture, Umeå

Glimskär, A. (2005) *Indikatorsystem för småbiotoper – metodutveckling för nationell övervakning av biologisk mångfald.* (in Swedish) Swedish Board of Agriculture, Report 2005:7, Jönköping, Sweden

Glimskär, A; Allard, A. & Högström, M., (2005) *Småbiotoper vid åkermark -indikatorer och flygbildsbaserad uppföljning i NILS*, (in Swedish), Report 134, Department of Forest Resource Management, Swedish University of Agriculture, Umeå

The National Heritage Board, (2004) *Karaktärsdrag och bebyggelsemönster - Modell för karakterisering och uppföljning inom miljömålsarbetet*, (in Swedish), Report 2004:8, Stockholm, Sweden.

Small-scale extraction of non-timber forest products in developing countries – a framework for ecological monitoring

A. Fröde

German Development Service (DED), Southern Alliance for Indigenous Resources (SAFIRE), Research and Development Section, P.O. Box 3362, Belvedere, Harare, Zimbabwe,
e-mail: alexander.froede@gmx.eu

Context

Small-scale commercialisation of Non-Timber Forest Products (NTFP) is one of the most important livelihood strategies in many woodland areas in developing countries. It was often claimed to be environmentally sustainable even without regulation (e. g. Wong *et al*., 2001). However, significant long-term decreases in ecosystem resilience, biodiversity and functional ability of the ecosystems were detected over time in numerous small-scale NTFP extraction systems. In case-specific studies, these proved to be hard to be predicted due to the complexity of woodland dynamics and human impacts (e. g. Sunderland *et al.,* 2004). In order to minimize destructive effects, ecological monitoring, i. e. the continuous collection, analysis and interpretation of data related to the environment in order to understand, determine or detect ecological trends in an area (Walsch, 2000), is of crucial importance in extraction systems. This article draws upon findings in the implementation of ecological monitoring in small-scale NTFP extraction projects led by SAFIRE (Southern Alliance for Indigenous Resources), a Zimbabwe-based non-governmental organisation.

Objectives and methodology

Against the mentioned background, an ecological monitoring framework had to be developed, which had to be easy and cost-efficient to implement and needed to provide the necessary results for decision support and NRM steering. It had to ensure compliance of the NTFP-extraction activities to ecological criteria, be based on the participation of the collectors and response to the challenging political, social and economical context in Zimbabwe.

The framework development was based on a report analysis, semi-structured interviews with stakeholders from the project context and experiences in three pilot implementations.

The monitoring framework

For all NTFP extraction activities, an expert-led ecological baseline survey is carried out at the project start. On this base, NRM plans are developed with the local users in a participatory way featuring on ecological risks and possibilities for mitigation (Sola, 2005). For the ecological monitoring, tentative indicators are finalised by a participatory methodology into a monitoring plan, which schedules for 6-monthly assessments of critical ecosystem features by key informant interviews and expert surveys. These also include Permanent Sampling. Evaluation of the monitoring results and determination of action options are carried out in community meetings and in staff workshops.

Outputs and Outcomes

An example of indicators developed and ecological risks addressed are provided in Table 1 for the mountainous woodland area of Nyanga. There, leaves from *Fadogia ancylantha* (Makoni Tea Bush) and *Myrothamnus flabellifolius* (Resurrection Tea Bush) are collected by small-scale entrepreneurs for processing and regional sale.

Table 1. Extract from Nyanga Ecological Monitoring Plan (SAFIRE 2006)

Indicator	Specifications	Ecological challenges addressed
Early/late fires per dry season	Number of fires per village, woodland/grassland area burned	Uncontrolled fires
Erosion gullies	Number of gullies wider than 1.5 m and/or longer than 3 m	Erosion
Alien plant populations	Number of *Eucalyptus* sp, *Acacia marnsii* and *Lantana camara* individuals in sampling plots	Alien plants
Number of *Fadogia* plots	Average estimated distance, time walked	Target species development
Area under Tobacco	Area under tobacco cultivation per village	Wood off-take
Trade in *Uapaca kirkiana* fruits	Amount of *Uapaca* fruits traded by collectors, distance	*Uapaca* population development

Significant effects from changes in land-use practices were already detected in the pilot implementation. Regulatory or corrective means are being developed accordingly. Amongst others, the considerable increase of the number and extent of erosion gullies over the last few years is being addressed by the local communities by reclamation and contour digging. Facts on the sharp increase of wood off-take caused by extended small-scale tobacco farming (which requires firewood for tobacco drying) calls for action by local authorities.

Conclusions

The process and the product are indicative of dealing with the challenges faced by applied landscape research and ecological monitoring in NTFP-related initiatives in developing countries: the lack of reliable baseline data, the need to define and use highly aggregated core indicators, limited financial, technical and human resources and difficulties in deducting evidence for long-term trends from locally and temporally limited natural phenomena. However, the pilot implementation has underlined the sustainability and effectiveness of the approach and calls for transfer into other projects and programmes.

References

SAFIRE (2006) *Ecological Monitoring Plan for the Makoni Tea Extraction Project in Nyanga*. SAFIRE, Harare. Internal document.

Sola, P. (2005) The Community Resource Management Plan: A tool for integrating IKS into natural resource management. *Ethnobotany Research and Applications* 3: 143-153.

Sunderland, T.C.H., Harrision S.T. 7 Ndoye, O. (2004) Commercialisation of non-timber forest products in Africa: History, context and prospects. Sunderland, T. & Ndoye, O. (Eds). *Forest products, Livelihoods and Conservation: Case Studies of Non-Timber Forest Product Systems: Volume 2 – Africa.* CIFOR, Bogor, pp. 1-24.

Walsch, A. (2000) *Participatory Environmental Monitoring: A Facilitators Manual.* German Foundation for International Development, Bonn.

Wong, J.L.G, Thornber, K. & Baker, N. (2001) *Resource Assessment of non-wood forest products: Experience and biometric principles.* FAO, Rome.

Monitoring landscape changes in the Netherlands

A.J.M. Koomen[1], W. Nieuwenhuizen[1], D.J. Brus[2], L.J. Keunen[1], G.J. Maas[1], T.N.M. van der Maat[1], T.J. Weijschede[1].

[1] Wageningen University and Research Centre, Alterra, Landscape Centre, P.O. Box 47, 6700 AA, Wageningen, Netherlands.
E-mail: Arjan.koomen@wur.nl
[2] Wageningen University and Research Centre, Alterra, Soil Centre, P.O. Box 47, 6700 AA, Wageningen, Netherlands.

Introduction

Monitoring landscape changes in the present-day landscape are generally approached from the perspective of biodiversity related to climate change. Another important approach for monitoring landscape is from a perspective of landuse, geomorphology and historical geography. These characteristics of the landscape function as a base for biodiversity and are therefore of equal importance. The geomorphological and historical geographical values are recognized as important by the Dutch government as most of the recent spatial developments have a deteriorating effect. Therefore a monitor system has been developed primarily aiming to describe changes in relation to these landscape qualities.

Method

A new monitor (*Steekproef Landschap*) for the Netherlands has been developed aiming to describe recent changes over the period 1996-2003 in landscape using probability sampling in 72 study areas with an extent of 1 square kilometre, using the characteristic Dutch landscape types as strata. In addition to this a map displaying ‘spatial pressure’ for future claims was used to further stratify the study areas so that the majority would be situated in areas with a higher ‘spatial pressure’. The year 1996 was used as a reference for establishing changes. Within the study remote sensing (aerial photographs, digital elevation data) in combination with detailed topographic maps and field investigation was used to describe changes in land use, patterns of cultural history (such as old roads, waterways, green lineair elements, land reclamation patterns) and geomorphology. Assessing data from the field was expected to give valuable and additional information next to the use of digital information and aerial photographs. All data has been statistically processed taking into account the stratification used.

Results

Results on the development of the Dutch landscape have been obtained for the period 1996-2003. Due to ground works related to urbanisation, agricultural adaptations and nature development (table 1) significant areas have lost their geomorphological identity. This is also the case for the features that reflect the historical development of landscapes (figure 1). Urbanisation obviously has a large influence on the land use that reflects a growing urban environment including additional changes linked to the transformation from rural to semi-urban in rather large areas surrounding the urban zones.
Table 1 shows that 1.5% of the rural landscape has been transformed into urban areas. The numbers are lower for agriculture and nature development but the combined effect makes clear that more than 2.4% of the rural landscape has been changed in a 7 year period. The effects these spatial developments have on the the geomorphological and historical geographical values are significant. The small scale relief elements and lineair green and blue historical elements rapidly disappear. This means for instance that small scale relief elements will have been completely erased within the next 40 years.

Table 1. Major changes in land use for the Netherlands 1996-2003.

Type of land use	Change in ha/100 ha	Total in ha (extrapolation)
Urbanisation	1.5	46.064
Agriculture	0.6	17.594
Nature development	0.3	8.957

Discussion

Method and results trigger a discussion that narrows down to two topics. The first is the number of study areas in relation to the level at which conclusions can be drawn. The number of 72 study areas allows significant conclusions to be drawn on the level of the Netherlands but not or only partly for the different landscape types that have been used to stratify. How many study areas does one need to incorporate to enable conclusions of the level of landscape types? This is dependent on the specific indicator and the quantity of change it shows.

The second topic for discussion is the use of field work. Is it really necessary (high costs) and does it contribute to the final results? Analysis shows that without field work about 40% of the small scale changes that influence geomorphological and historical geographical values will be missed when complete relying on digital land use maps. This primarily concerns small scale ground works (levelling) related to agricultural land use.

Conclusions

Four main conclusions can be drawn on basis of the result of this monitoring study:

1 – The rate of changes in land use in the Netherlands between 1996 and 2003 is high and dominated by urbanisation, agriculture and nature development;

2 – The changes in land use lead to significant loss of geomorphological and historical geographical values

3 – Fieldwork is essential for a good assessment as national digital data generally do not signal local and small scale changes.

4 – To enable conclusions for landscape type the number of study areas should be increased to allow significant conclusions.

References

D. J. Brus, W. Nieuwenhuizen and A. Koomen, 2006. Can we gain precision by sampling with probabilities proportional to size in surveying recent landscape changes in the Netherlands? Environmental Monitoring and Assessment (2006) 122: 153–169.

Koomen, A.J.M., W. Nieuwenhuizen, D.J. Brus, L.J. Keunen, G.J. Maas, T.N.M. van der Maat, T.J. Weijschedé, 2004. Steekproef landschap; actuele veranderingen in het Nederlandse landschap. Alterra report 1049, Wageningen, the Netherlands

Why is strategic conservation monitoring so rare in Europe?

R.G.H. Bunce, R.H.G. Jongman

Alterra, PO Box 47, 6700 AA Wageningen, The Netherlands.
e-mail:bob.bunce@wur.nl

Introduction

Landscape ecology has still not made a significant impact on policy makers and planners in Europe. who are concerned with strategic conservation planning.. In contrast, many papers in this congress provide worked examples of the successful implementation of landscape ecological principles into general planning. The present paper examines some of the reasons for this discrepancy.
The main reason is that many conservation agencies do not appreciate the need for objective figures on change nor the need to sample landscape complexity. Conservation managers are also not familiar with the methods of sampling, statistical procedures and analysis developed by landscape ecologists in recent years. Conservation priorities have been determined mainly by expert committees –for example the categories of the Habitats Directive (Council Directive 92/43/EEC) involve such diverse criteria that they are difficult to record consistently in the field.

European databases

The European databases that are available do not have the level of detail required to cover the necessary information on biodiversity eg habitats and vegetation. They do however have potential for converting in situ information into synoptic coverage .For example the CORINE Land Cover Map has complete coverage of the EU but the basic unit of 25ha inevitably misses any changes which involve smaller units as shown by Levin (2006).Other biodiversity databases do not contain sufficient detail for monitoring eg CORINE biotopes covers only the presence of categories and varies according to national definitions eg France has e few large sites and Italy many small ones.
Another difficulty is that there are no common standards between countries because member states have pursued there own agenda. However, recent work on habitats has shown that general habitat categories Bunce et al (2005) can be used to incorporate extant data, (Bloch-Petersen et al (2006)) indicating that, if sufficient financial resources were made available, then European figures could now be produced. It is now technically possible to link in situ data with satellite imagery, so that if all the sources of information were coordinated and modern high resolution satellites were used, then major advances could be made. However, such methods are unlikely to have sufficient replicates to adequately estimate changes in the small area of land under protection.

Natura 2000

The main European initiative specifically related to nature conservation is the Natura 2000 series of sites (http://ec.europa.eu.environment/nature/home.htm) and it is obligatory for member states to undertake monitoring in these sites to ensure that Favorable Conservation Status (FCS) is maintained. Whilst the requirements of the EU are laid out eg setting priorities for further monitoring, these have been interpreted in different ways by the member states. Local site managers are also directly involved with their individual conditions and have no reason to be concerned about transfer of any data collected to a European database. There is therefore not only the problem of compatibility of data but also any European monitoring scheme will need to deal with dispersed sites covering under 10% of the land and often in unique situations. Such sites should not be considered in isolation and it is not only necessary to set them in context, but also to have controls against which to measure the efficiency of the protection measures. This has been recognized in the assessment of the efficiency of European agri-environmental schemes eg in the UK and Austria, where farms inside and outside schemes were compared.

The ECOLAND Forum, a IALE working group on countryside and landscape monitoring in Europe, has had two meetings to discuss monitoring in Natura 2000 sites because of their importance. At the first meeting the general characteristics of the series were discussed. The sites vary in size from hundreds of square kilometers to a few hectares and, whilst some contain only semi-natural vegetation, others have a wide range of habitats including urban and industrial developments. The reasons for designation vary from individual species to extensive habitats and the information on their distribution and character is variable. There are therefore both scientific and practical issues involved. In developing monitoring protocols. The second meeting was held in the field to examine actual rather than theoretical problems of monitoring a large site (about 250 square kilometers) in south-east Spain. Initial field visits showed that unless local knowledge was available, it was not possible to assign habitats to those described in The Habitats Directive and which are needed for determining the FCS of the site. Many of those habitats had a very restricted distribution in the site. Mapping of habitats was tested in stratified 1 kilometre squares and, with local experts present, it was possible to identify and map widespread key habitats. It was concluded that a range of stratifications would need to be applied for scarce habitats or a separate procedure involving local knowledge could be used to identify very rare point features and a separate monitoring protocol would be then be needed for objective monitoring -eg random vegetation plots. It was also decided that an expert system formalizing local experience was required enable the information from the Habitats Directive to be converted to a repeatable system that could be transferred between sites and countries. The first stage of such a system could use the General Habitat Categories of Bunce et al (2005) as a framework, followed by site data, geographical location, species information from the Habitats Directive and finally where necessary, expert knowledge. Examples of such an expert system have been prepared.

Conclusion

Europe therefore has no coordinated programme for monitoring the wider countryside or key conservation sites. However, landscape ecologists in several countries have now developed sufficient experience to design appropriate protocols to fill this gap.

References

Bloch- Petersen M., Brandt J., & Olsen M. (2006). Integration of European habitat monitoring based on plant life form composition as an indicator of environmental change and biodiversity. Geog.Tids.106. p61-74

Bunce,R.G.H., Groom, G.B., Jongman, R.H.G. and Padoa Schioppa, E. (2005) Handbook for Surveillance and Monitoring of European Habitats .Alterra-Rapport 1219.Wageningen.The Netherlands

Levin,G., (2006). Farm size and landscape composition in relation to landscape change in Denmark. Geog.Tids. 106 p 45-60.

Indicators to Monitor changes and conservation in Natura 2000 sites: A focus on drivers, pressures and states

S. Luque [1], J. Pino [2], C. Basnou [2], R. Swetnam [3], C.A Mücher[4], G. Hazeu [4], L. Halada [5], F. Gerard[3]

[1]Cemagref, Groupement de Grenoble, UR AMM, 2, rue de la papeterie, BP 76, F-38402, St-Martin-d'Hères, cedex, France,
e-mail: sandra.luque@cemagref.fr
[2]Center for Ecological Research and Forestry Applications, CREAF, Universitat Autonoma de Barcelona, E-08193, Bellaterra, SPAIN, 3.
[3]Centre for Ecology and Hydrology, CEH, Monks Wood, Abbots Ripton, PE28 2LS, Huntingdon, Cambridgeshire, United Kingdom
Alterra, Centre for Geo-Information, PO Box 6780 AA, Wageningen, The Netherlands
[5] Institute of Landscape Ecology of the Slovak Academy of Sciences, ILE SAS, Stefanikova 3, PO Box 254, 814 99 Bratislava, Republic Of Slovakia

Introduction

In 2004, the European community adopted a framework within which indicators could be identified to facilitate the assessment of progress towards the 2010 target for biodiversity and communication of this evaluation (EEA-ECNC 2004). A few indicators were considered ready for immediate use. However it was recognized that new indicators were required to enable the assessment of progress towards the agreed goals and targets, taking into account indicators that were developed through other processes for regional (e.g. Pan-Europe and European Union) and national use. To contribute to this framework, in this work changes were examined over the last 50 years in selected transects over Europe.

The research was carried out within the framework of the BIOPRESS (EC-FP5 project to support GMES 'Global Monitoring for Environment and Security') project and AlterNET (A Long-term Biodiversity, Ecosystem and Awareness Research Network – EU-FPVI).

The paper focus on the discussion of the results obtained from analysing historic Land Cover Changes (LCC) in relation to patterns and processes for selected Natura 2000 sites. We quantified pressures on biodiversity (urbanisation, arable intensification, afforestation, deforestation, abandonment and drainage) associated with land cover changes within the framework of DPSIR (DPSIR - Driving forces, Pressures, States, Impacts and Responses model). In this way, in order to understand the driving forces and patterns behind the observed changes, we look at the consequences of the observed LCC on biodiversity for selected transects across Europe. Results show the performance of landscape level indicators to understand pressures at the biodiversity level. Particular emphasis was placed on to the analysis of patterns derived from different pressures in order to understand the relationship between observable patterns and driving forces causing changes that occurred during the study period (1950's – 2000).

Methods

The methodology, utilises archived historic and recent aerial photographs (a data source that has remained consistent over the last 50-60 years) to assess land cover change around Natura 2000 sites within 15 x 2 km transects from partner countries (United Kingdom, Spain, Finland, The Netherlands and Slovakia) (See Gerard et al. 2006).

The data consisted of 40 transects from five European countries. Landscape metrics were calculated for each of the transects using fragstats. From the 53 landscape metrics calculated only seven were analysed after performing a selection using Pearson's correlation coefficient ($r > 0.75$). The total variance explained was calculated with factorial analysis.

Three input data sets corresponding to the years 1950's, 2000 and changes were used for the analysis after eliminating the correlated variables.

Results

Canonical Variate Analysis (CVA), better known as Fisher linear discriminant analysis (Braak & Smilauer 2002) provided a good separation between observations from 1950's and 2000 ($p<0.002$). Changes in the European landscape from the 50's are important mostly in terms of pressures from urbanisation and agricultural intensification. The amount of land cover changes at CORINE level one (e.g. from agriculture to urban) increased with the distance outside Natura 2000 sites and decreases with the distance inside Natura 2000 sites. Furthermore, the types of land cover changes are very different inside from outside the Natura 2000 sites. In all, protection measures within Natura 2000 sites seems to have a positive influence on the type of land cover changes and their acreage. But at the same time it must be noted that conservation sites are becoming more isolated. We should therefore be concerned about changes taking place outside protected areas to maintain a sustainable habitat in terms of biodiversity quality towards the CBD 2010.

In the overall the landscape matrices studied for Europe showed an important division within the study period. In particular, Finland, Spain and the Netherlands are in the group with a very strong association with the Splitting Index (SPLIT), showing a landscape configuration with an important level of division. This loss of continuity is also evident for the United Kingdom and Slovakia in a second group that is associated with the increase on edge density. On the other hand, the previous configuration in the 1950's represented a more complex and connected matrix in particular for Spain and Finland.

The methods used are transferable and applicable to a wide range of landscape studies. The demonstrated methodology could be applied to general monitoring of landscape change or to more localized areas such as the landscape surrounding environmentally protected sites, as showed for Natura 2000 in Europe. Historic aerial photographs, once digitized, could provide an important tool for monitoring when combined with landscape metrics.

References

ECNC, EEA, UNEP, Council of Europe (2004) Joint meeting on development of plan and guidelines for indicators and monitoring to achieve the 2010 target for biodiversity in Europe. EEA in Copenhagen 21-23 April 2004. 26pp

Gerard, F.; Gregor, M.; Luque, S.; Huitu H.; Köhler, R.; Olschofsky, k.; Hazeu, G.; Mücher C.A.; Halada L.; Bugár G; and Pino J. (2006) Land Cover Change in Europe from the 1950'ies to 2000. Aerial Photo Interpretation And Derived Statistics From 59 Samples Distributed Across Europe. Edited by Raul Köhler, Konstantin Olschofsky. University of Hamburg, World Forestry Institute, Germany. 364 pp.

Ter Braak, C.J.F. & Smilauer, P. (2002) CANOCO Reference manual and CanoDraw for Windows User's guide: software for Canonical Community Ordination (version 4.5). Microcomputer Power (Ithaca, NY, USA), 500pp

Towards a standardized biodiversity assessment approach in topographically complex landscapes

G. Hofer[1], F. Herzog[1], H.H. Wagner[2], R.G.H. Bunce[3], P.J. Edwards[4]

[1] ART Agroscope Reckenholz, Swiss Federal Research Station for Agroecology and Agriculture, 8046 Zürich, Switzerland,
e-mail: gabriela.hofer@art.admin.ch
[2] WSL, Swiss Federal Research Station for Forest, Snow and Landscape, 8903 Birmensdorf, Switzerland
[3] Alterra, P.O. Box 47, 6700 AA Wageningen, The Netherlands
[4] Geobotanical Institute, Swiss Federal Institute of Technology, ETH, 8092 Zürich, Switzerland

The high plant diversity of mountainous farmland is increasingly threatened by land use change (MacDonald *et al*. 2000), and sensitive biodiversity indicators and efficient sampling designs are needed to monitor these areas. Although measures of habitat heterogeneity are often used as indicators for species diversity in agricultural landscapes (Benton *et al.* 2003) these usually assume a patch-mosaic model of the landscape, with homogenous patches and clear borders between patches. Mountain areas, however, exhibit gradual shifts within and between land units and so do not fit the patch-mosaic model well (McGarigal & Cushman 2005). To estimate species diversity in mountain areas, more appropriate heterogeneity indicators are needed which allow for gradual shifts and heterogeneous patches.

Topography is known to affect the variability of abiotic microsite conditions (*Swanson et al.*1988), which in turn affect vegetation and landuse patterns. In this study, we investigated effects of topographic variables from a digital elevation model on the variability of plant species richness and composition within and between local landscapes to develop a standardized and generally applicable sampling approach for topographically complex areas.

Within a biogeographically and climatically homogenous dairy farming area of 250 km^2 in the Swiss pre-Alps, 12 local landscapes of 1 km^2 were selected and plant species of 40 micro sites were recorded within each. Topography was integrated into the sampling design at two levels: 1) at landscape level to sample local landscapes randomly along a gradient of topographic variability within the study area, and 2) within coarse habitat types to maximize the environmental range among plant species relevées within each local landscape. Linear regressions were used to analyse the effect of topographic variability of local landscapes on alpha and beta components of species richness at landscape, habitat and microsite levels. Multivariate analyses were used to analyse species composition at landscape and microsite level.

All components of species richness increased with topographic variability of local landscapes at all levels of analysis (Figure 1). The main shifts in species composition at landscape level correlated with topographic variability (0.82) and also with mean nitrogen (-0.91), humidity (0.66) and pH (-0.66) indicator values of the plant communities. In the model to explain species composition at the microsite level, including topographic variables as well as habitat types increased the variance explained by 54 percent.

These results indicate that topographic variability is appropriate to estimate potential relative differences in species richness at landscape level. To assess biotic heterogeneity the ecological range can be efficiently covered by maximizing the gradient of topographic variability between samples of local landscapes and between species relevées within local landscapes. As this approach is based on maximizing relative differences between samples within defined units, it is independent of expert knowledge, which is important for an approach of general applicability.

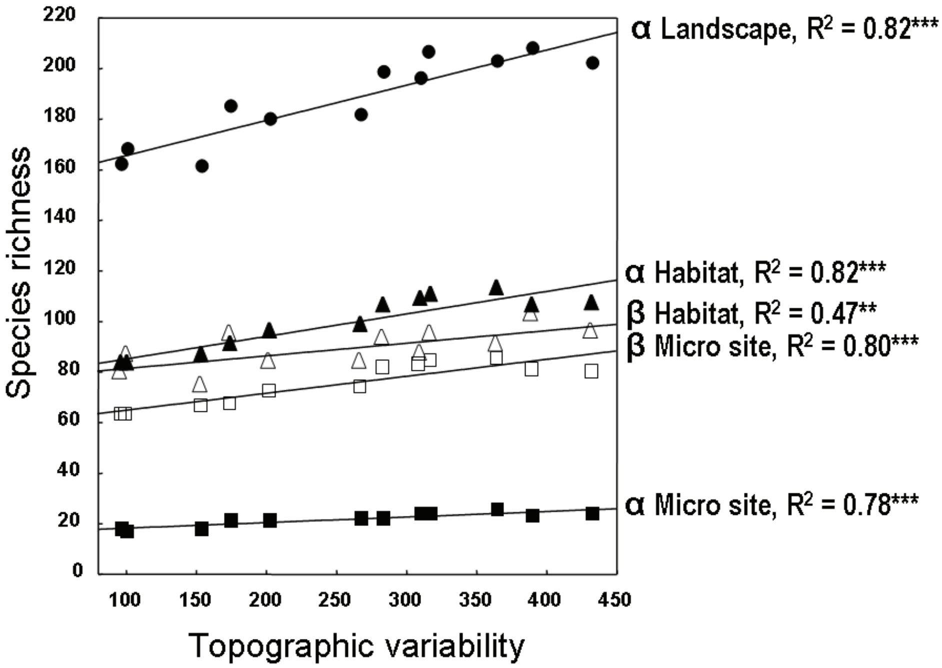


Figure 1. Effects of topographic variability of the landscape on α and β species richness components at microsite (squares), habitat (triangles) and landscape level (points). Each symbol denotes for a species richness component of one local landscape (*=p<0.05, **=p<0.01, ***=p<0.001).

References

Benton, T.G., Vickery, J.A. & Wilson, J.D. (2003) Farmland Biodiversity: Is Habitat Heterogeneity the Key? *Trends in Ecology and Evolution* 18, 182-188.

MacDonald, D., Crabtree, J.R., Wiesinger, G., Dax T., Stamou, N., Fleury, P., Lazpita, J.G. & Gibon, A. (2000) Agricultural Abandonment in Mountain Areas of Europe: Environmental Consequences and Policy Response. Journal of Environmental Management 59, 47-69.

McGarigal, K. & Cushman, S. (2005) The gradient concept of landscape structure. J. Wiens and M. Moss (Eds.) Issues and Perspectives in Landscape Ecology. Cambridge University Press, Cambridge, pp. 112-119.

Swanson, F.J., Kratz, T.K., Caine, N. & Woodmansee, R.G. (1988) Landform Effects on Ecosystem Patterns and Processes. *Bioscience* 38, 92-98.

Landscape monitoring of Spain based on air photo interpretation of a stratified network of land samples

R. Elena-Rosselló[1], J. Manuel García del Barrio[2], F. Bolaños[1], V. Gómez-Sanz[1], M. Ortega[2], C. García-Feced[1], S. González[1]

[1] Departamento de Silvopascicultura. Escuela Universitaria de Ingenieros Técnicos Forestales. Universidad Politécnica de Madrid. Ciudad Universitaria s/n. 28040 Madrid. Spain. e-mail: ramon.elena.rossello@upm.es

[2] Centro de Investigación Forestal. Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria. CIFOR-INIA. Carretera de la Coruña KM 7,500. 28040 Madrid, Spain.

Landscape monitoring of Spain has been carried out by developing a system called *SISPARES (**SIS**tema **PA**isajes **R**urales **ES**pañoles)* (Bolaños, *et al*, 2003). This system is based on the principles of (1) land stratification for selecting representative samples and (2) air photo interpretation for measuring and modeling their landscape spatial structure. The land stratification is based on a previously developed biogeoclimatic land classification *CLATERES* (Elena-Rosselló, 1997). The selected landscape samples are objectively representative of the land ecological structure of Spain and consequently, their evaluation can be statistically extrapolated for providing consistent national figures.

SISPARES has two main components: (a) *REDPARES* the Network of Spanish Rural Landscapes, with 215 samples, and (b) *SIGPARES* the Geographical Information System, where the information from surveys is stored and processed. At the moment, three overall surveys have been carried out: 1956, 1984 and 1998, and a fourth is to be done based on 2004 aerial photos.

Results from the surveys showed the potential of *SISPARES* for evaluating habitat and landscape spatial pattern. One of the best values of *CLATERES* as land stratification system arose when checking the correlation between habitat and landscape composition and land biogeoclimatic values (Ortega et al., 2006). Forest habitats declined following the main aridity gradient, as agricultural habitats increased their own presence. At the same time, landscape diversity reached the highest value in the middle of the environmental gradient.

Other important results showed the potential of the land classification for monitoring habitat changes. After three landscape surveys, statistically significant evaluation of the changes have being carried out, on features such as ecological quality, naturalness, fragility, accessibility etc.

*A*mong other national European experiences, *SISPARES* has been considered as a sound methodological contribution to the *BIOHAB* project.

Understanding the causes and consequences of landscape change: lessons from the British Countryside Survey monitoring programme

S.M. Smart[1], S. Petit[1], D.C. Howard[1], L.C. Maskell[1], L.R. Norton[1], R.C. Stuart[1], R.G.H. Bunce[2]

[1] Centre for Ecology and Hydrology, Lancaster Environment Centre, Bailrigg, LA1 4AP Lancaster, UK.
e-mail:ssma@ceh.ac.uk
[2] Alterra Green World, PO Box 47, 6700AA Wageningen, The Netherlands

Introduction

Over the last 40 years the Centre for Ecology and Hydrology has developed an integrated procedure for sampling at the landscape level in order to follow changes in a range of ecological parameters in space and time as described by Sheail & Bunce (2003) .This long term monitoring programme is designed to assess change in the extent and change in ecological parameters at the landscape level. Information is recorded in 1 km square samples randomly stratified in the country according to 40 Land classes sharing similar broad environmental characteristics Countryside surveys have taken place in 1978, 1984, 1990, 1998 and the fifth survey is currently underway in 620 1km square in Great Britain but also simultaneously in Northern Ireland. During the surveys, land use and landscape features such as hedgerows and ponds are recorded in the field and digitally mapped. The concept is to obtain an overall picture of what is happening in a range of different landscapes distributed to be representative of the UK. The vegetation data has been very successful in showing that changes in quality rather than the extent of habitats, is the recent trend in British landscapes. One overriding success of the approach, which involves quality control and assessment at all stages, is that the results are widely accepted by all national agencies.

Changes in vegetation and habitats

The results from the 1990 survey (Barr *et al*., 1993) showed that the major losses of habitats that had taken place because of the intensification of agriculture since the war had begun to slow down. However an exception was the length of hedgerows which are a central feature of British landscapes which had declined over 20% in the nine years since the previous survey. The major impact of the survey was however in the significant loss of species from many habitats - eg over 20% in relatively infertile grasslands that had stayed as the same habitat since 1978. Even the fields of crops had lost up to 20% of species over that period despite the intensive use of herbicides for many years. These losses involved not only botanical but associated biodiversity such as farmland birds and butterflies. Examination of the ecological consequences of these changes (Bunce *et al.* (1999) and Firbank et al. (2000).) showed that there were several dominant drivers such as eutrophication, more intensive farm practices and lack of management of linear features which had led to these losses. The survey carried out in 1998 (Haines-Young *et al*., 2003) confirmed that the rate of habitat loss had slowed but species losses continued.

Landscape ecological implications

Countryside Surveys indicate that land use is undergoing important changes across Britain and that although some trends are common, e.g. fewer but larger parcels of arable land, specific regional patterns can be identified . In particular, the potential for land use intensification seems to have been almost reached in some areas whilst other regions are currently experiencing important transformations including the rapid fragmentation of grasslands. The probability of such changes occurring at the field level clearly depends on spatial attributes such as the size of individual parcels and the amount of intensive land use within 1 km squares (Petit & Firbank, 2006). In parallel, landscape heterogeneity within 1 km squares seems to have increased in some areas of Britain (Haines-Young *et al*., 2003). These could be related to different processes including urbanisation and new woodland planting (Petit et al (2004a)).In terms of vegetation, regional trends segregate into a non-random draw of traits related to reproduction, dispersal and establishment (Smart *et al*., 2006a). The profile of 'winning' versus 'losing' plant species differs between habitat types suggesting the conditional effect of land use (Smart *et al*., 2006b). There is an overall positive relationship between the diversity of the land and plant species richness. Landscape structure is also affecting targeted functional groups of plant species, with clear regional patterns. For example, the size and isolation of woodland patches are strongly constraining the occurrence of specialist woodland species in the lowlands while no such effect could be detected in the uplands (Petit *et al*., 2004)

.

References

Barr C.J., Bunce R.G.H., Clarke R.T., Fuller R.M., Furse M.T., Gillespie M.K., Groom G.B., C.J., Hornung M., Howard D.C., Ness M.J. (1993) *Countryside Survey 1990: main report*, London: Department of the Environment..

Bunce R.G.H, Smart S.M., van de Poll, H.M., Watkins, J.W, Scott, W.A. (1999) *Measuring change in British vegetation*. ECOFACT vol. 2. London: Department of the Environment, Transport and the Regions.

Firbank, L.G., Smart S.M, Bunce, R.G.H, Hill, M.O., Howard, D.C., Watkins, J.W. and Stark, G.J. (2003) *Causes of change in British vegetation*. ECOFACT vol. 3. London: Department of the Environment, Transport and the regions.

Haines-Young, R., Barr, C. J., L.G., F., Furse, M., Howard, D. C., McGowan, G., Petit, S., S.M., S. & Watkins, J. W. (2003) Changing landscapes, habitats and vegetation diversity across Great Britain. *Journal of Environmental Management 67:268-281*

Petit, S., Howard, D,C., & Stuart R.C. (2004 a) A notional perspective on recent changes in the spatial characteristics of woodland in the British landscape.Landscape and Urban Planning **69**:127-35.

Petit, S., Griffiths, L., Smart, S.S., Smith, G.M., Stuart, R.C.& Wright, S.M. (2004) Effects of area and isolation of woodland patches on herbaceous plant species richness across Great Britain. *Landscape Ecology* **19**: 463-471.

Petit, S., Firbank L.G. (2006) **Predicting the loss of semi-natural habitat to intensive agriculture at the national scale. *Agriculture, Ecosystems and Environment*** 115**: 277-280.**

Sheail J., Bunce R.G.H. (2003) The development and scientific principles of an environmental classification for strategic ecological survey in the United Kingdom. *Environmental Conservation* **30**: 147-159

Smart, S. M., Clarke, R. C., van de Poll, H. M., Robertson, E. J., Shield, E. R., Bunce, R. G. H. & Maskell, L. C. (2003) National-scale vegetation change across Britain; an analysis of sample-based surveillance data from the Countryside Surveys of 1990 and 1998. *Journal of Environmental Management* **67**: 239-254.

Smart S.M., Thompson K., Marrs R.H., Le Duc M.G., Maskell, L.C. and Firbank, L.G. (2006a) Biotic homogenization and changes in species diversity across human-modified ecosystems. *Proceedings of the Royal Society B-Biological Sciences* **273**: 2659-2665

Smart S.M., Marrs R.H. Le Duc M.G., Thompson K., Bunce R.G.H., Firbank L.G. (2006b) Spatial relationships between intensive land cover and residual plant species diversity in temperate farmed landscapes *J. Appl. Ecol.* **43**: 1128-1137

A landscape integrated analysis and classification: application to a river valley in central Spain

A. Patrono[1], A. Saldaña López[2], A. Gómez Sal[2]

[1] European Union Satellite Centre – Apdo. de Correos 511, 28850 Torrejón de Ardoz (Madrid), Spain.
e-mail: a.patrono@eusc.europa.eu
[2] Department of Ecology, Faculty of Sciences, University of Alcalá – Ctra. Madrid-Barcelona Km 33.6, 28871 Alcalá de Henares (Madrid), Spain

Introduction

A method for landscape analysis and classification is presented. The method takes into account quantitative techniques to integrate biotic and abiotic variables (transformed into continuous ranges), minimizes subjective interpretations and avoids the predefinition of spatial regular units or constraints associated to a specific study area or scale. The purpose was to obtain a coherent organization of the land in some synthetic terrain units to be used in landscape analysis.

Material and methods

Study area and data

A set of environmental variables was considered to explore the landscape of the Lozoya River valley, located on the southern slope of the Guadarrama mountain range (Madrid, Spain). Topographic variables include the DTM and the slope. Climatic variables include the precipitation and mean annual temperature range, modelled using the DTM and watershed information. Irradiance (potential) was calculated modelling the yearly illumination condition. Soil variables were estimated from profile descriptions. Land-use variables were derived from a multi-temporal set of Landsat imagery, classified with a maximum likelihood algorithm to obtain the probability distributions of 10 pre-selected land cover classes.

Ecological classification

The approach sought a compromise between simplifying the spatial variability given by all possible combinations among variables (20) and the need of delineating terrain units with a feasible area and degree of homogeneity (Bryan, 2006). The method analysed the loss of internal variability (estimated by the standard deviation) within the terrain units defined by segmenting the area into an increasing number of clusters with the Isodata algorithm (Duda and Hart, 1973). The objective was to define the limit from where any further segmentation did not produce any remarkable change. The trend analysis was done by fitting a function to the clustering scores whose first derivative represented the rate of variability loss (Patrono and Saldaña, 2006). The resulting units were grouped into classes characterised by a unique combination of variables scores and transformed into a vector database.

Multivariate statistical methods were applied to examine the ecological significance of the obtained landscape classification. Principal Components Analysis was used to reduce the size of the database, minimising the loss of information. The relations among the transformed 20 variables were studied with a cluster analysis whose result was over-imposed on the vector space generated by the factor coordinates of the variables (Jongman *et al.*, 1987).

Results

The result of the classification yielded 40,538 homogeneous terrain units grouped into 962 classes. The derived vector database represented less than 2% of the original data volume. PCA successfully reduced the size of the database (the first eight principal components captured over 92% of the variation in the 20 input parameters). The result of the cluster analysis overlaid on the ordination by the first two principal components (Figure 1) highlighted the relations of the environmental variables scores that typify the terrain units. The grouping of the variables defined two main clusters that tended to characterize mountainous and valley bottom ecosystems respectively. Several subgroups could be defined in the two clusters. For example one gathered the variables typifying higher elevation ecosystems (including mountainous shrublands), one grouped more developed soils (including juniper stands) and one comprised a subgroup with deciduous and evergreen oak forests, dehesas, grasslands and shrublands (dominated by Spanish lavander).

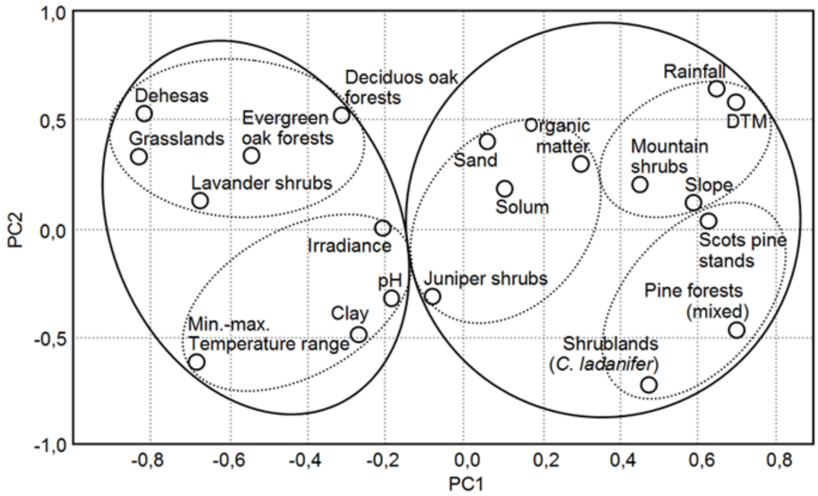


Figure 1. Ordination by the first two principal components of the transformed 20 variables. The result of the cluster analysis is overlaid.

Discussion and conclusion

The results confirmed that the proposed method could be used to summarize landscape complexity. In addition to an important data reduction, a systematic landscape subdivision into homogeneous and ecologically meaningful elements was obtained, minimising subjectivity and constraints. The result could be mapped at detailed scale and in a robust manner which offers environmental specialists a spatial database open to multiple applications as verified in the analysis of the relations and the ecological significance of the environmental variables that characterize the terrain units.

References

Duda, R.D & Hart, P.E. (1973) *Pattern Classification and Scene Analysis.* John Wiley and Sons, New York.

Bryan, B.A. (2006) Synergistic Techniques for Better Understanding and Classifying the Environmental Structure of Landscapes. *Environmental Management* **37(1)**: 126–140.

Jongman, R.H.G., ter Braak, C.J.F. and van Tongeren, O.F.R (1987) *Data Analysis in Community and Landscape Ecology*, PUDOC Scientific Publ., Wageningen.

Patrono, A. & Saldaña, A. (2006) A proposal for a landscape integrated classification. A. Marçal (Ed). *Global Developments in Environmental Earth Observation from Space*. Millpress, Rotterdam, pp. 233-240.

Optimising thematic resolution of landscape metrics for biodiversity monitoring in rural Europe

D. Bailey[1], R. Billeter[2], S. Aviron[1], M. Parracchini[3], O. Schweiger[4] and F. Herzog[1]

[1] Agroscope Reckenholz-Tänikon Research Station ART – Reckenholzstr. 191, CH-8046 Zurich, Switzerland.
e-mail: debra.bailey@art.admin.ch
[2]ETH Swiss Federal Institute of Technology, Geobotanical Institute, Zurichbergstr. 38, CH-8044 Zurich, Switzerland.
[3]Joint Research Centre of the European Commission, Institute for Environment and Sustainability, Rural, Water and Ecosystem Resources Unit, TP 262, 21020 Ispra, Italy
[4]UFZ - Centre for Environmental Research, Department of Community Ecology, Theodor-Lieser-Strasse 4, D-06120 Halle, Germany

Introduction

There is an urgent requirement for relatively cheap and rapid methods for monitoring the status of biodiversity in agricultural landscapes. Most direct monitoring methods are expensive requiring extensive field work and the use of multiple species groups with contrasted ecological requirements. The potential use of landscape metrics as inexpensive indicators was proposed by O'Neill *et al.* (1988). Whilst the identification of a generic set of metrics is challenging due to map interpretation issues, spatial scale and ecological appropriateness, it is widely acknowledged that biodiversity depends on landscape properties. Here we identify landscape pattern metrics that act as indicators for biodiversity in the context of monitoring Temperate European agricultural landscapes. As the affectivity of metrics will be highly influenced by the map classification (Bailey *et al.* 2006[a]) we explore the role of thematic resolution and examine a suite of biological and functional groups.

Materials and methods

Twenty four study sites of 16 km^2 were located within arable landscapes of seven temperate European countries. Land cover was digitised using recent orthophotos and classified using an adaptation of the European EUNIS habitat classification system (Davies and Moss 1999).To study the response of biological groups to landscape metrics at different thematic resolutions, the original land cover maps (47 habitats) were reclassified using three coarser classification systems (2, 3 & 14 habitats). The four resolutions were considered appropriate to taxonomic and functional biodiversity. Forty-one common landscape-level metrics representing five main aspects of landscape structure (grain, edge, shape, configuration, diversity) were then calculated using FRAGSTATS 3.3 (McGarigal *et al.* 2002). Manageable subsets of metrics for each thematic resolution were them obtained using exploratory analysis (Bailey *et al.* 2006[a]). Biodiversity of the sites were assessed using taxonomic groups that have different ecological requirements (plants, birds, wild bees, true bugs carabid beetles, hoverflies and spiders). The arthropod groups were also divided into functional groups representing body size. Linear mixed models were used to detect correlations between metrics and species richness values (Bailey *et al.* 2006[b]).

Results - discussion

The exploratory approach to landscape-level metric selection allowed for both the identification of metrics and the general areas of landscape pattern which correlate with taxonomic and functional groups at the different levels of thematic resolution. Few landscape-level metrics correlated significantly with the biodiversity data at the coarser scales of thematic resolution and grain metrics (patch density, largest patch index) were the only measures to correlate with perhaps the more robust biological groups (plants, large sized arthropods). At the fine scale of thematic resolution there were also few significant correlations with the biodiversity data and a diversity metric (e.g. Simpson's diversity index) was the most appropriate measure when using relatively heterogeneously defined biological groups. The intermediate thematic resolution offered most promise for biodiversity monitoring. Many metrics were significantly correlated to most taxonomic and functional groups. Metrics suitable to monitor biodiversity at this level of thematic resolution include the largest patch index, edge density, nearest neighbour, the proximity index, circle and Simpson's diversity index. The correlation of landscape-level metrics with biodiversity groups were therefore sensitive to thematic resolution and an intermediate scale proved the most informative for both taxonomic and functional groups. Our results show how very coarse parameters of landscape structure calculated at the intermediate scale can indicate whether landscapes are likely to sustain biodiversity. Higher biodiversity, for example, can be expected in European agricultural landscapes which have a greater habitat diversity (Simpson's diversity index), large variations in patch distribution (nearest neighbour) and more edge and patchy habitats (edge and patch density).

Conclusions

The thematic scale issue should not be underestimated. If simple landscape classifications have been used it is perhaps easier to choose metrics using an expert approach as the main effect of landscape pattern is likely to be a species-area relationship. High thematic resolution data is unlikely to correlate with generally defined biological groups and should be used to answer specific research questions related to carefully defined species data. Our findings suggest that for more general biodiversity monitoring, intermediate levels of thematic resolution are appropriate. The metrics calculated at this level correlate well with most species groups and provide information about interactions with landscape pattern. Two possible applications could be to incorporate the metrics identified in this study in a monitoring system for rural landscapes and to use them to identify biodiversity hot spots in European agricultural landscapes.

References

Bailey, D; Herzog, F. Augenstein, I. Aviron, S. Billeter, R. & Baudry, J. (2006[a]) Thematic resolution matters: Indicators of landscape pattern for European agro-ecosystems. *Ecological Indicators* 0.1016/j.ecolind.2006.08.001.

Bailey, D; Billeter, R. Aviron, S. Schweiger, O. & Herzog, F. (2006[b]) The influence of thematic resolution on metric selection for biodiversity monitoring in agricultural landscapes. *Landscape Ecology* DOI 10.1007/s10980-006-9035-9.

Davies, C. & Moss, D. (1999) EUNIS Habitat Classification. Final Report to the European Topic Centre on Nature Conservation. European Environment Agency, Paris. 256pp.

McGarigal, K; Cushman, S. Neel, M. & Ene, E. (2002) FRAGSTATS. University of Massachusetts: www.umass.edu/landeco/research/fragstats/fragstats.html.

O'Neill, R; Krummel, J. Gardner, R. Sugihara, G. Jackson, B. DeAngelis, D. Milne, B. Turner, M. Zygmunt, B. Christensen, S. Dale, V. & Graham, R. (1988) Indices of landscape pattern. *Landscape Ecology* **1:** 153-162.

The use of species compositional dissimilarity to assess the effectiveness of ecological classification schemes

B.E. Lawson[1,3], S. Ferrier[2], G. Wardell-Johnson[1], D.V. Pullar[3], R.J.S. Beeton[1]

[1]School of Natural and Rural Systems Management, The University of Queensland, Gatton QLD 4343, Australia.
email: b.lawson@uq.edu.au
[2]New South Wales Department of Environment and Conservation, P.O. Box 402, Armidale NSW 2350, Australia
[3]Department of Geographical Sciences and Planning, The University of Queensland, Brisbane QLD 4072, Australia

Introduction

Ecological classification schemes implicitly assume that map units represent some level of species similarity within each unit and some level of species dissimilarity between units. We describe our use of species compositional dissimilarity (SCD) to assess the utility of an existing ecological classification scheme from Queensland, Australia. The 'bioregional hierarchy', as described by Sattler and Williams (1999), comprises three levels:

- *Subregions* which represent significant associations of geological, geomorphology and climate within a bioregion, and are mapped at 1:500 000 scale.
- *Land zones* delineate major geological types and their associated landforms, and are mapped at 1:250 000 scale.
- *Regional ecosystems* (REs) are vegetation communities that are consistently associated with a particular combination of geology, landform and soil in a bioregion. They are mapped at 1:100 000 scale and finer.

Although there is significant work relating to the importance of SCD in determining the efficacy of ecological classification schemes (e.g. Phillippi *et al*. 1998, Ferrier 2002), its application to existing classification schemes remains understudied and under-reported.

Methods

Site-based floristic presence-absence data from 418 survey sites in the South-east Queensland Bioregion were used. Each site included details of its membership to bioregional hierarchy units. SCD was calculated using the Kulczynski metric, which is considered to provide the best representation of non-linear ecological gradients (Faith *et al.* 1987).

Firstly, pair-wise species dissimilarity comparisons were calculated for all within-unit and between-unit comparisons for every classification unit at each level of the bioregional hierarchy. This was done to assess the general patterns of SCD for classification units and to determine the extent to which each hierarchy level portrayed floristic patterns.

The second phase used randomisation to determine the effects of number of sites per unit on SCD patterns. From the pool of sites belonging to a particular unit, the requisite number of sites were randomly drawn. Due to the time consuming nature of the analysis, only 10 permutations of each number of sites for each unit were performed. A random site allocation was also performed to provide a baseline against which units could be compared.

Terminology

Within-unit dissimilarity refers to the per cent floristic dissimilarity between sites within the same map unit, and *between-unit* dissimilarity to the per cent dissimilarity between sites in a map unit with sites outside of that unit. *Differential dissimilarity* refers to the per cent difference from within-unit to between-unit dissimilarity for a particular map unit.

Results and Discussion

Comparisons of SCD between units revealed that dissimilarity levels and the variation increased from broader-scale subregion level to finer-scale regional ecosystems. The five subregion units examined exhibited an average of 4 % differential dissimilarity, the seven land zones an average of 10 %, and the 59 REs an average of over 19 %. This shows finer-scale classifications to be more effective at discriminating SCD than broader classifications. Figure 1 shows these trends for representative units from each bioregional hierarchy level.

Analysis of the effects of site number on SCD showed consistent trends across all levels of the hierarchy. For all hierarchy levels, minimal variation in differential dissimilarity was evident when 10 or more sites are used to derive the information. This suggests that very few survey sites per classification unit are required to obtain a meaningful estimate of a unit's SCD. Results from a representative unit from each hierarchy level are presented in Figure 2.

The results reveal a robust and transparent way to guide future 'lumping' or 'splitting' decisions for *a priori* classification schemes, to achieve a more even balance in SCD levels between classification units as advocated by Ferrier 2002. However, more widespread use will require the development of software to efficiently derive and display such information. Our current research is focussed on using this approach to disentangle the effects of sample size and ecosystem area on SCD, and to gain a better understanding of its relationship to species richness within units. Additionally, we also aim to test whether similar patterns are evident for different classification schemes and environments.

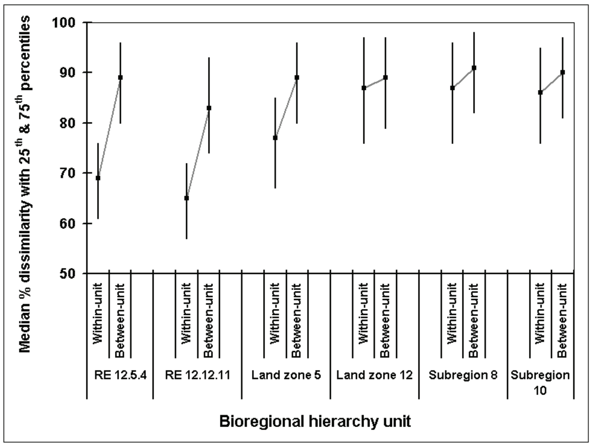


Figure 1. The extent and variation of within- and between-unit species compositional dissimilarity at the three levels of the bioregional hierarchy from the South-east Queensland bioregion. Several units representative of the trends are shown.

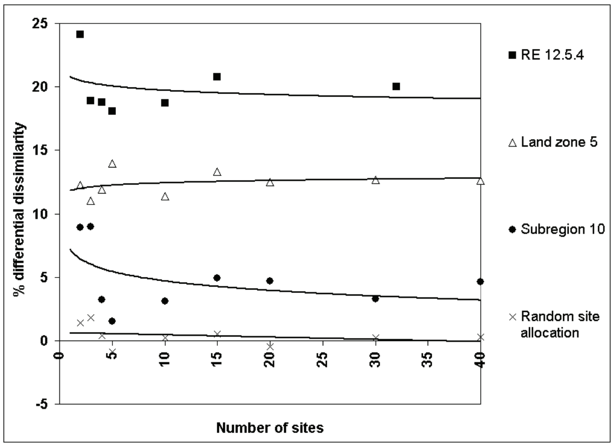


Figure 2. The effect of site number on species compositional dissimilarity at the three levels of the bioregional hierarchy from the South-east Queensland bioregion. Several units representative of the trends are shown.

References

Faith, D.P; Minchin, P.R. & Belbin, L. (1987) Compositional dissimilarity as a robust measure of ecological distance. *Vegetatio* **69:** 57-68.

Ferrier, S. (2002) Mapping spatial pattern in biodiversity for regional conservation planning: where to from here? *Systematic Biology* **51:** 331-363.

Philippi, T.E; Dixon, P.M. & Taylor, B.E. (1998) Detecting trends in species composition. *Ecological Applications* **8:** 300-308.

Sattler, P.S. & Williams, R.D. (1999) *The Conservation Status of Queensland's Bioregional Ecosystems.* Environmental Protection Agency, Brisbane.

Large scale land cover classification systems – a pragmatical appraisal

C.S. Cruz[1], J.P. Fernandes[2], N. Guiomar[2], T. Baptista[3], M.J. Mateus[3],

[1] Universidade de Évora, Rua Romão Ramalho, 59 – 7002-554 Évora, Portugal e-mail: souto_cruz@hotmail.com
[2] CEEM, Universidade de Évora, Rua Romão Ramalho, 59 – 7002-554 Évora, Portugal
[3] AMDE, Rua 24 de Julho, 1 – 7000-673 Évora, Portugal

Introduction

Large Scale Land Cover classification systems are critical instruments for landscape planning, ecological assessment, environmental evaluation and every landscape assessment and management process.

Different systems of classification have been proposed and are being currently used such as the CORINE Land Cover classification - CLC (prepared for a medium scale of 1:100 000) and the EUNIS habitat classification system (more adapted to the classification of vegetation formations). Their adaptation to large scales (above 1:25 000) and to complex vegetation covers (e.g. classifying simultaneously the habitat type, dominant land use and the varying type of undercover) poses increasing problems because of one hand to the need of using automatic classification methods for remote sensing data and on the other, the need for a detailed classification not only of the dominant vegetation layer, but also of the other layers present.

The development and implementation of an integrated CLC classification adapted to large scales (detailed to the 5th digit) and its comparison with complex classification systems combining both information on the habitat, dominant vegetation or land use, the associated vegetation and the conservation status are presented and discussed.

The use of complex classification systems, combining information on the morphology, geology and pedology (meaning globally the geocenosis), the vegetation complex (phytogeocenosis) and the human influence (namely type of vegetation management), is also discussed in terms of their utility, in comparison with the combination of thematic cartography. Comparative examples of application of different systems are presented and their relative advantages compared.

Development of a conceptual framework

At the large scale of landscape zoning the main differences or units derive from microclimatic variations, soil differences (e.g. water and nutrient availability) and, eventually, morphology in terms of local variation of spatial dynamic patterns (e.g. flow direction, flow intensity, erodibility). Land use builds an additional zoning factor in which it conditions many of these factors and introduces energy factors that determine disturbance particular disturbance patterns that emerge as circumstantial landscape features (eg. matrix, patches or corridors).

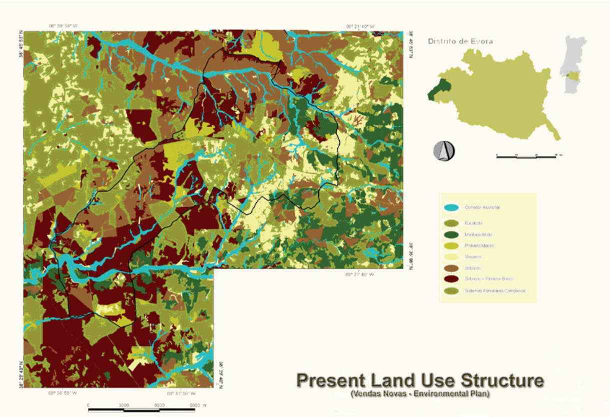
Stability patterns of some spatial variables are presently prone, due to human influence to experiment accelerated cycles of variations that determine that man's management intervention must be based on the knowledge of the different factors that determine a given landscape pattern at a given moment. It is also necessary to assess the different stability of that pattern according to spatial and temporal arrangement of disturbances. This implies that a good land use classification should be able to characterise and classify simultaneously not only the present land use mosaic but also the landscape organisation according to its natural resources and processes and should eventually be linked to disturbance factors.

This classification system implies the simultaneous consideration of the stable geocenotical patterns (presenting a high stability), related or not to vegetation descriptors (e.g. potential natural vegetation) and of the antropic land use spatial patterns with its lability.

Our classification system is aimed in the first stage at enlarging the CLC classification until the 5th level of detail:

1. **AGRICULTURAL AREAS**
    - **1.1 Arable land**
        - 1.1.1 <u>Non-irrigated arable land</u>
            - 1.1.1.1 Rainfed herbaceous cultures
                - *1.1.1.1.1 Cereals*

This classification system is only aimed at present land uses and is not able to represent other landscape features, such as geocenosis or natural or potential phytocenosis. Neverthless, it is possible to build combined classification systems (e.g. aaaaaa bbbbbb cccccc) where each of the three sets of digits represents one landscape characteristic (Loureiro & Cruz, 1993, FAO, 2005). Such a combined classification (e.g. CLC (land cover); EUNIS (natural vegetation); geology, geomormology or morpholitology) would give the planners and managers an integrated appraisal, not only of the present actual character of a landscape, but also of the set of factors that determine and characterise the given situation in terms of stable factors. This information allows simultaneously an identification of eventual disturbance processes and intensities, a better characterisation of the spatial arrangement of dynamical processes and the characterisation of the natural arrangement of landscape features like Matrix, patches and corridors (disturbed and not disturbed).



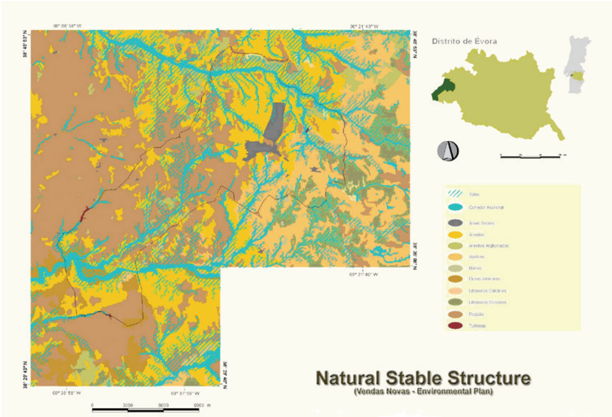


Figure 1. Comparision between the present land use structure and the natural stable structure

References

Cruz, C. S. (2002) *A cartografia das fitogeocenoses aplicada à gestão de áreas protegidas*. Tese de Doutoramento, Universidade de Évora.

Loureiro, N. S.; & Cruz, C. S (1993) *Cartografia dos usos do território e dos habitats de Portugal*. Projecto INASP, ICN, Lisboa..

FAO (2005) *Land cover classification system: classification concept and user manual (Software version 2)*. FAO, Rome.

Fernandes, J. P. (1993) *Classificação das Unidades Ecológicas Adoptada para Portugal*. Seminário sobre Avaliação de Impacte Ambiental em Sistemas Ecológicos, CEPGA, SPRCN, Serra da Estrela.

Guiomar, N.; Fernandes, J. P.; Cruz, C. S.; Baptista, T.; & Mateus, J. (2006) *Sistemas de classificação e caracterização do uso e ocupação do solo para zonamento microescalar*. Proceedings of ESIG 2006, Oeiras.

5.2 Symposium 25: Advances and Applications of Landscape Character Mapping

European Landscape Typologies as a Reference Base for Data on Cultural Heritage and Traditional Knowledge Systems in the Mediterranean

T. Kizos

Department of Geography, University of the Aegean, University Hill, Mytilini 81100, Greece,
0030 22510 36447,
e-mail: akizos@aegean.gr

Introduction:

Cultural heritage lies in the heart of current debates on conservation, preservation and sustainable development in Western societies. A way to estimate, manage and evaluate cultural heritage can be by the knowledge it produces. This 'traditional knowledge' stands for practices, representations, expressions, knowledge, skills as well as instruments, objects, artefacts and cultural spaces associated with communities, groups and, in some cases, individuals that recognize them as part of their cultural heritage. This intangible cultural heritage is constantly recreated by communities and groups in response to their environment, their interaction with nature and their history (2003 UNESCO Convention). Landscape, as the footprint of all human activities on nature, can be the medium for identifying, studying and marking traditional practices and knowledge in an area. Landscapes can offer the spatial framework for associating bio-environmental, social and management sciences and provide the reference base for data on cultural heritage and traditional knowledge systems.

In the Mediterranean, cultural heritage, from the cultural landscapes of rural areas to the historic town centres, is the expression of its identity, but also part of the everyday environment of numerous people. Threats of this rich heritage may come from 'modernization' of production and society, for which cultural heritage is often viewed as a constraint. In attitudes, practices and worldviews, it may be viewed as 'conservative' and 'backward' and for knowledge issues most if not all 'traditional knowledge' is considered as 'outdated' and 'obsolete'. But, cultural heritage and the knowledge produced during its making and reproduction can be used in order to enrich 'modern' practices for sustainable use of resources while continuing to mark local identities.

In this paper, existing European landscape typologies are used as a reference base against traditional knowledge systems in the Mediterranean. Recent landscape typologies are examined in three examples of traditional knowledge farming systems to evaluate the suitability to describe actual landscape differences.

European Landscape Typologies and Landscape Character

Landscape typologies at the European scale are rare, due to environmental conditions and habitats diversity on one hand and the variety and depth of human interventions on the other. Existing efforts tend to focus either mostly on natural forces (Mucher et al. 2003), or on human management systems (Meeus 1995). A recent effort that attempts to combine both approaches has been a typology developed for the ELCAI (European Landscape Character Assessment Initiative) initiative that is based upon the use of different layers of human elements (land cover, land use, special characteristics) upon natural landscape elements (climate, altitude) (Wascher 2005). This typology is developed to be used for defining and assessing Landscape Character (LC) that is a distinct, recognisable and consistent pattern of elements in the landscape that makes one landscape different from another. The emergence of LC assessments has brought forward 'new' spatial units that can be used for landscape typologies (Wascher 2004).

Traditional Knowledge Systems in the Mediterranean and Landscape Typologies

The link between landscape typologies and traditional knowledge systems is not as straightforward as the use of information on the cultural elements for the making of these typologies might imply. Traditional knowledge systems are complex systems that may be not is use today and therefore not considered when creating such typologies, although their marks may be still evident in the landscape. In the Mediterranean, where agriculture has undergone great changes: replaced by ‘modern’ agriculture or abandoned.
Such an example is terracing. Cultivation terraces are very characteristic of a landscape, combining value (ecological, economic, symbolic, etc.) and function, if the terraces are not abandoned. In the Mediterranean, they are found in many places (Grove and Rackham 2002). Existing LC assessments and landscape typologies of the Mediterranean ignore them, focusing on land uses. Reasons behind this relate with the lack of relevant data.
The examples examined in this paper include three very different systems of traditional knowledge systems on three different Aegean Islands that involve cultivation terraces (Figure 1): (a) Olive plantations on Lesvos; (b) Vines on Serifos; and (c) Mixed farming (cereals and trees) on Nisyros Islands. The basic principles of these systems are described briefly to assess differences and similarities. They are all characterized as “Mediterranean hills of pasture land or permanent crops”, but the empirical material presented demonstrates that they are very diverse, including high diversity inside each type, that they clearly should be assigned with different landscape characterizations as a result of the different traditional knowledge systems they have resulted from. Therefore, new ways of creating typologies and characterizing landscapes have to be used that have to consider traditional knowledge systems in the cultural elements they use. Local research is required for the concretization of the relationship for specific spatiotemporal settings.
Another issue briefly touched in this paper is the future of such systems. The examples offered here demonstrate that this approach marks heritage and knowledge as concepts that should not be preserved as ‘museums’ of a past however ‘golden’, but actively conserved to enrich contemporary practices and that landscape typologies which consider them can serve as a reference base for successful and meaningful landscape characterizations in the Mediterranean.

References
Grove, A.T. & Rackham, O. (2002) *The Nature of Mediterranean Europe: An Ecological History*, Yale University Press, New Haven.

Kizos, T. & Koulouri, M. (in press) Same Land Cover, Same Land use, Different Landscapes: Small Scale Landscape Change in Olive Plantations on Lesvos Island, Greece. *Landscape Research*.

Meeus, J.H.A. (1995) Pan-European Landscapes. *Landscape and Urban Planning* **31**, 57-79.

Mucher, C.A.; Bunce, R.G.H.; Jongman, R.G.H.; Klijn, J.A.; Koomen, A.J.M.; Metzger, M. & Wascher, D. (2003) *Identification and Characterization of Environments and Landscapes in Europe*, Alterra Rapport 832, Alterra, Wagenigen.

Wascher, D. (2004) Landscape-indicator development: steps towards a European approach. R. Jongman (Ed.) *The New Dimensions of the European Landscape*, Springer, Wageningen UR Frontis Series Nr. 4, Berlin, pp. 237-252.

Wascher, D. (2005) *European Landscape Character Areas: Typologies, Cartography and Indicators for the Assessment of Sustainable Landscapes*, Final Project Report of the ELCAI, Project, available at www.elcai.org.

From Landscape Character Assessment to Sustainable Design – Tools for Planning and Policy

D. Wascher, P. Smeets, W. Timmermans, V. Kuypers

Alterra, P.O. Box 47, 6700 AA Wageningen, The Netherlands.
e-mail: dirk.wascher@wur.nl

Landscape Character Assessment

Landscape Character Assessment (LCA) stands for an assessment technique that is descriptive without being judgmental regarding the state of a landscape. As a means for developing landscape profiles and typologies, LCA is recognized as a key reference system for researchers and planners dealing with integrated land use and spatial planning.

Its integrative and synergetic power links LCA well to a variety of research and policy objectives in the field of sustainable development. Sustainable land use is considered to be intrinsically linked to the concept of *multi-functionality*. Rural, urban and peri-urban landscapes provide a variety of integrated functions including production, living, regulation, and information functions. The way and degree to which these functions are being offered determine the environmental and socio-economic qualities of a landscape – from the perspective of policy makers, researchers, planners, investors, land users and a variety of stakeholders. Linking LCA to landscape planning tools can hence be considered as an essential prerequisite for sustainable design in the wider countryside.

This paper will analyze the rural and urban dimension of introducing sustainable design principles when developing spatial development perspectives by drawing upon selected cases in the Netherlands and examining possible applications of above landscape tools for the wider European context.

Spatial Development in Europe

Europe's rural landscapes are traditionally perceived and appreciated for their diversity, traditional character, regional identity and high qualities with regard to standards of living, transport infrastructure and the level of spatial planning. Another important aspect is the historically and functionally defined relation between rural and urban areas. However, during recent decades, uncontrolled urban sprawl, agricultural intensification coupled with land abandonment have resulted in a clear decline of landscape diversity, biodiversity, 'green values' in and around cities and cultural heritage. Rural areas have continually shrunk as residential districts, recreational facilities and business estates have been built. In many places, the rural areas are fragmented due to an increase in scattered construction and new infrastructure. The spatial contrasts between the city and the countryside are diminishing, as is the diversity of urban and rural environments. These developments make many regions more monotonous, less attractive, more exchangeable and less distinct. As a consequence, the boundaries between rural and urban areas do not reflect the spatial and structural characteristics of the 'parent' landscapes. At the same time, demand from society for a greater diversity of environments is increasing, not in terms of the traditional, physical distinction between the city and the countryside, but in terms of attractive, safe city areas in which to spend time and live - attractive, distinctive landscapes, and accessible rural areas for recreation and relaxation. The rural areas are taking on the function of public space.

The Rural Dimension

The task is to analyze and assess the quality of the rural areas in relation to current and planned policies, especially with regard environmental pollution, biodiversity and amenity values of cultural landscapes. Of relevancy here are the European and global agricultural policies, land areas policy, and the environmental, nature and spatial policy. In response to severe epidemics of Classical Swine Fever (1997) and of critical nitrate loads due to high livestock densities, Dutch authorities have launched massive *reconstruction plans* for large rural regions. The Dutch law on reconstruction for concentration regions (2002) offers a spatial framework for the restructuring of intensive livestock farming in areas with high livestock densities. Within the concentration regions, mono-functional *'development zones'*, multi-functional *'interwoven zones'* and zones where livestock densities are substantially reduced, among other things by transfers of farms (*'expansion zones'*) have been established. Reviewing the implementation of these reconstruction plans will form the basis for examining the question whether the Dutch experience can find application at the European level with special attention to the role of landscape character assessment. EU environmental standards, aspects of regional identity and economic efficiency must be considered as key objectives for sustainable European rural areas. Special emphasis will be on the role of landscape assessment tools for the identification of regional profiles relevant for sustainability assessment and of their corresponding thresholds and risks regarding pressures and driving forces affecting land use change.

The Urban Dimension

As in the Dutch context rural and urban development is not only a matter of fringes, but can be regarded as a spatial transformation to a metropolitan landscape, these tools are also highly relevant for the urban dimension. Planning of whole new towns like Almere are based on historical, cultural and ecological conditions and characteristics. Methodological the actual landscape is stripped into layers from the past to the future. A former great lake – Haarlemmermeer - became a polder at the end of the 19th century, because it was a threat to the development of the city of Amsterdam. It became rationalized farmland and was later consumed by Schiphol airport. Nowadays the pressure of urban development and mainport facilities lead to scarcity of space, that poses questions of multiple land use such as combining flood risk areas with housing (www.bouwenmetwater.nl). For such a development the basic principles are the characteristic lines in the landscape, the design of the polder and water system, sweet and salt groundwater patterns, peat and clay layers. These layers have been analyzed in order to create a 60 hectare sustainable water basin in which up to 1500 houses can be build. The size makes it possible to relieve large parts of the water system and in the same time respect the cultural and ecological conditions that "made" the landscape.

This paper reports on ways of applying landscape character assessment tools such as landscape typologies, indicator-based landscape functions, and landscape change models, when developing integrated and stakeholder-oriented design concepts for sustainable design in rural and urban areas.

Risk and vulnerability of landscape identity

É Konkoly-Gyuró[1], S Jombach [2]

[1] University of West Hungary 1 – H-9400 Sopron, Bajcsy-Zsilinszky ut 4. Hungary
e-mail: egyuro@emk.nyme.hu
[2] Corvinus University of Budapest 2 – H-1118. Budapest, Villányi ut 35-43. Hungary

Introduction

Landscape is the tangible and perceivable result of the co-existence of culture and nature. Landscape identity reflects the way different cultures interact with nature, shows how adaptive their land-use techniques are, how harmonious or disharmonious settlements, infrastructures, production surfaces are inserted into the biophysical environment. Man creates landscape identity; it is the imprint of the human activities driven by culture. Landscape identity is strongly related to sustainability, as it is the expression of the interaction between environment, economy and society. If any of these three pillars is damaged, identity will be destroyed.
Risk and vulnerability are adjunct terms in a cause effect chain. Risk refers to external impacts, but the factual effect of them depends on the vulnerability of a system. Based on the ongoing research within the SENSOR project (www.sensor.org), this presentation will give an overview about the possible assessment of the risk and vulnerability of landscape identity at a European scale.

Research goal and method

The SENSOR, a EUFP6 Integrated Project (2004-2008), aims to create an ex-ante assessment tool, for evaluating the policy impacts on sustainability focusing on the regional multifunctionality of land-use. In addition to the 32 impact issues, listed in the Impact Assessment Guidelines (European Commission, SEC 2005), a new issue, the landscape identity was introduced. Landscape identity can be best described by landscape character areas formed by unique characteristics of the cultural and natural heritage. In the SENSOR project however our spatial reference framework (Renetzeder, Ch. et al. 2004) consists of 571 regional units of the EU 27+2 at NUTSX (2/3) level. The first task has been to create adequate indicators for showing the persistence of the valuable landscape identity. Three crucial questions have arisen: 1) What can be considered as valuable identity of a region, where the continuity is desirable? 2) What are the most important, land-use sensitive components of the landscape identity? 3) Which relevant indices can be calculated within a model for which the data availability is given now and also in the future at NUTSX level for the whole Europe?
We suppose that identity is valuable if attractivity and the unique sense of place exist and the landscape are also perceived and appreciated by people. Thus we've chosen visual attractivity, appreciation of existing landscape heritage and unique character as key issues of the assessment. Accordingly two indicators, reflecting the persistence of the valuable identity, have been created.

Indicator 1. Change of visual attractivity

Visual attractivity means the scenic value of the landscape and environment that is perceived and appreciated by people. It depends predominantly on the land cover diversity that can be measured by the edge density (Kiemstedt, 1971) Edges between the visually different land cover types are visible manifestation of landscape structure and fundamental elements of landscape identity. Scale and speed of its change show not only loss or gain in diversity both visually and biologically but also risk and vulnerability of identity. First results of the indicator value calculation affirmed the assumption that the most significant transformations occurred on the peripheries of Europe (Ireland, Iberian Peninsula, Eastern-Central European countries).

Indicator 2. Continuity of appreciated landscape heritage

The higher the level of appreciation is the stronger the landscape identity is manifested. The level of appreciation is calculated in each spatial unit from the designations and legal protection measures and from the attendance by tourists. In those areas where the appreciation level is high the continuity of land-use, accordingly the land cover structure, is highly important as it contributes largely to the preservation of landscape identity. The transformation risk of the cherished traditional landscapes in the new accession countries, especially in Bulgaria and Rumania, is extremely high.

Risk and vulnerability

The indicators reflect change or continuity of important landscape identity factors. In the further step of the research we will define thresholds in NUTSX regions according to the risks and vulnerability. Risk and vulnerability can be evaluated at scales that are ended by opposite qualities, like security and stability. So there are counter-impacts and value pairs like risk/security and vulnerability/stability. The assessment of these can be done by SWOT analysis. Risk and security are external impacts: threats and opportunities. Risk level coincides with the lack of protection measures and the extreme growths of tourism. An important security factor is the designation of heritage. Vulnerability and stability are internal qualities: weaknesses and strengths. A region is vulnerable if the land-cover is homogenised, as the landscape diversity and the population is decreasing. Sign of stability is the diverse and persistent landscape structure as well as moderately changing population density.

SENSOR project provides an important first step toward the methodical development of the risk and vulnerability assessment of landscape identity. The fact that this topic is considered as a sustainability impact issue reflects a new approach, the growing acknowledgement of culture's importance. Nevertheless the large European scale and the given spatial framework (regions instead of landscape character areas) of the current research result in some generalisations and erase certain differences between and within the regional units. Future research scope should be enlarged toward the accurate assessment of the richness and diversity of the smaller scales.

References

European Commission, (2005) Impact Assessment Guidelines, *SEC(2005) 791* pp. 29-31

Kiemstedt, H., (1971) Harzlandschaft und Freizeit Harzer Ferkehrsverband*: Schriftenreihe des Harzer Verkehrverbandes*

Renetzeder, Ch., **Eupen**, **M. van, Mücher, S., Wrbka, T., Wascher, D., Kienast. F., (2004)** Report on methodology and map for integrated Spatial Regional Reference Framework *SENSOR Deliverable 3.1.3*

Comparative review of European national and international landscape classifications with regard to future applications

G. Groom[1], D. Wascher[2], S. Mücher[2]

[1] NERI – Grenaavej 14, 8410 Roende, DK.
e-mail: gbg@dmu.dk
[2] ALTERRA – Droevendaalsesteeg 3, 6708 PB Wageningen, NL.

Introduction

The last 10 – 15 years have seen significant developments in Landscape Character Assessment (LCA) work. Today LCA is recognised as an important tool for policy stakeholders, providing them with quantitative and qualitative evidence to reach a dynamic management adjustable to new demands of regional identity. LCA has come to be seen as central to sustainable development and management of land. Many organisations have developed sophisticated landscape character mapping tools that are scientifically sound, region-specific and stakeholder-oriented.

Two recent developments in relation to Europe-wide LCA work have been a review of over 50 examples of regional, national, and pan-European LCA works (Groom *et al*. 2006) and production of a pan-Europe landscape typology and map, LANMAP2 (Mücher *et al*. 2003; Wascher 2005). The former activity focused on the characteristics of LCA as a process of classification-orientated mapping. The picture from that review was one of both convergence and differences in terms of the landscape factors considered and the mapping methods applied. Questions were noted relating to the mapping of landscape character types, the use of crisp mapping approaches and the representation of landscape change. The latter activity, LANMAP2, was successful in identifying and mapping consistently for pan-Europe the major biophysical landscape characteristics and using land cover information to add interpretation representative of the cultural characteristics of Europe's landscapes. However, comparisons of LANMAP2 to regional and national LCA data revealed mixed results (Wascher 2005).

This paper re-visits the questions raised by the earlier LCA-review work and shortcomings in the LANMAP2 evaluation work to identify possibilities for clarification of the European LCA arena and further development of pan-Europe landscape characterisation work.

From review to refinement

The 2005 review of European LCA work was structured around the predominant mode of the examined LCA works, their structure properties, the landscape factors (*e.g*. biophysical environment, cultural) that they considered and the classification/mapping methods used (Groom *et al*. 2006). Distinction between landscape character types (*i.e*. generic, repeated spatial units) and landscape character areas (*i.e*. unique spatial units) was noted mainly as an aspect of the structural properties of an LCA activity. What has become apparent since is the more fundamental nature of the differences between LC-Type work and LC-Area work. Through this paper and conference presentation two apparent patterns are investigated:
(a) That overlap between the ranges of significant spatial scales for LC-Type and LC-Area work breaks down as one focuses upon the more local, micro-scale (*i.e.* sense of LC-Type is lost), but less-so as one focuses upon the global, more macro-scale (*i.e.* sense of LC-Area is preserved, as in LC-Areas such as The Dordogne, or The Weald).
(b) That "classification" has different roles, forms and degrees of prominence between LC-Type and LC-Area work. In the former, scientifically formulated classification, in most of its classic forms including its spatial extensions, has been the engine applied to the job of systematising a breadth of landscape into a set of boxes. Though a variety of classifications have yielded LC-Areas, the emphasis in much LC-Area work, particularly at the more local

scale, moves towards the *organisation* of information. Systematic classification work itself has only a sub-ordinate role.

The earlier work (Groom *et al*. 2006) noted that whilst consideration of a broad range of landscape factors is recognised and understandable for LC-Area work, the degree to which landscape factors other from the biophysical ones have a role in LC-Type work is less clear. This question is also re-examined through re-evaluation of LANMAP2 (see below). The aim of this paper and presentation is to inquire into the nature of "LCA" as either just one, or else two, or possibly several, distinct types of activity, and, if it is considered as not being merely the former of these, then how best to develop clear understanding and communication of the respective forms.

Stable vs. dynamic aspects of landscape units

The prevailing understanding of European LCA work was the basis for evaluation of LANMAP2 (Wascher 2005). This had a number of consequences. Firstly, the fundamental differences between LC-Types and LC-Areas were not, at that time, considered sufficiently, with LANMAP2 evaluation comparisons made to examples of both. Restriction of comparison to typologies (LC-Types work) could have provided a more objective evaluation. Secondly, the comparative evaluation should have been applied to LC-Type work representative of spatial scales most appropriate to the LANMAP2 mapping scale (1:1,000,000), in particular landscape issues that are manifest at regional as well as national levels.

Follow-on evaluation exercises upon LANMAP2 that are reported by this paper / conference presentation have aimed to address these earlier shortcomings. These have involved comparison of LANMAP2 to two regionally well-documented landscape types, with particular attention to the nature of the boundaries (e.g. sharp, straight indistinct) and the respective area profiles. Comparisons are made firstly with respect to the biophysical factor driven main layer of LANMAP2, and secondly to the land cover information layer of LANMAP2, in order to investigate to question of the role of non-biophysical factors in LC-Type work, which was noted above.

The issue of LCA-change with respect to landscape change was another key question raised by the review of LCAs. The ways that the major national exercises in LCA mapping, for LC-Types and LC-Areas, can accommodate changes in the patterns of landscape character, due to environmental, land use or other changes is not clear. In this paper a demonstration is made of how dynamism, based upon regular updates in the source data can be incorporated into a temporal series of LANMAP products.

References

Groom, G; Wascher, D., Potschin, M. & Haines-Yong, R. (2006) Landscape character assessments and fellow travellers across Europe : a review. R.G.H. Bunce & R.H.G. Jongman (Eds) *Landscape Ecology in the Mediterranean: inside and outside approaches. Proceedings of the European IALE Conference 29March – 2 April 2005 Faro, Portugal.* IALE Publication Series 3, pp.221-231.

Mücher, C.A.; Bunce, R.G.H., Jongman, R.H.G., Klijn, J.A., Koomen, A.J.M., Metzger, M.J., Wascher, D.M. (2003) *Identification and characterisation of environments and landscapes in Europe.* (ALTERRA report 832). ALTERRA, Wageningen (NL)

Wascher, Dirk M. (2005) *European Landscape Character Types – Typoloies, Cartography and Indicators for the Assessment of Sustainable Landscapes. Final Project Report as deliverable from the EU's Accompanying Measure project "European Landscape Character Assessment Initiative (ELCAI).* (ALTERRA report 1254). ALTERRA, Wageningen (NL).

Mücher, C.A., Wascher, D.M., Klijn, J.A.,. Koomen, A.J.M, Jongman, R.H.G (2006) A new European Landscape Map as an integrative framework for landscape character assessment. R.G.H. Bunce and R.H.G. Jongman (Eds) *Landscape Ecology in the Mediterranean: inside and outside approaches. Proceedings of the European IALE Conference 29 March – 2 April 2005 Faro, Portugal.* IALE Publication Series 3, pp. 233-243.

The role of landscape science in higher education in Europe: the ATLAS experience.

G.B.M. Pedroli [1], H. Palang [2], M. Bogers[1]

[1] Alterra Wageningen UR, P.O. Box 47, NL 6700 AA Wageningen, The Netherlands.
e-mail: bas.pedroli@wur.nl
[2] Tallinn University, Uus-Sadama 5, EE 10120 Tallinn, Estonia

Landscape education and training: a fragmented provision

The fragmented nature of education and training provision in sustainability impact assessment for landscape planning is a major barrier to the management of rapid land use change. The European Spatial Development Perspective (Potsdam 1999) recognises the challenges posed by European enlargement: while levels of environmental damage in accession countries are declining due to declining manufacturing industry and successful environmental protection policies, the future success of such policies depends on economic prosperity. Large-scale abandonment of agricultural landscapes poses particular questions for the environmental and social sustainability of rural populations. Sustainability Impact Assessment Tools (SIAT) are currently being developed worldwide and also under different nomenclature. In the European Union (EU) and especially in the European Commission the term SIAT is favoured today and large research projects are developing such tools in coordination with policy makers. Sustainable impact assessment tools consist of various indicator systems and effect prediction instruments to determine the contribution to sustainable development of changes in land use brought about by defined policies.

Inventory of educational provision over Europe: www.ATLAS-EU.org

If one focuses on an environmentally sustainable situation for European citizens, the planning and management of landscape that contributes to sustainable development involves the analysis of a number of complex issues. As a result, the skills and knowledge required are often fragmented, so that the capacity of both professional and non-professional groups to resolve sustainable land use issues is often limited. The EU funded project ATLAS (*Action for Training in Land use And Sustainability*) analysed educational provision in a broad sense from complete university courses to professional short courses and pays special attention to training in landscape management taking particular account of the issues raised by transition. The ATLAS website (www.atlas-eu.org) provides an interactive route planner about courses and material available all over the 25 EU member states. One aim is to enhance the demonstration of assessment tools that apply for instance to landscape and landscape change, not just for the evaluation of major initiatives, but also to examine longer term effects of predictable changes and changes that are policy driven.

The ATLAS project was designed to:
- take stock of what educational resources exist;
- assess their adequacy; and
- stimulate the development of appropriate strategies and initiatives for the future.

The status quo in relevant educational provision for policy and practice in this area throughout Europe was analysed:
- through a comprehensive survey of the status of educational provision at practitioner's, professional, undergraduate and Master's levels, within Europe
- followed by a SWOT-analysis (strengths, weaknesses, opportunities, threats) of the extent to which this provision meets current needs, with clear recommendations for improvement;

- leading to an *interactive route planner* for training in land use sustainability assessment providing better European organisation of the educational provision leading to appropriate professional qualifications.

Although ATLAS focuses on the EU, the results of this comprehensive overview of more than three thousand courses is of relevance as well for the exposure of the European educational provision to the rest of the world. Firstly, about a fourth of the courses explicitly address landscape development issues worldwide. Secondly, more than half of the courses focus to a high degree on methodological issues and on SIAT. Improved co-ordination of their efforts on education and training would have great benefits for the effectiveness of the policies currently developed. This will open up a large number of existing educational programmes to enhance coordinated capacity building for policy makers in the field of land use management practice, design, planning and research.

Conclusion: need for educational cooperation for proper covering of landscape issues

It is concluded from our analysis that, even though sustainability has been part of European society already for a few decades, in all EU countries there is still an apparent need for clearer definitions, practical guidelines and information of which aspects to consider in implementation, especially related to landscape management and policy.
In Norway, Sweden, Denmark, the Netherlands, Belgium, France and the UK the situation in sustainability teaching related to landscape issues seems to be better than in the other countries. Thus, one could say that these countries form the core of educational provision. The new EU countries, Czech Republic, Estonia, Latvia, Lithuania, Hungary, Poland, Slovakia and Slovenia are still struggling with the different assessment tools and basic issues related to sustainable development and landscape. On the whole, practical work and training should be offered more. Teaching sustainability in landscape development should be carried out in cooperation of different academic disciplines by professionals that are aware of the aspects of sustainability in their fields. This is easier said than done, since the current trend in science is more towards the opposite – fragmentation and specialisation.

Acknowledgement
The project was effectively implemented in strong mutual cooperation by: Thomas Blaschke, Marion Bogers, Philippe Deuffic, Annelene Kammer, Grete Kukk, Carla Oonk, Hannes Palang, Bas Pedroli, Marion Potschin, Ingrid Sarlöv-Herlin, Milada Stastná and Gabor Turcsanyi

Defining and mapping the landscapes of Italy

C. Blasi[1], D. Guida[2], V. Siervo[2], M. Paolanti[3], L Michetti[1], G. Capotorti[1], D. Smiraglia[1]

[1] Dept of Plant Biology, University of Rome "La Sapienza", P.le Aldo Moro 5, Rome Italy. e-mail: blasilab@uniroma1.it
[2] Dept of Civil Engineering University of Salerno, Via Ponte Don Melillo 1, Fisciano (SA) Italy
[3] CHOROS, Via Pietro Cuppari 33, 00134 Rome - Italy

Ecosystems are the result of a complex interaction of physical, social and economic factors. Due to the importance of land management and biodiversity conservation, ecosystems need to be described, characterised and spatially located (Sims *et al.*, 1996). Recently, ecosystem classification and mapping has received renewed attention, since its relevance for understanding ecological patterns and processes and addressing environmental tasks (Urban *et al.*, 1987; Klijn and de Haes, 1994; Zonneveld, 1995; Metzger *et al.*, 2005; Jongman *et al.*, 2006). Factors controlling pattern can be used for classifying types as well as for mapping their boundaries (Bailey, 1996).

Spatial structure of landscape elements is recognized as a crucial factor in affecting ecosystems functions (Forman, 1995; Turner *et al.*, 2001) and its relevance is considered also in the international legislation. With the Convention on biological diversity (Summit of the Earth, Rio de Janeiro, 1992), the Habitats Directive (92/43/EEC) and the European Landscape Convention (Council of Europe, Florence, 20.X.2000), the importance of landscape diversity in the strategies of nature conservation is fully acknowledged. Moreover, the Pan European Biodiversity and Landscape Strategy (1996) introduced the need to protect Europe's natural heritage and landscape diversity in order to protect and enhance the natural environment. At present, the European Landscape Character Assessment Initiative (ELCAI) represents the most important EU project for reviewing and documenting the state-of-the-art of landscape character assessment techniques in Europe (Wascher, 2005). It can be applied at a range of scales, from national to regional and local, and its importance to support decision making about conservation and socio-economic goals is arising.

Within this context, a project for mapping the landscapes of Italy at broad scales (1:500,000-1:1,000,000) was recently undertaken with the support of the Ministry of the Environment of Italy, in order to provide a reference model at national scale. Classification and mapping of landscape types was based on a hierarchical spatial framework developed by Blasi *et al.* (2000), that integrates the basic physical aspects of the landscape. The overlay of different environmental layers enables to define and map homogeneous units of land characterised on climatic, lithological and geomorphological basis. The Climatic Regions have been derived from an existing map (Blasi and Michetti, 2005). The proposed approach employs real monthly data to define and map climatic types. A review of the geological maps produced in Italy was necessary for the lithological final product and a new geomorphological map was realised using an innovative method for landform identification, classification and mapping. This method follows a new proposal of multi-scale geomorphological map legend. The Lithological Map was produced from a systematic reinterpretation and homogenization of existing regional and national geological units in term of multi-scale hierarchical lithological units (IAEG-UNESCO, 1976). The following nested lithological entities was thus recognized and mapped: *Litho-System*, adequate at scale 1.000.000 to 1:250.000 and national analysis level, corresponding to Sequence in the IAEG-UNESCO classification (1976), as rock succession with lithogenetical homogeneity; *Litho-Complex*, adequate at scale 1:250.000 to 50.000 and regional analysis level, as rock succession with litho-stratigraphical homogeneity (i.e. arenaceous-conglomerate complex, coral reef carbonate complex); *Litho-Type*, adequate at scale 1:50.000 to 1:25.000 and basin or local analysis level, as rock succession with litho-technical or litho-pedological homogeneity (i.e. arkose sandstone or conglomerate with clayey matrix). The Morphological Map, instead, was achieved using a semi-automatic method from a digital elevation model with 75m resolution and implementing a step-by-step procedure: i) basic morphometric analysis, ii) topographic position analysis; iv) grid-based neighbourhood geomorphometric analysis, iv) object-based geomorphic analysis, and v) grid-to-vector translation and comparison with sample areas maps carried out with the traditional geomorphological approach. The following nested morphological entities was thus recognized and mapped: *Morpho-System* (i.e. summit, hillslope, piedmont, plain, coastal morphological systems), adequate at scale 1.000.000 to 1:250.000 and national analysis level, with physiographic and morphogenetic homogeneity; *Morpho-Facet*, adequate at scale 1:250.000 to 50.000 and regional analysis level, as part of a Morpho-System with morphological and morpho-evolutive homogeneity (i.e. talus, alluvial fan and scree in Piedmont Morpho-System); *Morpho-Type*, adequate at scale 1:50.000 to 1:25.000 and basin or local analysis level, as part of a Morpho-Facet with morphometric and morphodynamic homogeneity (i.e. apex, mid-fan or proximal fan Morpho-Types in the Alluvial Fan Morpho-Facet). Each Landscape Type, obtained from progressive overlapping of the above themes, has been successively analyzed and characterised in terms of potential natural vegetation and land cover, employing the 1:250,000 “Map of the vegetation series of Italy” (Blasi *et al.*, 2004) and the 1:100,000 CORINE Land Cover Map IV level.

This project highlights the role of physical determinism in characterising landscapes, as pointed out in the European Landscape Convention. The land classification scheme provides descriptive land units useful for survey, monitoring, management and for adequate sustainable development initiatives. Furthermore, it provides a framework for comparing the actual and potential heterogeneity of landscapes on a structural basis, in order to assess their state of conservation.

References

Bayley, R.G. (1996) *Ecosystem geography*. Springer-Verlag, New York.

Blasi, C; Carranza, M.L; Frondoni, R. & Rosati, L. (2000) Ecosystem classification and mapping: a proposal for Italian Landscape. *Applied Vegetation Science* **3**:233-242.

Blasi, C; Filibeck, G; Frondoni, R; Rosati, L. & Smiraglia, D. (2004) The map of the vegetation series of Italy. *Fitosociologia* **41(1) suppl. 1**: 21-25.

Blasi, C. & Michetti, L. (2005) Biodiversità e clima C. Blasi; L. Boitani; S. La Posta; F. Manes & M. Marchetti (Eds). *Stato della Biodiversità in Italia*. Palombi Editori, Roma, pp.57-66.

Forman, R.T.T. (1995) ***Land mosaics. The ecology of landscape and regions*. Cambridge University Press, Cambridge.**

Jongman, R.H.G; Bunce, R.G.H; Metzger, M.J; Mücher, C.A; Howard, D.C. & Mateus, V.L. (2006) Objectives and applications of a statistical environmental stratification of Europe. *Landscape Ecology* **21**: 409-419.

Klijn, F. & Udo de Haes, H.A. (1994) A hierarchical approach to ecosystems and its implications for ecological land classification. *Landscape Ecology* **9(2)**:89-104.

Metzger, M.J; Bunce, R.G.H; Jongman, R.H.G; Mücher, C.A & Watkins, J.W. (2005) A climatic stratification of the environment of Europe. *Global Ecology and Biogeography* **14**: 549-563.

Sims, R.A; Corns, I.G.W. & Klinka, K. (1996) Global to local: ecological land classification. *Environmental Monitoring and Assessment* **39**:1-10.

Turner, M.G; Gardner, R.H., O’Neill R.V. (2001) *Landscape Ecology in theory and practice. Pattern and process*. Springer, New York.

Urban, D.L; O’Neill, R.V., Shugart, H.H. (1987) Landscape ecology. A hierarchical perspective can help scientists understand spatial patterns. *Bioscience* **37(2)**:119-127.

IAEG - UNESCO (1976) *Engineering geological maps. A guide to their preparation*. UNESCO Press, Paris.

Wascher, D.M. (2005) *European Landscape Character Areas. Typologies, Cartography and Indicators for the Assessment of Sustainable Landscapes*. Final Project Report as deliverable from the EU’s Accompanying Measure project European Landscape Character Assessment Initiative (ELCAI), funded under the 5th framework Programme on Energy, Environment and Sustainable Development. Landscape Europe – ELCAI, Wageningen.

Zonneveld, I.S. (1995) *Land Ecology*. SPB Academic Publishing, Amsterdam.

Developing a science-based approach for delineating natural heritage system in Southern Ontario

D. Puric-Mladenovic, S. Strobl

Information Management and Spatial Analysis Unit
Southern Science and Information Section, Ontario Ministry of Natural Resources
300 Water St., 4th Floor South Tower, Peterborough, ON, Canada K9J 8M5
e-mail: danijela.puricmladenovic@ontario.ca

Introduction

In southern Ontario, natural areas are facing threats from unsustainable urban development that fragment and degrade natural heritage features and functions. In order to sustain ecosystems and quality of life in southern Ontario, we need to understand where the critical natural areas that protect biodiversity, ecological functions and ecological services are, so we can actively work to conserve them. In Ontario, planning authorities are required to identify natural heritage systems (NHSs) as part of the land use planning process and have generally applied Geographic Information System (GIS) analyses based on scoring patches for several, often related, ecological criteria.

To provide a strategic basis for implementing a voluntary stewardship program to encourage private landowners in southern Ontario to protect and restore natural areas we were challenged to develop a science-based methodology to identify and delineate NHSs that still considers expert input. We developed and tested an iterative spatial analysis approach that: incorporates empirical targets for biodiversity and habitat protection based on *a priori* gap analysis; utilizes the best available data and a mathematical algorithm to optimize numerous targets; provides a number of NHS scenarios that can be comparatively assessed and selected by experts; and is adaptable and repeatable over time as new information becomes available.

Methods

The methodology was piloted in two ecodistricts, 7e5 and 6e6 representing distinct climatic zones and differing amount of natural cover (14% for 7e5 and 36% for 6e6), land use and amount of protected area.

Goals for the NHS included protection of the diversity of ecological communities, sensitive surface water and groundwater features and aquatic and wildlife habitats. For each ecodistrict, a gap analysis identified the current levels of biodiversity conservation (e.g., representation of natural vegetation communities), ecological function (e.g., total amount of forest cover; amount of interior forest) and ecological services (e.g., amount of natural vegetation in headwater and riparian areas). On the basis of available standard data layers for each ecodistrict, empirical targets for over 60 objectives were developed e.g., conserve: 35 % of each vegetation community; natural vegetation within 75 % of the riparian buffer (30 m); 100 % of the forest interior (100 m from edge).

Available spatial information on biodiversity, including current, standard land cover mapping was prepared, assembled and tessellated to 5-ha hexagon planning units for the ecodistrict and a 2.5 km surrounding buffer. Since fine-scale vegetation maps were not available we combined natural cover mapping with soil texture and drainage mapping to derive a surrogate vegetation type mapping.

A simulated annealing algorithm available in MARXAN (Ball and Possingham 2000) was used to find a system of spatially cohesive sites that met the suite of targets. The program was run 100 times for each scenario, and units identified in 60 % of the time were identified as a possible NHS. Several scenarios were run by varying the levels for targets and the treatment of planning units (i.e., locked-in, preferred, or available) for each ecodistrict. All scenarios excluded planning units with > 50 % urban or > 10 % road area.

Results and Discussion

In Ecodistrict 7e5 where natural cover is low (14 %) and with the more than 60 targets set at levels identified by the Canadian Wildlife Service (2004), Scenario 7e5-S1 with provincial parks (PP) locked in and previously evaluated natural heritage (NH) features preferred resulted in an NHS that overlapped by 85 % (and identified similar total area) with Scenario 7e5-S2 where all planning units were available.

In Ecodistrict 6e6 where natural cover is higher (36 %), however, scenario runs (6e6-S1T4) with the levels for targets set the same as those used in Ecodistrict 7e5 demonstrated greater sensitivity to planning unit treatment. In addition, setting the levels for targets the same as those used in 7e5 identified an NHS that comprised a much larger proportion of the ecodistrict (> 80 %) and likely unacceptable to planning authorities. The MARXAN model was considerably more sensitive to the levels set for targets in Ecodistrict 6e6 since there were considerably more hexagons that could meet targets (Scenarios 6e6-S1T2, S1T3, S1T5). Thus, in ecodistricts with higher natural cover, there is both a greater need to carefully consider target levels and the model's sensitivity with locally-knowledgeable experts and a greater need to have fine-scale vegetation composition and structure and key species habitat mapping in order to set more specific targets for conservation and protection of biodiversity and ecological functions.

Table 1: Percentage of targets achieved among scenarios for just 5 of the over 60 targets. All scenarios excluded planning units with > 50 % urban or > 10 % road area.

Ecodistrict-Scenario	**7e5-S1**	**7e5-S2**	**6e6-S1T2**	**6e6-S1T3**	**6e6-S1T4**	**6e6-S1T5**
Planning Unit Treatment[1]	PP-L NH areas-P	All available	PP-L NH areas-P	PP-L NH areas-P	PP-L NH areas-P	PP-L NH areas-P
% existing forests in NHS	65%	65%	40%	62%	99%	62%
% underrepresented forest in NHS	Not Tested	Not Tested	29%	53%	96%	43%
Interior forests (100 m from edge)	86%	88 %	45 %	71%	99%	62%
Interior forests (200 m from edge)	100%	100%	23%	87%	99%	79%
Riparian forest (30 m)	67%	71%	26%	70%	100%	71%
Patch size > 200 ha	99%	99%	56%	80%	66%	66%
% of ecodistrict in NHS	39%	39 %	26%	41%	82%	57%
% of NHS capturing lands intensively cultivated for agriculture	24%	23%	11%	12%	17%	18%

[1] PP - provincial parks; NH- previously evaluated natural heritage features; L= Locked-in; P=Preferred;

References

Ball, I.R., H.P. Possingham. 2000. MARXAN (V1.8.2): Marine Reserve Design Using Spatially Explicit Annealing, a Manual.

Environment Canada. 2004. How Much Habitat is Enough?: A Framework for Guiding Habitat Rehabilitation in Great Lakes Areas of Concern (Second Edition). The Canadian Wildlife Service of Environment Canada. 80 pp.

Habitat opportunity mapping at the landscape scale in the UK

G.H. Griffiths[1], I.N. Vogiatzakis[2]

[1]Department of Geography, The University of Reading, Whiteknights, Reading, UK.
e-mail: g.h.griffiths@reading.ac.uk
[2]Centre for Agri-Environmental Research (CAER), The University of Reading, Earley Gate, Reading, UK

Introduction

The identification of suitable sites for habitat restoration and re-creation given limited resources and competing land use is a challenging and urgent task given continuing concerns about the loss of species and habitats. There is a long tradition of site selection for nature conservation based upon a coherent and well understood set of criteria (Ratcliffe,1977). However, there is mounting evidence that the protection of statutory sites is failing to arrest habitat loss and species decline (Robinson & Sutherland, 2002). This, combined with increasing public awareness of the importance of diverse and species-rich landscapes has resulted, in recent years, in a shift from a site-centred approach focussed on protected areas to a landscape scale approach.

This change of direction is being accompanied by increasingly sophisticated tools for identifying sites for habitat restoration and re-creation, often using GIS (Store & Jokimaki, 2003). However, many of these spatially explicit tools fail to recognise the significance of the landscape context. The paper suggests ways in which contrasts in the physical and cultural attributes of the landscape can be accommodated into habitat models using Landscape Character Assessment (LCA). We present and review a number of case studies from the U.K. in contrasting landscapes ranging from lowland agricultural to upland.

Habitat potential and condition

In the heavily modified cultural landscapes of the UK and other parts of Europe, small-scale differences in soil type, geology, landform, climate and cultural patterns need to be accounted for in setting targets for biodiversity and identifying suitable sites for habitat restoration and re-creation. Landscape Character Assessment provides a relatively simple and objective system for dividing the landscape into homogeneous environmental strata or landscape units. The resulting maps provide a convenient spatial framework within which to set biodiversity targets based upon *habitat potential* and *ecological condition*.

Ecological condition is defined spatially in this context, a set of indices that measure the extent and distribution of surviving semi-natural habitat within a landscape unit. Survival may depend upon physical factors alone, such as slope and elevation or, equally importantly, it is related to the historical evolution of the landscape. Frequently, it is the interaction of these two forces that is important – physical factors limiting the habitat to sites that may also be marginal for agriculture.

An important methodological challenge is to measure the difference between the potential of a landscape unit to support a target habitat and its ecological condition. A unit with a high potential for a specific habitat but with only a small area surviving, may indicate a significant opportunity for habitat restoration and re-creation.

GIS habitat Models

Recent developments in ecology have moved the discipline away from the largely descriptive to quantitative distribution models that formulate the species–habitat link to predict where species and habitats should occur as well as improved understanding of the factors involved (Hobbs & Morton 1999). Matrices indicating the likelihood of the presence of a habitat (widespread or localised) in relation to landform (slope and elevation) and soil type (fertility and drainage) were established for selected Annex I Priority Habitats and the results mapped by landscape unit. In this way, maps of habitat distribution are intersected with habitat potential to determine the extent to which habitat potential is realised in relation to the extent of surviving habitat.

However, this landscape scale approach is only useful at a national scale: the identification of optimal sites for a target habitat at the local scale based upon spatially explicit ecological decision rules is equally important. A GIS habitat model has been developed that uses a set of spatially explicit ecological decision rules to determine the potential suitability of a site for a range of target habitats based upon the need to increase habitat area and reduce isolation.

Summary

The combination of these two approaches: setting biodiversity targets at the broad scale based upon the ratio of the difference between habitat potential and condition, combined with local-scale GIS habitat modelling is proving to be a powerful policy tool. In particular the approach is being developed and tested in Wales with funding from the Countryside Council for Wales and in other parts of the UK including the lowland heath restoration in the Midlands and ecological sensitivity analysis in a southern county of England.

References

Hobbs R.J. and Morton, S.R. 1999: Moving from descriptive to predictive ecology. Agroforestry Systems 45: 43-55

Ratcliffe D, 1977. *Nature Conservation Review*, Cambridge University Press, Cambridge.

Robinson, R.A. & Sutherland, W.J., 2002. Changes in arable farming and biodiversity in Great Britain. *Journal of Applied Ecolog*y, **39**, 157–176.

Store, R. and J. Jokimaki, 2003. A GIS-based multi-scale approach to habitat suitability modeling. *Ecological Modeling,* 169: 1-15.

The assessment of landscape diversity for the purposes of spatial organisation of tourism: the case study of Brest region

I. I. Schastnaya

Department of Geography, Belarus State University, av. Nezalezhnasti, 4
221050 Minsk, Belarus
e-mail: schastnaya@tut.by

The concept of landscape diversity (LD) is a new research problem in landscape science. The concept is meant in different lines, the most explored of these being the traditional-landscape (classical) and anthropogenic ones (Grodzinski, 1999). The classical interpretation of LD has been more widely developed and is related to the assessment of uniqueness and mosaics of Natural Territorial Complexes (NTC).

Anthropogenic line of LD is not widely used concept. It is associated with a diversity of technogenic and Natural-Anthropogenic Complexes (NAL). NAL dominate in our Republic. They are the result of use of resources of a natural landscape in the certain types of human activity and include both elements of natural complexes, and anthropogenic elements. NAL depend on their development first on natural laws. At the same time attributes of their functioning and dynamics are closely connected with social and economic conditions (Schastnaya I.I., 2004). The type of economic use is a basic attribute and classification feature of NALs. This factor can be described by land use distribution, which can be seen as a premise for calculation and assessment of LD of NAL.

Classical and anthropogenic lines of the concept of LD are interconnected and mutually complementary. The creation of various types of natural-technical systems is a necessary element of the expansion of a society. Therefore, the main research problem is to maintain a diverse and optimum proportion of NTC and anthropogenic complexes. It can be achieved as a result of LD assessment, which is integrated parameter giving the information on the system organization of a landscape. LD is an indirect indicator of quality of landscape functioning (Martsinkevich, Schastnaya, 2005). There are many landscape indexes for assessment of LD of natural and “natural-anthropogenic” complexes. The number of species (*vid*) landscapes (or number of patches of landscape species) and their area are the basic parameters of assessment of LD of natural complexes.

Calculation of indexes of a landscape diversity of NAL includes many indexes, first of all:

1) *Area and perimeters of patches,*
2) *Patch numbers within landscape (indicate landscape fragmentation)*
3) *Number of land use type*
4) *Proportion of different land use type within landscape*

$$Pi = \frac{Si}{S}, \quad \textbf{(1)}$$

S_i – area of particular land use type,

5) *Mean area of patches within landscape.*

$$So = \frac{S}{n}, \quad \textbf{(2)}$$

n – number of patches.

According to the results of analysis, the following indices have been selected - Menchinik, Margalef, Shannon and focally an index of complexity. Natural territorial complexes have been used as a unit for assessment. A map of NTC for Brest region has been made (scale 1:100 000). Widely spread terracing and fluvioglacial landscapes have the most complex horizontal structure. Unique flood-plain landscapes locate in the western part of region. Secondary-moraine landscapes have simple structure and spread in northern part of research area. The assessment of LD according to selected factors allows to define the natural complexes having a high values of LD. Terracing and fluvioglacial landscapes have the maximal and high values of Menchinik and Margalef indexes. The index of complexity has defined the maximal degree of diversity of fluvioglacial complexes.

A map of natural-anthropogenic complexes of the study area (scale 1:100 000) has been made. This map reflects the certain regional features of economic development of territory (Marctsinkevich et al., 2002). The system of classification units of NAL includes three levels: class - subclass – species (vid). Each level is based on primary indicators. The highest unit of classification - a class NAL – is recognized by main direction of economic activities in different branches of national economy. Agricultural and agro-forestry class of NAL dominate in our Republic. The relative abundance of various type of land use within landscape (arable, forest-arable, etc.) is the indicator for determination of NAL subclasses. The species of a landscape considers a type of economic activities within natural complex (for example, arable secondary-moraine). Agricultural, agro-forest and forest classes of landscapes are defined in Brest region. Agricultural and agro-forestry landscapes dominate. They have diverse horizontal structure and include 5 subclasses and 9 species for agricultural landscapes and 3 subclasses and 12 species for agro-forest landscapes.

The analysis (according to the indices of Menchinik, Margalef and the coefficient of complexity) has shown that the diversity of natural and anthropogenic complexes differs. Only their estimates on the Shannon index are similar to each other for both types of landscapes. The assessment of LD helps to choose the sites having similar values of diversity for both maps. These sites together with a network of settlements and areas with high recreational potential for the region have formed a basis for the creation of a scheme of spatial organisation of tourism. The sites of maximal and high landscape diversity, as elements of a natural framework of territory, are recommended for the primary organisation of all ecological, scientifically cognitive and partially recreational tourism. Areas with lower values of LD can be used for organisation of recreational tourism with elements of agro-tourism, rural and business tourism.

Results of research have confirmed that it is possible and necessary to use more widely parameters of a landscape diversity of natural and natural-anthropogenic complexes in spatial planning. Application of landscape indexes allows to recommend alternatives for development of territory and to predict consequences of economic activities.

References:

Grodzinski M.D. (1999). Diversity of landscape diversity *Landscape as an integrated concept of XXI,* Kiev State University Press: 34-35.

Schastnaya I.I. (2004). Natural-anthropogenic complexes of Mahilew district *Geography of Mahilew district*, Mahilew State University Press. Mahilew: 174-180.

Martsinkevich G.I., Schastnaya I.I. (2005) The landscape diversity assessment of natural and natural-anthropogenic complexes *Environmental Management,* **61:** 98-205.

Martsinkevich G.I., Klitsunova N.K., Schastnaya I.I. (2002). Principles of natural-antropogenic complexes classification *Dynamic of landscapes and problems and conservation and sustainable development of biodiversity,* Belarusian State Pedagogic University Press: 90-91.

Landscape characterisation in Belgium: integration of different scale levels and analysing temporal differences

V. Van Eetvelde, M. Antrop

Department of Geography, Ghent University, Krijgslaan 291 S8, 9000 Ghent, Belgium.
e-mail: veerle.vaneetvelde@UGent.be

Introduction

Stimulated by the European Landscape Convention, Landscape Character Assessment (LCA) became popular. Most of the initiatives elaborated so far, identify landscapes using classic methods of land(scape) classification, in particular the ones based on a parametric approach. In these approaches, landscape character is defined through a combination of different thematic maps, mostly using GIS overlaying, and is related to certain landscapes types. The Landscape Convention also emphasises the importance of studying landscape change, including the forces and pressures causing it (Council of Europe, 2000). Landscape character is believed to be rather stable, while land use is a more dynamic property of landscape. The core question is how much change in a specific data layer is needed to make significant changes in landscape character. This is analysed for the landscape characterisation in Belgium, using the CORINE land cover from 1990 and 2000.

Characterisation of the contemporary landscapes of Belgium

At the national level of the federal Belgian state, the landscape character typology of the contemporary landscapes is based on four basic datasets that cover Belgium as a whole: a digital terrain model, CORINE Land Cover 1990, a soil map and a Landsat 5 TM satellite image. A hierarchical parametric classification method is used, as well as geostatistics and GIS (Van Eetvelde, 2006, Van Eetvelde *et al.*, 2006). The typology has two scale levels. At the first scale, landscape types were assigned to a grid with 31473 square kilometre cells using 18 variables which were derived from the four datasets. The variables were used in a k-means cluster analysis to define 48 landscape types. At the second scale level, 222 landscape character areas are delineated by a manual holistic interpretation of the spatial patterns formed by the landscape types of the first scale level. The spatial patterns in these areas are described using landscape metrics. Landscape types and pattern characteristics are subsequently used in a hierarchical cluster analysis to define 54 landscape character types at the second scale level.

Methods and materials

CORINE Land Cover is the only available dataset in the typology that gives temporal variation. The land cover changes were analysed between 1990 and 2000. First, a transition matrix was made for the whole of Belgium between 6 main groups of land cover used in the typology at a resolution of 10ha. These groups were urban fabric, industrial units, arable land, pastures, forest and semi-natural areas, and water bodies. In this paper, the focus goes to the urban land use to analysis the problem.

Second, the land cover changes of these groups were defined for each kilometer cell at the first scale level of the typology. The relative changes were used to detect cells where probably change in landscape type could occur.

Results

Looking at the overall changes of land cover in the transition matrix, some differences can not be explained by real changes in the landscape. For example, according to CORINE, urban fabric is mainly transformed to arable land and pastures, industry changed into forest, and water bodies changed into arable land or forest. This is illustrated in figure 1A, were 4090 cells (13%) have a loss of urban fabric, which is highly improbably to be a real landscape change. These differences are due to differences in method and technology used in the two CORINE inventories. CORINE 2000 is an update of 1990 and is results in a more accurate and detailed classification, resulting in less generalised and smaller patches.

For the CORINE category of urban fabric, 8513 (27%) of the cells show an increase since 1990. 1264 (4%) of the cells are classified as urban in the first scale level, but will not affect a change in their landscape type or character. Figure 1B shows 7249 cells (23%) which have a growth of the urban fabric and are classified as non-urban landscape type in the typology. Only 18 of these cells, indicated in black, have an increase of more than 33% urban fabric and could potentially change the landscape character of the cell into the urban type.

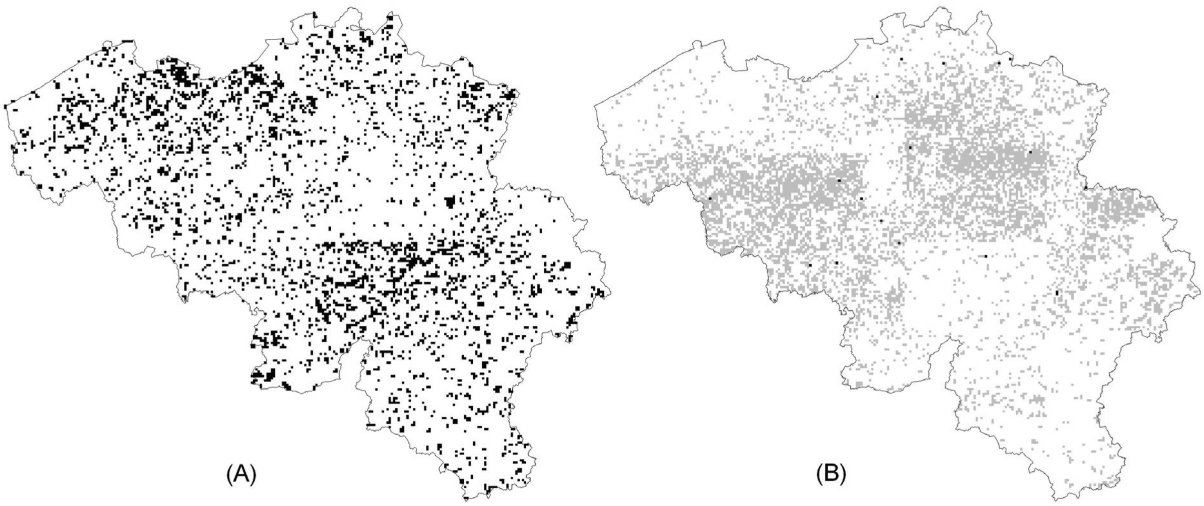


Figure 1. (A) cells with loss of urban fabric; (B) possible changes in landscape type, based on land cover changes of urban fabric between 1990 en 2000.

Conclusions

Land cover is the only data layer in the typology that could identify temporal differences of the landscape character of the kilometre cells at the first scale level. However, most of the changes are caused by differences in data quality and not by real landscape changes, but it is possible to identify cells with potential changes in landscape character.

References

Council of Europe (2000) *European Landscape Convention and Explanatory Report*. Council of Europe, Document by the Secretary General established by the General Directorate of Education, Culture, Sport and Youth, and Environment.

Van Eetvelde, V. (2006) *Van geografische strekenkaart tot landschapsdatabank. Gebruik van GIS, informatietheorie en landschapsmetrieken voor het karakteriseren van landschappen, toegepast op België*. PhD thesis, Universiteit Gent, Vakgroep Geografie, Gent.

Van Eetvelde, V.; Sevenant, M. & Antrop, M. (2006) Trans-regional landscape characterization: the example of Belgium. R.G.H. Bunce & R.H.G. Jongman (Eds.). *Landscape Ecology in the Mediterranean: inside and outside approaches. Proceedings of the European IALE Conference, 29 March - 2 April 2005, Faro, Portugal*. IALE Publication Series 3, pp. 199-212.

Open Session 2: Landscape modelling and earth observation

Problem of characteristic space scale of landscape processes

A.V. Khoroshev, G.M. Aleshchenko, K.A. Merekalova

Moscow State University, Faculty of Geography, Vorobyovy Gory, 119992, Moscow, Russia.
e-mail: khoroshev@geogr.msu.ru

.

Introduction

At the moment there is common understanding of the fact that geographical and ecological processes are scale-specific. Multidimensional systems, such as landscape are often referred to, are being involved simultaneously in multiple interactions at a certain number of levels. The concept of multiscale organization is recognized as a critical idea of modern landscape study. Most studies of the scale problem in landscape ecology are based either on remote sensing or on digital elevation models. Hence, the establishment of hierarchy is realized for only one of the landscape components, plant cover or relief respectively, assuming that it is perfectly indicative of driving forces that operate in the landscape. However, since landscape is a holistic entity, its distinguishing properties are determined by *interaction* of components. Results of interactions (e.g. between landforms and plant cover) can vary across a heterogeneous landscape, and occasional events can cause bifurcations of structural properties. We hypothesize, that two types of landscape patterns should be distinguished in nature: the first based on uniformity of a set of landscape properties, the second based on uniformity of relations between components in heterogeneous environment. New data storage systems show that the concept of one-to-one correspondence between landforms and plant cover should be considered as a particular case of the more general regularity, namely multi-structure organization of landscape. The concept of multi-structure organization of landscape assumes that relatively independent systems are controlled by factors of different origin that can co-exist in space and through time. The core of the multi-structure concept is multiplicity of driving factors of spatial organization at each hierarchical level.

Materials and methods

The case study is situated in the central taiga region of European Russia (the Arkhangelsk region). We modeled types of relations between moisture-sensitive properties of plant cover (evaluated from space images) and drainage conditions (calculated from digital elevation model). To reveal specific scale of landscape processes we developed novel approach based on multiple regression modeling that enables the comparision of types and the strength of relations between landscape components across the area. We understand the concept of “type of relations” as follows: 1) a set of independent variables (e.g. relief morphometry) that affects the value of the dependent variable (e.g. groundwater level); 2) the relative contributions of independent variables to spatial variability of dependent variables; 3) the degree to which the dependent variable is determined by the integrated effect of the independent ones (r^2). The challenge is to assess the diversity of factors that organize the territory under study at the hierarchical level. The territory is represented as a set of intersecting squares. The size of squares is user-defined and related to the hypothesized characteristic space with uniform type of between-component relations.

The purpose is to reveal, whether the spatial diversity of the given area can be explained by the diversity of a single driving force values. If this holds true, then land use decisions should be adapted to anthropogenic loadings and landscape pattern taking into account the gradient of the principal driving force. For example, if bioproductivity is proved to vary continuously within the territory depending on groundwater level, land reclamation measures should vary according to the model of relations between plant cover and groundwater.

Our approach aims at “bottom-up” determination of hierarchical levels using multiscale analysis of between-component relations. We do not identify levels based on a single binding factor, but generate levels based on relations between components. The technique includes multiple regression modeling of relations in a moving square window by means of consequent examination of various combinations of scale parameters (extent and cell size) until “resonance” combinations are found. “Resonance effect” means that the agreed spatial variability of a set of landscape attributes under certain combination of scale parameters indicated by high r^2 value. The Operational Unit (OU) is characterized not only by its own properties (e.g. species composition, microrelief) but also by properties imposed by the higher-level unit (e.g. drainage conditions, mesorelief). When we increase moving window size we consequently evaluate relative importance of higher order units (levels “+1”, “+2” etc.) for the focus unit (level “0”) properties. A set of OU within a moving window is used to design a statistical model that relates properties of OU to properties of higher-order unit (level “+1”). If a set of OU within moving window covers the territory comparable to the landscape level, then the model answers the question: do the relations between properties of OU (level “0”) and level “+1” within the landscape (level “+2”) belong to one type or to many types? Comparing accuracy of models designed for different window sizes one can assess adequacy of the environment for subordination of between-component relations.

Changing linear dimension of OU (from 30 m to 400 m in this study) we pose the question as follows. If some law of relations “level “0” – level “+1” within the level “+2” is proved to exist, whether the same law describes relations in the system “level “+1”-level”+2”? This analysis clarifies, whether the relations at adjacent levels are self-similar or driven by different factors. Processes responsible for differentiation at each level can be revealed using a combination of regression coefficients. To verify the results of multiple regression modeling Spearman nonparametric correlations, Jacobian determinant and information measures were calculated following the same routine.

Results and conclusion

Resonance effects are multiple at most of the territory, showing that between-component relations also operate at multiple hierarchical levels. At the level 2 (OU 400 m) moisture-sensitive properties of plant cover are related to drainage effects in larger areas as compared to the level 1 (OU 30 m). At the level 2 the linkage is realized in the most perfect way in transitional zones between flat watersheds and gentle upper portions of river valley slopes. Linearity of relations is inherent for space with linear dimension 5 times as long (2000 m) as OU (400 m). This holds true for more than a half of the territory. Recalculation of the model for increased moving window (more than 2000 m) detected that linearity disappeared on the most territory. Normally, in the valleys r^2 decreases as extent increases. Thus, diversity of relations in the “relief – plant cover” system is greater in the valleys in comparison with watersheds, i.e. characteristic space scale of relations decreases in valleys. At the level 2 relations are revealed distinctly for the square environment with a linear dimension of 2000 m. In larger environments it is replaced by other types of relations, i.e. a shift to another scale results in change of driving force. However, in certain areas with mean diameter 3-4 km the type of relations is repeated at various hierarchical levels. We identified two types of locations: with self-similarity of relations at different hierarchical levels and with scale-dependent process. While comparing parametric and nonparametric calculations we revealed a particular scale at which linear relations are replaced by non-linear ones. For the fragment of the watershed the type of relations remains the same if linear dimension of moving window increases from 2000 m to 5200 m, but changes abruptly under linear dimension 6800 m accompanied by critical decrease of determination coefficient r^2. This indicates disappearance of linearity. At the same time, nonparametric Spearman correlations are significant. This proves that the functional linkage between moisture factors and drainage conditions is significant, but linearity is inherent for the scale domain 2000-5200 m being replaced by non-linearity in broader scale.

Using between-patch boundaries parameters for conservation status assessment on coastal dune ecosystems

M.L. Carranza[1], S. Feola[2], A. Acosta[2], A. Stanisci[1]

[1]Dip. STAT. University of Molise. Contrada Fonte Lappone - 86170 Pesche (IS), Italy.
e-mail: Carranza@unimol.it
[2] Dip. of Biology. University of "Roma Tre", V.le Marconi 446 - 00146 Roma (RM), Italy.

Introduction

Coastal dune systems are natural formations characterized by a strong sea-inland zonation. In such conditions of landscape sustainability is greatly influenced by the specific contiguity between natural habitats patches.

In the present work we propose to use an adjacency matrix for landscape analysis and conservation status assessment on coastal dune ecosystems. Specifically we analyze the variation in the number and extension of boundaries between adjacent land cover categories using the Rènyi parametric generalized entropy profile. The study was carried out based on detailed CORINE land cover maps of the Molise Region coast, central Italy.

Materials and Methods

A detailed land cover map (scale 1:5,000) of the Molise coast (central Italy) was used covering a 500-m-wide strip starting from the coastline towards inland. Land cover was manually interpreted on video, with the help of a Geographic Information System (ArcView 3.1. ESRI 2000) and field survey. The legend followed CORINE land cover (Anon. 1993) expanded to a fourth level of detail for natural and semi-natural areas (Acosta et al. 2005). 22 land cover typologies were identified and mapped.

Then, three 1 km x 350 m. windows with different disturbance regimes were analyzed and compared. For each window, number and extension of the edges between each pair of land cover categories were calculated and synthesized in an adjacency matrix.

In order to analyze differences in landscape diversity, the variation in the number and extension of boundaries between adjacent land cover categories (patches) from the three windows were evaluated. To do this, for each window a Rènyi parametric generalized entropy profile based on the number and extension of the boundaries was calculated. Boundaries were applied because they could be more informative than the use of patches. Rényi's generalized entropy represents the cornerstone for a continuum of possible diversity measures. In fact, for a distribution function characterized by its proportional abundance $p_i=(p_1, p_2, ..., p_N)$ Rényi's (1970) extended the concept of Shannon's information (entropy) defining a generalized entropy of order (α) as $H_\alpha = \frac{1}{1-\alpha}\log\sum_{i=1}^{N} p_i^\alpha$ Where $0 \geq\alpha\geq\infty$ and p_i denote the relative abundance of the i^{th} element in a system (i=1, 2, ..., N) such that $0\leq p_i\leq 1$ and $\sum_{i=1}^{N} p_i = 1$. Note that in our context N denotes the total number of boundary types for each data and *ni* is the total extension of boundaries belonging to the i^{th} boundary type.

Results and discussion

Rènyi's diversity profiles vary from α= 0 up to α= 10 in the three compared windows, as shown in Fig. 1. From Campomarino (W3) to Frantoio di pietrisco (W2), diversity curves show an increasing number of boundary types with higher richness (α=0), higher diversity values according to Shannon's entropy index (α =1), and higher evenness. Note that no curve cross or touch any other.

Results concerning the increasing richness, Shannon's diversity values and evenness on Frantoio di pietrisco area (W2), were related to an increase in landscape fragmentation. This area is characterized by a diffuse coexistence of artificial and natural areas.

On the other hand, Lido di campomarino area was very simple (W3), as expressed by very low richness and diversity and dominance by few contact types related to consistently human pressure. This window is actually characterized by extensive urban areas in the foredunes and by high tourist pressure and managed dunes.

In our case, the intermediate values of Ramitelli area indicate a quite good conservation status. In fact, this area is inside a pSCI because of the integrity of its coastal dune vegetation zonation.

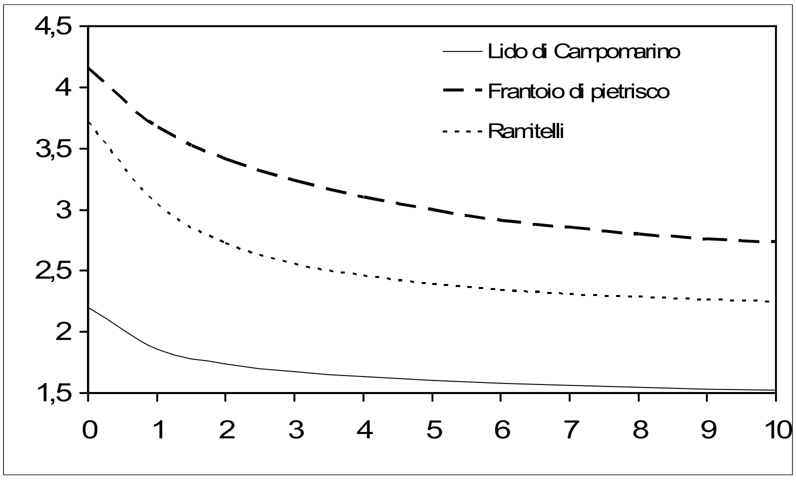


Figure 1. Rènyi's diversity profiles (Hα) vs α of the edges in the different compared windows extending from α=0 to α=10. Frantoio di Pietrisco (W1), Ramitelli (W2), Lido di Campomarino (W3)

Conclusions

In the analyzed areas, results showed a good relation between adjacency matrices information and conservation status. In natural conditions few adjacency types, most of them between natural areas, dominated the landscape. Moderately disturbed coastal areas were characterized by a fragmented landscape with high number of adjacency types. By contrast, in highly disturbed sites there were a few dominant adjacency types.

The major advantage in applying the Rènyi generalized parametric diversity function to compare landscape mosaics is that diversity profiles display not just a single index but a family of indices, many of which currently applied and widely used in landscape ecology. In this way, profiles allow a complete summarization of trends in landscape richness and dominance concentration.

Since it was based on standard land cover classification, the proposed method could represent a good tool in planning issues regarding coastal dune areas in many other European countries.

References

Anon. (1993). *CORINE Land Cove*r. Guide technique. CECA-CEE-CEEA. Bruxelles.

Acosta A.; Carranza M.L.; Izzi F. (2005) Combining Land cover mapping with coastal dune vegetation analyses. *Applied Vegetation Science*. **8**: 133-138.

ESRI. (2000). *Arc-View 3.1*. CA, US.

Rènyi, A. (1970). *Probability theory*. North Holland Publishing Company. Amsterdam**.**

Landscape-dynamical analysis: studies in the North-Western Russia

G.A. Isachenko

University of St. Petersburg,
Research Institute of Geography; 33, 10 line, V.O., 199178, St.-Petersburg, Russia
e-mail: greg@gi1395.spb.edu

By the end of the 20th century the necessity of synthesis of morphologic («static») and functional-dynamic approaches in landscape studies has been clearly recognised. Such studies have been created in the different centers of landscape science and in many respects were initiated by the development of applications of a landscape approach: landscape planning and design, environmental assessment etc. The author and his colleagues the from Laboratory of Landscape Research and Ecological Mapping (University of St. Petersburg) since 1990 have carried out field studies of landscapes in the north-western part of the European Russia, within the limits of taiga and hemi-boreal forest zone. On the basis of a 15-year research programme the concept of the landscape-dynamic analysis has been developed. The main substantive principles can be formulated as follows:

1. In each landscape (geocomplex, natural territorial complex) different components and elements have different characteristic time (time of full change of object or time of one full cycle at cyclic character of changes).

2. Depending on the characteristic of time, in any elementary landscape (geocomplex) the stable part, or a site, and a dynamic part which is described by a set of states of different duration (from diurnal up to long-term ones) are recognized. The site is described by the basic elements as a form of a relief and the upper layer of pedogen (soil-forming) bedrock. It was established based on extensive of evidence that the basic morphological features of relief and the characteristics of the upper layer of bedrocks in identical climatic conditions unequivocally cause a character and degree of moistening regime (or conditions of natural drainage) of sites and a mode of migration of substances. Characteristics of states (concerning basically vegetation and some soil properties) change 1-3 orders more slowly, than attributes of sites. Borders of geocomplexes are drawn on the maps first of all as borders of sites. The characteristics of environment vary more strongly between sites, than within the limits of sites (= geocomplexes).

3. The dynamics of a geocomplex is understood as a sequence of all the states of different duration, and also the set of transitions between the states. Transitions which have certain duration can be examined as states (using a longer time scale). It is possible to speak about short-, middle-and long-term dynamics of geocomplexes (correspondingly states duration is less than 1 year, from 1 year up to 10 years, tens and then hundreds years).

4. Irreversible changes of a relief and substratum (upper layer of pedogen bedrock) under impact of processes with characteristic time, as a rule, are more than 1000 years and may be considered as the evolution of geocomplexes. It should be pointed out that a geocomplex at a local level can transform in other geocomplex as a result of catastrophic processes (earthquakes, landslides etc) or strong technogenic impacts (e.g. open mining).

5. Processes in landscapes and its components have a different causality. Some processes have spontaneous character, i.e. occur without any human participation, and sometimes without an opportunity of such participation. Spontaneous processes can be caused by exogenic (e.g. the development of bogs under influence of climate changes) or endogenic factors (the development of bogs due to neo-tectonic lowering of territory). Some processes are determined by self-development of separate natural bodies: for example, overgrowing of the surfaces which have been freed from the water. The majority of

spontaneous processes are caused by simultaneous action of several external factors. An impact is understood as the event caused by external (natural and/or anthropogenic) factors and causing relatively fast change of a state of geocomplex. Three basic groups of impacts on geocomplexes can be determined: point-source, linear and areal impacts. Anthropogenic influences can be short-term, playing the role of an initial push with subsequent «start» of spontaneous processes (e.g. natural forest regeneration after clear cutting), or long-term (ploughing up the territory and its use as an arable land).

6. The character and intensity of human impacts on a landscape in each historical period are determined by set of the economic, social, political, ethnic factors realized in regional system of landscape management. To study the modern state and trends of change of any geocomplex, it is necessary to analyze changes at previous historical periods.

7. Concerning processes it is necessary to note two basic moments. First, the superposition of different processes always takes place. So, forest regeneration on clearings is complicated and slowed down by periodic local fires, overgrowing by herbs, partial bogging etc. Second, processes of different causes can have similar character of manifestation in landscapes. As an example we can mention forest fires which result in similar consequences irrespective of the reason of the concrete fire.

8. Each impact can be considered as a starting point of the subsequent dynamic trajectories of a geocomplex. The trajectory represents a sequence of long-term states. We can not always indicate with hundred-per-cent probability, in what direction the given geocomplex will change after the impact. In contrast, the number of possible trajectories of the given geocomplex as a result of any impact (or during its realization) usually exceeds one. The set of possible trajectories is less than the connections in a landscape which are more rigid and than the set of plant and animal species which can occupy the released ecological niches. In the taiga of North-West Russia the lowest variety of dynamic trajectories is typical of geocomplexes of extreme sites e.g. granite rocks and oligotrophic bogs.

9. Every superposition of the impacts complicates a dynamic trajectory of a geocomplex and brings in it various «lateral branches». Our studies show, that the number of additional branches is not infinite as the amount of influencing factors in nature exceeds the number of possible reactions to impacts. Any type of a landscape at any period of time is represented in space by various states (or their modifications) of one or several dynamic trajectories (e.g. different stages of coniferous forest regeneration after different-time clearings and fires).

Hence, the key idea of landscape-dynamic analysis is to divide the characteristics of basic landscapes into two categories: *site* characteristics and *state* characteristics. Sites are relatively stable in time, states are «mobile» and change due to spontaneous processes and numerous impacts. Both sites and states can be classified and typified. Typology of sites gives a basis for landscape-dynamic mapping. We have developed a typology of sites for landscapes of the taiga in North-West European Russia, including 30 main types of sites. This typology is applied to landscape-dynamic mapping in scales varying from 1: 5000 up to 1: 500 000.

Spatial modelling of landscape patterns derived from land use and land cover changes

J. P. Fernandes, N. Guiomar

CEEM, Universidade de Évora, Rua Romão Ramalho, 59 – 7002-554 Évora, Portugal
e-mail: nunogracinhas@hotmail.com

Introduction

Land use is the instantaneous expression of the best solution of the equation operating environmental functions such as production, regulation and information, social economical functions such as land use history, available techniques and investment capacity culture and traditions. This implies that the solutions vary along time and throughout space according to natural conditions and social, economic and cultural factors.

The representation of this equation through a spatial model is of major importance in order to evaluate the impact of land use activities on natural and cultural resources. At the same time, the possibility of forecasting such spatial land use distributions according to development scenarios allows the evaluation of incremental and cumulative effects of the diverse activities.

The analysis of environmental and social-economical factors that determine or lead to a given land use system and therefore to a given landscape, is developed in order to determine the existence of regular patterns, allowing the development of simulation models and assessing the relative weight of each factor throughout space and time.

This evaluation makes use of geo-statistical analysis of the eventual dependences of land use on environmental factors. A detailed analysis of the regional land use systems and history is also performed in order to identify spatial and temporal patterns of influence or interdependence as well as its inertia. This process allows the identification of areas with homogeneous behavior.

On the basis of these homogeneous areas stochastic land use simulation models will be developed according to socio-economical development scenarios.

Conceptual framework and methodology

Land use patterns can be interpreted and analyzed from many perspectives. For example, they can, to a greater or lesser degree, provide information about landscape function, economic opportunity, and environmental amenities (Zube, 1987). To understand the structure, function, and dynamics of ecosystems it is necessary to integrate both ecological and human processes (Jennerette & Wu, 2001). The distribution of landscape patterns is strongly influence by environmental discontinuity, human persecutions and other social activities (de la Ville *et al*., 1998).

Applying transition probability models and geostatistical descriptions to generate simulations of future landscape patterns requires one to assume some degree of temporal stationarity in the process (i.e., that the types of locations that change the and patterns of change will be constant over time). Furthermore, applying the models generated in one place to another place would require the assumption of spatial stationarity (Brown *et al*., 2002).

Modelling the relationships between land use, landscape structure, land policies and biophysical environment provides a framework structured fro decision making. This is particularly important to the evaluation of conservation measures for given targets species faces the difficulty that those species demand particular spatial habitat arrangements, factor of particular complexity when we deal with agricultural landscapes and complementary habitat demands. For example, when considering alternative rotations or different combinations of production, the resulting spatial patterns have different impacts on the populations of those species which need to be previously assessed.

This issue is of particular importance when agriculture land use factors are changing rapidly. These changes determine that evaluation instruments of foreseeable impacts on particularly threatened species will constitute a critical instrument for future conservation policies in agricultural environments. Based on economic simulations of foreseeable land use changes in the area of Castro Verde (southern Portugal) the agricultural use of individual parcels is simulated through random allocation of the different components of alternative rotations (traditional and conservation-aimed). This detailed spatialisation of the land management patterns allows the evaluation of habitat suitability for different target species, based on the particular demands of those species to given spatial arrangements. The results were then analysed in order to explain variations between the occurrence of some of those species and predictions obtained trough traditional Habitat Suitability Models.

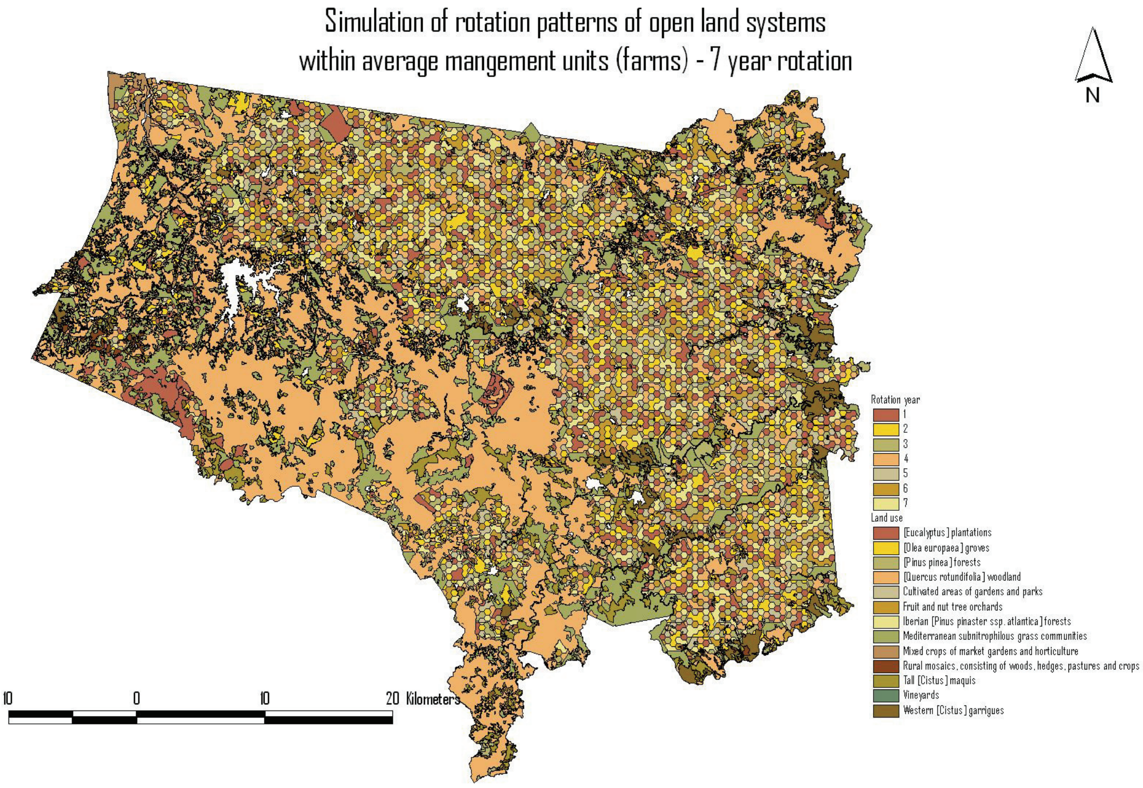


Figure 1. Patterns of land use and land cover change analysis

References

Brown, D. G.; Goovaerts, P.; Burnicky, A.; & Li, M.-Y. (2002) Stochastic simulation of land-cover change with geostatistics and generalized additive models. *Photogrammetric Engineering & Remote Sensing*, 68(10): 1051-1061.

de la Ville, N.; Cousins, S. H.; & Bird, C. (1992) Habitat suitability analysis using logistic regression and GIS to outline potential areas for conservation of the Grey Wolf (*Canis lupus*). S. Carver (Eds). *Innovation in GIS*, Taylor & Francis.

Jenerette, G. D.; & Wu, J. (2001) Analysis and simulation of land use change in the Central Arizona – Phoenix Region, USA. *Landscape Ecology*, 16: 611-626.

Zube, E. H. (1987) Perceived land use patterns and landscape values. *Landscape Ecology*, 1(1): 37-45.

The application of satellite imagery to identify landscape structure

C.A. Mücher[1], C.C. Vos[1], C. Renetzeder[2], T. Wrbka[2], M. Kiers[1], M. van Eupen[1], R. Bugter[1]

[1] Alterra, Box 47, 6700 AA Wageningen, The Netherlands.
e-mail: Sander.Mucher@wur.nl
[2] University of Vienna, Department of Conservation Biology, vegetation and Landscape Ecology, Althanstraße 14, 1090 Vienna, Austria.

Introduction

Habitat fragmentation is widely recognized as one of the major causes for the loss of biodiversity. Spatial cohesion (Opdam *et al.* 2003) is a sustainability indicator to determine whether the size and connectivity of ecosystem networks is sufficient for sustainable biodiversity protection. Spatial cohesion is one of the biodiversity indicators used within the SENSOR project of the Sixth Framework Programme. The landscape permeability of cultural landscapes determines for a large part the spatial cohesion for specific species groups. The landscape permeability is especially related to the land use and landscape elements present within a specific landscape. The presence (veining) of all kinds of semi-natural (green) elements within a cultural landscape is also referred to as green veining, and offers refuges and corridors for a large array of species. The Greenveins project (www.greenveins.nl) indicated relationships between the amount of green veining, the landscape structure, the intensity of agricultural land use and biodiversity. However, actual information on landscape structure and amount of green veining does often not exist for many areas. Many landscape elements can be measured directly by the use of aerial photographs or very high resolution satellite data with spatial resolutions below one meter (Mücher et al. 2001). However the disadvantage of such satellite imagery is that it is mostly used for small areas and certainly not throughout Europe. Although high resolution satellite data such as Landsat or SPOT, with spatial resolutions between 10 and 25 meters for multispectral data do cover the globe and are in general cheaper to obtain, they do have a limitation in that most linear and small landscape elements cannot be detected directly. The hypothesis is that measuring landscape structure might be a good substitute for the amount of green veining. The major objective of this paper is to show the applicability of satellite imagery to identify landscape structure and to show that there exists a relationship between the satellite derived landscape structure and the amount of green veining in a landscape. Special attention is given to the segmentation of Landsat 7 ETM+ satellite imagery of the Image2000 database (image2000.jrc.it) that covers almost the whole of Europe.

Materials

Image2000 was produced from ETM+ Landsat 7 satellite, providing both multi-spectral (6 bands and 25 m spatial resolution) and panchromatic data (1 band and 12.5 m spatial resolution) for the reference year 2000. Image2000 products cover Europe almost entirely (image2000.jrc.it) and are intended to be the main data source for updating the CORINE land cover database. However, the CORINE land cover database provides very limited information about the landscape structure and therefore the Landsat satellite images were segmented to provide additional information about the landscape structure.

Methodology

For the derivation of the SENSOR biodiversity indicator “Spatial Cohesion” at a regional level we need information about the landscape structure – which we want to derive by segmentation of Landsat-TM satellite imagery. Although the IMAGE2000 database covers the EU28 it was not be feasible within the project to derive the landscape structure for the whole of Europe. Therefore a sampling strategy was needed. Stratified random sampling is obvious choice to take representative samples over entire Europe. Since the SSRF (Spatial Regional Reference Framework) cluster regions are determining the spatial reference framework within the SENSOR project it seemed to be logical to use the SRRF clusters (Renetzeder et al, 2007) as the strata for the sampling. Finally, ten cluster regions were selected randomly. For each cluster regions three samples of 50 by 50 km (using the INSPIRE spatial grid) were selected randomly to describe the variation within the cluster region. So, in total we selected 30 samples, each covering an area of 50 by 50 km. For the segmentation of satellite images to determine the landscape structure in terms of individual field parcels there is a wide variety of software packages available. At this stage eCognition is still one of the advanced software packages for segmentation and classification of satellite images and was used within this study. The selection of the best parameters thresholds in eCognition is the most difficult task and is to a large degree depending on experience and “trial & error”.

Results and discussion

The best segmentation results of all thirty European sample sites were found with all six Landsat bands and a scale factor of 30 and a shape factor of 0 (these are eCognition parameter settings). Segmentation results are directly exported as shapefiles. The land cover information was derived from the CORINE land cover database (CLC2000) and was labelled as an attribute to the shapefiles. These results are now available for all thirty European samples. Fragstats will be used to calculate specific landscape metrics that describe the landscape structure in the best manner. The correlation between the specific landscape metrics and the amount of landscape elements (focussing especially on hedgerows, lines of trees, and small woodlands) – as available within the 25 Greenvein sites and the digital topographic map of the Netherlands (Top10-vector) – still has to be determined. If there exists a significant correlation between specific landscape metrics as derived by the above mentioned methodology and specific landscape elements for the whole Europe or for example biogeographical regions, these results can be used to assess the amount of greenveining within the thirty SENSOR samples to assess finally the spatial cohesion of these areas for specific species groups.

References

Mücher, C.A; Thunnissen, H.A.M.; de Bont, C.; Clement, J.; Kramer, H. & Koomen, H.J.M. (2001). Toepassing IKONOS satellietbeelden in het Meetnet Landschap. BCRS rapport 01-40, Delft.

Opdam, P.; Verboom, J. & Pouwels, R. (2003). Landscape cohesion: an index for the conservation potential of landscapes for biodiversity. *Landscape ecology* 18, 113-126.

Renetzder, C.; van Eupen, M.; Mücher, C.A. & Wrbka, T. (2007). Linking landscape characterics and socio-economic profiles for sustainable impact assessment at the regional level – the spatial reference framework (SRRF). To be published in the IALE world conference proceedings 2007, Wageningen, the Netherlands.

Identification of geosystem formative factors on the basis of field and remote sensing data

D.N. Kozlov[1], M.Yu.Puzachenko[2], M.V. Fediaeva[1], Yu.G.Puzachenko[2]

[1] Lomonosov Moscow State University Faculty of Geography, 119899, Moscow, Leninskiye Gory 1, Russia,
e-mail: danilko@nm.ru
[2] A.N. Severtsov Institute of Ecology and Evolution RAS, 119071, Moscow, Leninsky prospect 33, Russia

In spite of all inconsistencies of various scientific interpretations, the term “landscape forming factors” mean in landscape science the properties of components which determine endogenous character and intensity of interaction. Among these important properties are climate, geological structure, relief, biotic and soil features. While researching a specific territory the main task of a researcher is to reveal a role of zonal and azonal factors in landscape structure differentiation as well as to determine dominant and subdominant factors for different hierarchical levels. The special task is to reveal individual and integral properties for each landscape component. Individual ones which determine regularities of structure organization of particular landscape components are the object of branch sciences of geography. Integral properties provide wholeness of natural geosystem is studied by landscape geography.

Decisions of stated tasks differ for various territories and depend of basic perceptions of researcher and selected methods of material collection and analysis. Development of methods of an objective estimation of factors which form the complex of environment conditions is an actual task of modern landscape science.

The stated aim is complicated because we need to extract hypothetical factors from huge number of properties which determine conditions of landscape components. Each component has its own characteristic time. Moreover, these properties inevitably need various methods of description and with various accuracy. The most optimal scheme of landscape factors search we can offer the way of consequent, step-by-step decreasing number of properties for each functional part of component. For example, soil can be described by the following properties: thickness of each genetic horizon, their color and texture. Similar functional parts for vegetation are separate layers of canopy characterized via species composition, height etc. Relief as the factor of moisture redistribution on various scales can be presented through relative elevation, slope and its form. Reflected solar radiation registered by satellite sensor is in fact momentary measurement of energy balance components, different spectral indices reflect biophysical properties of vegetation.

Joining this massif of data and using different methods of multidimensional statistical analysis, we can sequentially present each measured property or combination of properties through relief and remote sensing data characteristics. In simplest case this operation can be realized by step-by-step discriminant and factor analysis. Properties which discrimination statistically is not confident are excluded from further analysis. Eventually, few dozens of field measured properties are reduced to a few (5 to 6) independent factors. During this transformation a number of properties excluded from final system. These are the ones which variation in space is very specific or, only the determined in whole system part of this property can be determined. The properties that are described by independent factors are admitted as belonging to unified landscape system. The disadvantage of the offered method is selection of all initial properties on the basis of relief and remote sensing data and mapping via factor analysis only linear relations. Its advantage is visualization of any property and independent factors variation directly in cartographic form. This allows us to semantically control the obtained results and to make physical interpretation of independent factors through analysis of their connection with functional properties.

Decreasing of system dimension essentially possible using method non-parametric scaling. Using this method we do not need to use remote information as unified base. But the second way in more bulky although it provides the informative analysis. Results of proposed method are demonstrated on the example of searching landscape forming factors for southern taiga landscape of Walday Hill (Central Forest Reserve, 33º E, 56.2º N). It is based on 1150 field descriptions of 20 properties.

We have stated that all diversity of properties measured in situ, can be described by eight independent factors which reflect properties of landscape components in more than 30% cases. For example three variables of Munsell soil color charts (HUE, VALUE, CROMA) reconstructed in 50% cases. First factor determines 21.3% of total variation and leading for most of landscape components. It reflects redistribution of moisture depending on slope steepness on various hierarchical levels and determines development of raised peat bogs and forest bogs, main properties of soils, development of moss cover and pine distribution in space. Second by its significance factor (16.5%) also reflects moisture redistribution but through form of surface. It is closely connected with amount of sun radiation used for transpiration and biological productivity and sort of humus (soft or coarse). Third independent factor (14.5%) reflects succession stages. Maximum of factor corresponds to forests with highest biological productivity with spruce and birch domination. Fourth factor (12.5%) again connected with moisture redistribution and with degree of humus accumulation dependently of backwater moisture. It determines distribution of alder and elm trees. Fifth factor (9.5%) do not depend on relief, it determines development of thin podzoloc soil horizon hypothetically in places where ground water unloaded through carbonated moraine deposits. Here the low sparse forests with poor productivity appear. Sixth factor (7.9%) is connected with absolute elevation and determines thickness of humus layer and way of organic decomposition. All other equal the higher territories characterized by thinning of humus layer and more soft humus sort. Seventh factor (7.3%) is connected with soil texture and absolute elevation. The higher elevation is, the more dense soil forming rock. Thickness of humus and podzolic soil layers increases under grassy spruce-birch forests. At last the weakest eighth factor (5.7%) is connected with slope steepness at microlevel and determines the type of redox regime which influences the color of podzolic soil layer.

All factors with different weights determine states of various landscape properties. Their real state is a result of relatively independent forces. But generally relations resolve to multidimensional redistribution of moisture by relief, independent vegetation disturbances and various mineralization of ground water.

Stated relations allow to obtain landscape map with utmost possible portrayed genesis of landscape properties and to prepare basis for landscape forming processes modeling.

The research is made with support of RFBR projects # 03-05-64280.

Integrated Remote Sensing Monitoring for Environmental Changes of a Solid Mineral Deposit Area (Diamond Deposit. Arkhangelsk District. Russia)

T.V.Orlov

Institute of Environmental Geoscience Russian Academy of Sciences (IEG RAS). Ulansky pereulok 13, building 2, P.O.Box 145, 101000 Moscow, Russia.
e-mail: tim.orlov@gmail.com

Introduction

Extreme geoecological conditions and high level environmental impact characterized solid mineral deposits in northern regions. But solid mineral deposits exploitation is important part of development modern society. However, mineral resource industry bring about irreversible environmental changes. Mechanical, geochemical, hydrogeological impacts and their non-linear interference determine this changes.
Integrated geoecological monitoring system should be an obligatory part of any solid mineral deposit project. Different orientation of local impacts, their interference and changes, non-linear finish result are the main problems of integrated geoecological monitoring. Integrated geoecological monitoring system is number of measures to study and control different nature component changes.
Remote sensing monitoring is a component of the integrated environmental monitoring system of the diamond deposit. Field researches show environmental changes, remote sensing monitoring shows spread of these changes for the whole investigated area.
The purpose of this issue is to investigate environmental conditions of diamond deposit area using remote sensing data and field researches. The aim of this issue was to develop map of natural and human-caused ecosystems and map of environmental changes.

Methods and Materials

Landsat 7 images (30m/pix, 2000), QuickBird (2.4, 0.6 m/pix, 2004, 2005, 2006), aerial images (2000) and field researches of 2004-2006 were the basic issue materials. Unsupervised and supervised classifications of satellite data were used for developing map of natural and human-caused ecosystems. Samples for supervised classification were based on types and features of natural ecosystems and degree of human-caused variations, observed during field researches. Results of these classifications were verified by check data set. Maps of natural and human caused ecosystems of different years are compared with each other. The environmental changes map was developed using difference between ecosystems maps of various years. Final map are verified by last satellite data and field researches data.

IEM development problems

Problem of the monitoring point's location.
A monitoring point is located at a way of influence. The method to solve the problem is suggested: monitoring points groups are located at main ways of influence, other ways of influence are controled by remote sensing data..
Problem of the monitoring point type selecting.
Another problem is to select monitoring point type and consider natural component interaction. One of the methods to solve the problem may be characteristic-indicator search. These indicators are specified for each region and impact type.
Problem of the observation characteristic set selecting.
Observation characteristic set selection came from prospective ecosystems changes and the most sensitive environmental elements. Besides, there are monitoring points oriented on the

environmental changed flow control (e.g. waste water after bog passing). In that case observation characteristic set should to consider flow changes. In example with waste waters it is exchange reactions within wasted waters, bog and natural bog composition. Modeling and field experiments are needed for those reaction describing.

Problem of measurement frequency

IEM system controlled processes have different rates.It is sufficient to find characteristics-indicators that display this process in most completed way.

Conclusion

The main principles of rational IEM system develop was determined. They are: considering landscape differentiation, considering of natural components interactions and reaction integrity, considering primary impact processes, considering geochemical migration flows, combination of point-contacted filed researched method and areal remote sensing methods, integration of analyze and processing data, using indication characteristic, adaptivity of structure and work order.

The IEM system for diamond deposit on the north of Russia was developed, based on thus principles,. The IEM system consists of approximately 100 monitoring points, 20 routes and profiles and covers the area of 40 sq.km. Maps of natural (fig. 1a) and man caused ecosystems (fig. 1b) were developed.

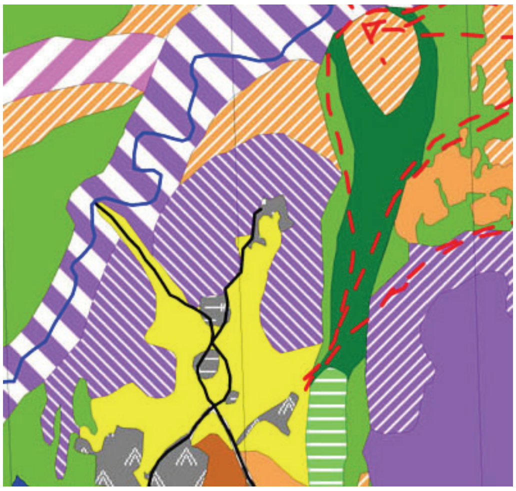


Fig. 1a. Map fragment of natural ecosystems. (green colors different bogs, purple colors – different spruce forests, orange colors – pine forests, yellow and grey – men changed areas

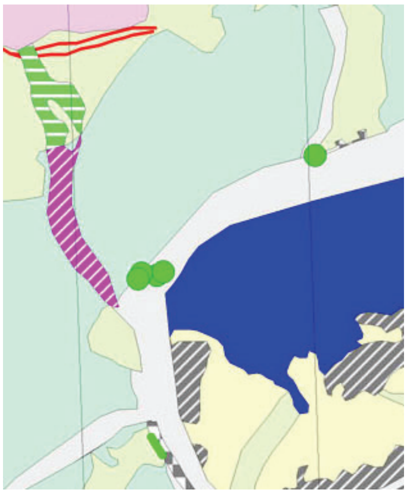


Fig. 1b Map fragment of man caused ecosystems (purple and green polygons – forest bogging, green circles – man caused subsidences, green line - man caused underflooding, blue polygon - water flooding

One of the most spread environmental changes is the land clearing and expansion of waste piles and dams. Forest ecosystems bogging is the second type of changes. Soil wetness grows up, water surfaces and streams appear as a result of bogging. Land subsidence appears on the dams and vegetation cleared surface. Soil denudation and accumulation present on the grass slopes, covered with 2-5 sm alluvium. Processes of environmental changes are local at the present day; this investigation hasn't fetch out significant spatial changes. But diamond deposit exploitation impact is rather serious, and it will be heavier in future.

Landscape mapping: does the scale lie within?

F. Tolle, J.-C. Foltête

ThéMA UMR 6049 CNRS - Université de Franche-Comté, 32 rue Mégevand, 25030 Besançon cedex.
e-mail: florian.tolle@univ-fcomte.fr

Introduction

The question of scale is a major issue in landscape ecology. Li and Wu (2004) do stress the fact that a distinction should be made between the scale of landscape patterns and the scale to which ecological processes are sensitive. These scales are not necessarily equal and they might even not be linked (Wu, 1999). It is therefore critical that the scale at which the landscape is described coincides with the process of interest. The way species use their environment is constrained at various scale levels (Thies *et al.*, 2003). It is now the landscape approach that is privileged in most studies (Kareiva and Wennergren, 1995; Wiegand *et al.*, 1999). Gehring and Swihart (2003) explored the influence of habitat fragmentation on mammal predators. Generalist predators and small animals do not have the same perception of landscape (Vos *et al*., 2001). Inter-species relationships and the complexity of prey-predators systems do require a multiscale approach (Brown and Litvaitis, 1995). This study aims at characterizing the functional response of species to landscape structure without any *a priori* assumptions on the species behaviour. The influence of landscape on the presence of the parasite *Echinococcus multilocularis* in a vector-borne disease system has been explored. This parasite is responsible for the fatal zoonotic disease alveolar echinococcosis in humans. The life cycle of the parasite is dependent upon two animal vectors. Micromammals such as voles do host the larval form of the parasite and foxes carry its adult form. The main goal of this work was to identify critical scale levels favourable to the presence of *Echinococcus multilocularis* in the Doubs department in eastern France. This area is known as endemic for the parasite and most of French human cases have been diagnosed in the Doubs (Giraudoux *et al.*, 1996).

Material and methods

In the study area, a database of 175 georeferenced samples has been constituted and nine samples revealed the presence of the parasite. A classified image of the study area was derived from IRS remote sensing data and resampled at a 25 m resolution. Landscape contexts were derived around each sample and the composition of these landscapes was recorded. The ratio of each land use class for each sample was expressed as a composition vector (Wharton, 1982). This vector was expressed for each point data P of an image with c land use classes as $X_P = (d_1,d_2,\ldots,dc)$. Manhattan distances were then used to calculate the distance between two composition vectors. A method developed by Foltête *et al.* (2002) was used to compare the distance between the mean composition vector of all samples and the composition vector of positive samples, at each analysis radius. This index, noted *u*, shows low values when the distance between positive- and all-samples landscape composition vectors is the greatest. It has been computed at radii ranging from 25 to 10000 meters and revealed three scale levels of interest. Landscape proved the most different at radii of 700 m, 2200 m and 4775 m. These scales were selected for subsequent analysis.

Results

At the three scales of analysis, the composition of the landscape has been compared. The first conclusion is that the landscape surrounding positive samples consistently shows a higher ratio of complex patches (abandoned agricultural areas, hedges, forest margins…) which can be interpreted as the expression of the need for species to find both food and shelter. Conversely, cultivated fields are not attractive and are inappropriate to the development of the parasite's life cycle. This was expected as fields are not optimal habitat for the intermediate hosts because of the disturbances caused by ploughing. Other parameters such as forest do not seem to have an influence on the epidemiological processes. Three maps were computed and illustrate the Manhattan distance of the landscape of each cell of the study area to the mean composition vector of positive samples. At a 700 m radius, forest edges seem to appear significant whereas important uniform agricultural areas do not seem to play a role. At a 2200 m radius, the most complex areas are opposed to the same main field areas. Eventually, at a 4775 m radius, the area of the first plateau and the high land of the Jura mountains seem to be of value to be parasite. As shown here, both a precise and spatial description of the specificities of landscapes related to *Echinococcus multilocularis* can be established using these methods. The main interest of this approach lies in the fact that the scale of analysis is expressed by the data and not based on expert knowledge, therefore excluding potential mistakes in the critical choice of the scale level at which the ecological phenomenon should be observed. Subsequent sampling campaigns could be designed based on these results and used to validate the conclusions of this work.

Acknowledgments

The authors are grateful to Patrick Giraudoux and Francis Raoul from the Laboratoire de Biologie Environnementale, Déborah Gottschek, Stéphanie Favier and Frantz Catarelli at the ERZ for the coordination of the monitoring survey. Denis Augot, Franck Boué and Anne Thuault at the AFSSA for the samples' analysis work. Financial support from the European EchinoRisk program QLK-2-CT-2001-01995 "Risk assessment and prevention of Alveolar Echinococcosis" and US National Institutes of Health and National Science Foundation "Ecology of infectious diseases" (TWO1565-02).

References

Brown, A.L. & Litvaitis, J.A. (1995) Habitat features associated with predation of New England cottontails: what scale is appropriate? *Canadian journal of zoology*. 73, 1005-1011.

Foltête, J.C.; Monteil, C. & Deconchat, M. (2002) Habitat animal et image numérique : méthode de reconnaissance exploratoire appliquée à des occurrences d'espèces. *Proceedings of the 6èmes journées Cassini*, 187-206.

Gehring, T. M. & Swihart, R. K. (2003) Body size, niche breadth, and ecologically scaled responses to habitat fragmentation: mammalian predators in an agricultural landscape. *Biological Conservation*. 109, 283-295.

Giraudoux, P.; Vuitton, D.A.; Bresson-Hadni, S.; Craig, P.; Bartholomot, B.; Barnish, G.; Laplante, J.J.; Zhong, S.D.; Wang, Y.H. & Lenys, D. (1996) Mass screening and epidemiology of Alveolar echinococcosis in France, Western Europe, and in Gansu, Central China: from epidemiology towards transmission ecology. In: J. Ito et N. Sato (eds.), *Alveolar echinococcosis: strategy for eradication of alveolar echinococcosis of the liver*, Fuji Shoin, Sapporo 060, Japan, 197-211.

Kareiva, P. & Wennergren, U. (1995) Connecting landscape pattern to ecosystem and population processes. *Nature*. 373, 299-302.

Li, H. & Wu, J. (2004) Use and misuse of landscape indices. *Landscape Ecology*. 19, 389-399.

Thies, C.; Steffan-Dewenter, I. & Tscharntke, T. (2003) Effects of landscape context on herbivory and parasitism at different spatial scales. *Oikos*. 101, 18-25.

Vos, C.C.; Verboom, J.; Opdam, P.F.M. & Ter Braak, C.J.F. (2001) Toward ecologically scaled landscape indices. *American naturalist*. 157, 24-41.

Wharton, S.W. (1982) A contextual classification method for recognizing land use patterns in high resolution remotely sensed data. *Pattern Recognition*. 15(4), 317-324.

Wiegand, T.; Molony, K.A.; Naves, J. & Knauer, F. (1999) Finding the missing link between landscape structure and population dynamics: a spatially explicit perspective. *Am. Nat*. 154, 605-627.

Wu, J. (1999) Hierarchy and scaling: extrapolating information along a scaling ladder. *Canadian journal of remote sensing*. 25, 367-380.

Investigation of spatial resolution in remote sensing of fragmented environments for ecological models

A.M. Lechner[1], S.D. Jones [1], S.A. Bekessy [2]

[1] School of Mathematical and Geospatial Sciences, RMIT University,
GPO Box 2476V, Melbourne 3001, VIC, Australia.
e-mail: S3070282@student.rmit.edu.au
[2] School of Global Studies, Social Science & Planning, RMIT University,
GPO Box 2476V, Melbourne 3001, VIC Australia.

Introduction

This project investigates the use of high spatial resolution remote sensing for ecological models, particularly in fragmented environments. Due to the lack of accurate up-to-date maps of an appropriate scale, fragmented natural habitats such as peri-urban areas are some of the most difficult to model. Remote sensing is often heralded as a solution to fill this information void, however objects may be spectrally and spatially similar and may thus confound mapping - fragmented environments are spatially complex with habitat patches varying in size from median strips (~10m^2) to large vegetation remnants contained within national parks (100km^2).

Correctly mapping habitats is often critical for the development of accurate ecological models. However, depending on the remote sensing data, classification technique and class description, large differences in the classification of landcover may occur, and the resulting map might vary in the extent, patchiness and accuracy of classified areas. This study compares different sensor resolutions, the influence of changing the extents of the study area and the final mapped products.

Measuring the effect of changing spatial dependent factors

This study utilizes presence / absence tree cover data produced for the state of Victoria in Australia that covers an area of approximately 227,416 km^2. The study area includes agricultural, urban and wilderness areas with a variety of levels of habitat fragmentation.

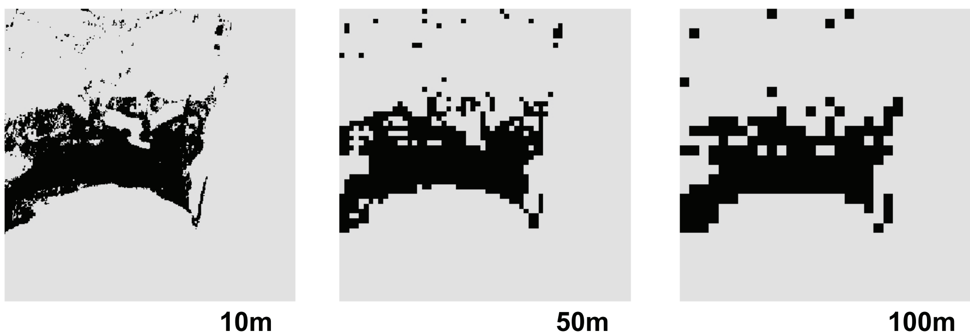


Figure 1. Example of a clipped area where the resolution has been degraded from the original 10m pixel size to the lowest resolution of 100m.

Subsets of this image were randomly clipped at 3000m, 10000m, and 20000m replicating landscapes of different extents (see figure 1). Other studies have compared scaling effects on landscape metrics (e.g. Wu et al. 2002), however this study is unusual in that the large study area allows for multiple replications at the landscapes level of real landscapes. Simulated landscapes have difficulties in capturing all the characteristics of real landscapes

(Li et al. 2004). For each clip the image was degraded from the original 10m pixel size to 100m at 10m intervals. Landscape metrics were then calculated using the fragstats package (McGarigal et al. 2002).

Results

The study found that while the total area classified remained relatively constant when the image resolution changed there were large differences in the patchiness (see figure 2). As image resolution increased the fine scaled levels of patchiness no longer appeared. Small patches either aggregated into larger patches or disappeared. Furthermore, the relationship between resolution and patchiness was not linear and changed at different extents.

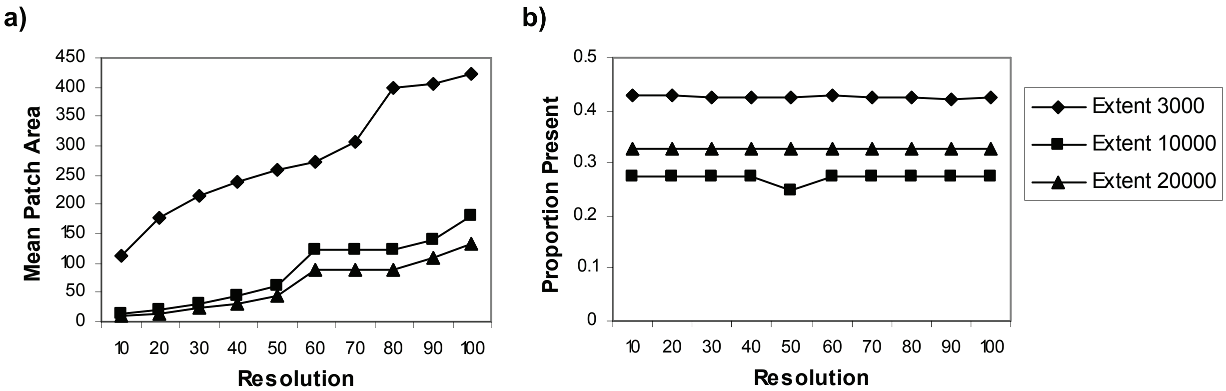


Figure 2. a) Mean patch Area. b) Proportion of imagery classified as having vegetation present.

Conclusion

It can be seen that changes in scale dependent factors affect the patchiness and total area classified. This study demonstrates that landcover maps are the product of the resolution of the imagery and study extents.

This paper is part of a larger project that aims to assess multiple scale dependent factors and compare the magnitude of their influence on accuracy, patchiness and total area classified.

References

Li, X, He, HS, Wang, X, Bu, R, Hu, Y & Chang, Y (2004) Evaluating the effectiveness of neutral landscape models to represent a real landscape, *Landscape and Urban Planning* **69**(1): 137-48.

McGarigal, K, Cushman, SA, Neel, MC & Ene, E (2002) *FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps. Computer software program produced by the authors at the University of Massachusetts, Amherst.*, <Available at the following web site: www.umass.edu/landeco/research/fragstats/fragstats.htm>.

Wu, JG, Shen, WJ, Sun, WZ & Tueller, PT (2002) 'Empirical patterns of the effects of changing scale on landscape metrics', *Landscape Ecology*, **17** (8): 761-82.

5.4 Open Session 15: Landscape metrics and geostatistics

Ecological Aspects of Landscape Fragmentation Measurements

P. Csorba

University of Debrecen, Departement of Landscape Protection and Environmental Geography, H-4010 Debrecen Egyetem tér 1, Hungary,
e-mail: csorbap@delfin.unideb.hu

Landscape metrics deal with characteristics of landscape patterns, like spatial structure of patches, corridors and barriers. Landscape metrics often examines the fragmentation of landscapes due to its importance from the aspect of landscape aesthetics, general landscape and nature protection planning (Farina, 1998).

It is not necessary to take into consideration the ecological features of visual landscape structure for landscape aesthetic analyses. In such cases aesthetic parameters of landscape pattern, balance of patches, color, and tone are important factors. (Wöbse, 2002).

In the case of general landscape protection – e.g. a World Heritage cultural landscape – the aim is the maintenance of a landscape structure that is considered to be valuable by the society. Ecological aspects are not of primary importance in such cases, because usually, the main purpose of those efforts is to conserve traditional cultivated plants and land use – vineyard, pasturing, forestry (*dehesa, kampen, bocage*) for instance (Wascher and Jongman, 2000).

On the other hand, when data of landscape-metrics analyses are used in nature protection planning, ecological aspects are stressed (Hawkins and Selman, 2002, Klopatek and Gardner 1999, Vos *et al.* 2001).

The degree of fragmentation of 229 microregions of Hungary by roads, railway lines and settlements was determined (Csorba, 2006). Our datasets were compared to those of Dosh and Beckmann (1999) for Germany. Results have showed that for estimation of ecological consequences of fragmentation it is necessary to take into account some other factors in addition to data on the density of traffic infrastructure.

For landscape metrics based on ecological aspects, important factors are the size, scatter and shape (pheriphery/area) of patches; ecological contrast of neighboring patches, quality (width) of ecotones, connectedness of patches and quality of corridors (strip, line, dispersal corridor). From the aspect of ecological functions traffic loads of roads and railway lines are also important parameters. Other important factors are: whether there are busy roads and railroads close to each other, their position relative to the protected areas and whether there are sections of those traffic routes which cross protected areas.

For the weighting, traffic density of roads was first taken into account. Data for this parameter is easily accessible from the national database. Traffic density data for Hungarian road network is divided into eight motor car unit categories: 0-499, 500-999, 1 000-1 499, 1 500-1 999, 2 000-4 999, 5 000-7 999, 8000-19 999, and over 20 0000 car units/day. On that base five categories were formed by a contraction for ecological weighting (Csorba, 2000a).

In the case of railway lines different weights were given to main lines, branch lines and narrow gauge lines.

The picture gained this way was refined further by the consideration of consequences of the topographic situation (Csorba, 2000b). It is quite usual that busy roads and railways run parallel to each other. In this way they form a dual barrier for the migration of animal and plant species. The scale of the base map (1 to 250 000) made possible to use a higher weight in places where a road and a railway line runs closer to each other than 1 km.

In places, where roads or railway lines cross nature protection areas, it is advisable to use a higher weight again.

Because of lack of data on their traffic density, the fragmentation effect of tourist tracks could unfortunately not be taken into consideration, although these tracks cross nature protection areas, and act as strong barriers (mass tourism in the environment of the cities) in many cases.

It is not easy to quantify the fragmentation effect of settlements. According to Hungarian landscape protection regulations there must be an at least 200 meters wide migration corridor left between settlements. In places where degree of agglomeration of settlements reaches this level it is advisable to also use a higher weight.

It would be reasonable also to take into consideration the ecological migration effect of the typical scattered settlement type (homesteads) in the Great Hungarian Plain. This problem has not completely been solved yet, as there are not enough data for the qualification of the impacts of special land use sites like quarries and airports as well.

References

Csorba, P. (2005) Landscape ecological fragmentation of the small landscape units (microregions) of Hungary based on the settlement network and traffic infrastructure. *Ekológia* in press.

Csorba, P. (2005a) Ecological corridors in the foothill area of the Tokaj Mts. *Greenways. Conference Presentations of the Ecological Corridors, Green Corridor,* Sopron, pp. 31-44.

Csorba, P. (2005b) Kistájaink tájökológiai felszabdaltsága a településhálózat és a közlekedési infrastruktúra hatására. *Földrajzi Értesítő* LIV, 3-4., pp. 243-263.

Dosch, F. & Beckmann, G. (1999) Trends der Landschaftsentwicklung in der Bundesrepublik Deutschland. *Informationen zur Raumentwicklung*, H. 5/6. pp. 291-310.

Farina, A. (1998) *Principles and Methods in Landscape Ecology*. Chapman and Hall, 235 p.

Hawkins, V. & Selman, P. (2002) Landscape scale planing: exploring alternative land use scenarios *Landscape and Urban Planning* 60. pp. 211-224.

Klopatek, J.M. & Gardner, R.H. (eds.) (1999) *Landscape Ecological Analysis. Issues and Applications*. Springer Verlag, 400 p.

Vos, C.C. & Verboom, J. & Opdam, P.F.M. & Ter Braak, C.J.F. (2001) Toward Ecologically Scaled landscape Indices. *The American Naturalist* 183. 1. pp. 24-41.

Wascher, D. & Jongman, R. (2000) *European landscapes, Classification, assessment and conservation*. European Environmental Agency, Coppenhagen

Wöbse, H. (2002) *Landschaftsästhetik*. Ulmer Verlag, 304 p.

Determining patch-level metrics in naturally disturbed and managed forest landscapes: implications for enhancing ecological attributes and processes

R. Lafortezza[1], R.C. Corry [2], R.D. Brown [2], G. Sanesi[1]

[1]greenLab – Department of Scienze delle Produzioni Vegetali, University of Bari, via Amendola 165/A 7026 Bari, Italy.
e-mail: r.lafortezza@agr.uniba.it
[2]School of Environmental Design & Rural Development, University of Guelph, Guelph, Ontario, Canada N1G 2W1

Introduction

Relatively biodiversity-rich habitats in highly fragmented landscapes tend to be few and their characteristics tend to be modified by pressures from the surrounding matrix. The woodlands, wetlands, and grassland or prairie habitats that are some of the most valued refuges for biodiversity are valued in part because of their rarity. Beyond the presence and number of these habitats are other characteristics of their relative quality, like patch size, shape, and location. Patch shape relates to habitat quality by the ways in which it allows or enables interactions with adjacent ecosystems. Complex patch shapes are considered to provide more locations for different foraging behaviours and for encouraging more boundary-crossing animals through coves and lobes (Dramstad *et al.* 1996).

Complex shapes lead to microclimatic variability and greater plant diversity along edges (Forman 1995). Simple patch shapes, conversely, encourage movement along edges (rather than across) and lead to less interaction between the habitat patch and the matrix (Dramstad *et al.* 1996). While complex patch shapes may provide for more interaction among species, the pervasive effect of human beings has been to divide, settle, and manage land in ways that simplifies patch shapes into regular linear corridors, rectangles, triangles, and geometric polygons (Fig. 1) (Corry and Nassauer 2002; Brown *et al.* 2007).

Beginning with a primeval ecosystem (forest, wetland, grassland/prairie), the perforation of clearing and settlement gradually converts the intact ecosystem to smaller, fewer, and more geometrized patch shapes (Forman 1995). Patch shapes would not be simplified only under circumstances of unusually-high required effort, exorbitant costs, or technical limits (Corry and Nassauer 2002). Patch sizes and shapes have been shown to have a relationship in particular locations. Larger patches tend to have more complex shapes, while smaller patches have more regular shapes. A study in Mississippi (USA) for example noted that forest patches that were smaller in area were more regularly shaped, while large forest patches were more complex (Krummel et al. 1987). In another study forest patch shapes were found to be simpler in Wisconsin (USA) landscapes that were more affected by human activities. In this paper, we explored the size:shape relationship of forest patches in two distinctly cultural, yet different landscapes: Southern Ontario and Southern Italy (Apulia region). The Ontario landscape is relatively young (about 12,000 years since last glaciation) and its transformation to broad-scale settlement is relatively recent. Southern Ontario has been surveyed and divided under several different land division systems, creating a patchwork of towns, fields, and forests with odd angles, gores, and unusual intersections (Hart 1998). The Southern Italy landscape is older (about 100,000 years since glaciation), has been settled much longer, and is typified by finer-scale management. The patterns of land division and settlement have commonly fragmented primeval ecosystems along lines that coincide with road networks, farm boundaries, and field patterns (Brown *et al.* 2007). Cultural artifacts, cropping patterns, and remnants of vegetation (generally) typify the structure of the landscape and its inherent spatial heterogeneity.

Objectives

Our exploration had the following research objectives:

- to compare similarities and differences between Ontario and Italy forest patch size:shape relationships
- to learn if patch size and shape were related in ways similar to other studies (i.e., larger patches had more complex shapes; smaller patches had more simple shapes)
- to learn if the duration of settlement (i.e., the length of time that culture has modified the landscape) is related to more simple patch shapes.
- to estimate – by comparison to spatial attributes – the degree of cultural and acultural shape effects on patch size classes.
- to suggest how forest patch size:shape relationships can inform landscape planning, design, and management.

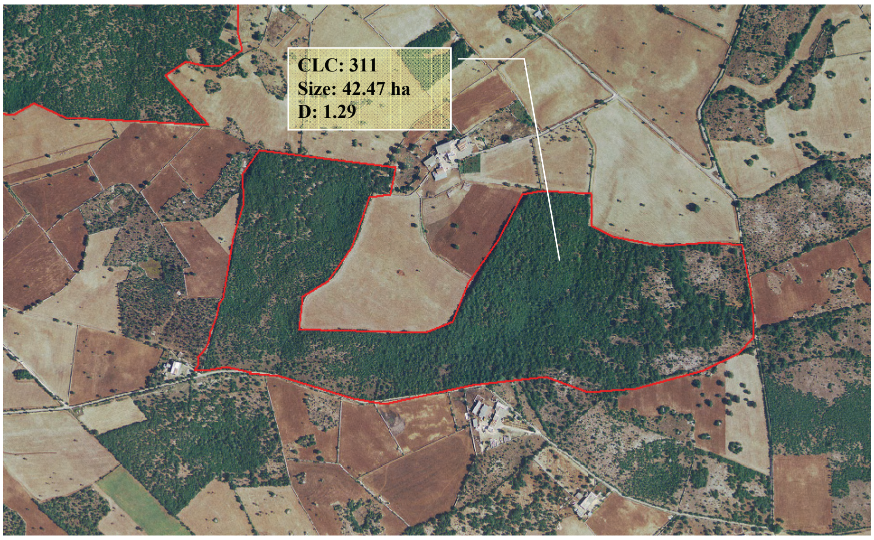


Figure 1. Aerial photograph of southern Italy landscape showing forest patch size and shape (D= fractal dimension; SI= shape index).

References

Brown, R.D., Lafortezza, R., Corry, R.C., Leal, D. & Sanesi, G. (2007). Cultural patterns as a component of environmental planning and design. In: Hong SK, Nakagoshi N, Fu B, Morimoto J, Wu J.G. (eds.) *Landscape Ecological Applications in Man-Influenced Areas: Linking Man and Nature Systems*, Springer.

Corry, R.C. & Nassauer, J.I. (2002) Managing for Small Patch Patterns in Human-dominated Landscapes: Cultural Factors and Corn Belt Agriculture. In: Liu J, Taylor W (ed.) *Integrating Landscape Ecology into Natural Resource Management*, Cambridge University Press. Cambridge, Massachusetts: pp. 92-113.

Dramstad, W.E., Olson, J.D. & Forman, R.T.T. (1996). *Landscape Ecology Principles in Landscape Architecture and Land-use Planning*, Island Press, Washington, DC**.**

Forman, R.T.T. (1995). *Land Mosaics*, Cambridge University Press, Cambridge, Massachusetts.

Hart, J.F. (1998). *The Rural La*ndscape, Johns Hopkins University Press, Baltimore, Maryland.

Krummel, J.R., Gardner, R.H., Sugihara, G., O'Neill, R.V. & Coleman, P.R. (1987). Landscape patterns in a disturbed environment. *Oikos* 48: 321-324.

Mathematical models of landscape patterns

A.S Viktorov

Institute of Environmental Geoscience of Russian Academy of Science
Ulanskii per., 13, P.O. Box 145,101000, Moscow, Russia,
e-mail: dist@geoenv.ru

Quantitative studies of landscapes spatial patterns face with problems resulting from unpredictable relationships among different metrics of landscape patterns (Ritters *et al*, 1995). It is very difficult to determine their sufficiency and superabundance for pattern analysis and to choose optimal sets of metrics. Mathematical models of landscape patterns can solve these problems. Our research allowed us to formulate the mathematical models of landscape patterns. They are specific to areas characterized with a certain set of processes, such as soil subsidence, fluvial erosion, karst, and other processes. The models are based on the theory of random processes and describe behavior of patterns' geometric features.

Mathematical analysis of the models gives us *landscape pattern laws* such as:

- Poisson distribution for arrangement of subsidence sites,
- Wiener stochastic process describes size logarithm growth for thermokarst depressions,
- Raleigh distribution of khasyrey (drained thermokarst lakes) size.
- Using of the mathematical models of landscape patterns allows us to *predict dynamics of a territory.*

Let us examine a good example of nature dynamics at a territory with long time of diffuse process development. The diffuse nature process is a process generating numerous often roundish sites randomly located within the area of process development. Processes of this type include karst, soil subsidence, thermokarst, aeolian processes (wind erosion dimples), and others.

The model of diffuse processes within a uniform area is based on the following assumptions (Victorov, 2003):

1. Appearance of a new site during any time within any clear area is an event independent of other sites and its probability is directly proportional to the time period and size of the area. The probability that two or more sites occur is negligibly small in comparison as appearance of only one site.

$$p_1 = \lambda \Delta s \Delta t + \hat{\imath}\,(\Delta s \Delta t), \qquad (1)$$

where λ is a parameter,

2. A new site cannot appear within another site.

3. Changes of a new site of isometric form are described with an occasional process $F_0(x,t)$ (probability density is $f_0(x,t)$) if obstacles are absent. Different sites change independently of each other.

4. Changes of a new site of isometric form are described with an occasional process (probability density is $F(x)$) if obstacles are absent. Different sites change independently of each other.

Thus, the territory can be regarded as a certain flow of developing sites of the diffuse process. Every site appears at a random moment independently from each other, enlarges under influence of different factors including random ones and finally reaches a critical value at a random moment and comes to the stage of degenerate sites. In this very case it possible to show that under rather general conditions (Victorov, 2003) the territory in question reaches a certain state close to stationary one with characteristics of dynamic balance. Thus, after a long period of development a number of quantitative characteristics become stable:

- process impact (P_d^*) , share of area affected by the dangerous process
- radii distribution for the active sites

$$f\ (x,\infty)=\frac{[1-F(x)]\int_0^{+\infty} f_0(x,u)du}{\int_0^{+\infty}\int_0^{+\infty}[1-F(x)]f_0(x,u)dxdu} \quad (2)$$

- average area density of the active sites

$$\gamma_{a_\infty}=\lambda[1-P_d^*]\int_0^{+\infty}\int_0^{+\infty}[1-F(x)]f_0(x,u)dxdu \quad (3)$$

- radii distribution for the degenerate sites

$$f_{dk}(x,\infty)=f(x) \quad (4)$$

In other words, new active sites continuously appear and disappear within the observed area, their dimensions change, new degenerate sites appear but the main quantitative statistic characteristics, such as area density of the active sites, the dimensions of degenerate and active sites remain stable.
For example, It shows that under certain weak conditions after a long period of time the термокарстовая plain reaches dynamic equilibrium with constant area and constant spatial density of thermokarst lakes and constant average khasyrey area.

The mathematical models of landscape patterns give us analytical decision for *estimating damage risk* for engineering constructions under exogenous geological hazards.

Using the described above mathematical models of landscape patterns for diffuse processes one can get impact probability for different types of constructions.

The roundish construction (a cycle with radius *l*):

$$P_{ds}(l)=1-\exp[-\pi\gamma(t)[(\bar{r}(t)+l)^2+\sigma^2(t)]-\pi\gamma_{dg}(t)[(\overline{r_{dg}}(t)+l)^2+\sigma_{dg}^2(t)]] \quad (5)$$

The linear construction (with length *L*)

$$P_{dl}(L)=1-\exp[-2[\gamma(t)\bar{r}(t)+\gamma_{dg}(t)\bar{r}_{dg}(t)]L] \quad (6)$$

where $\gamma(t)$, $\bar{r}(t)$, $\sigma(t)$, $\gamma_{dg}(t), r_{dg}(t), \sigma_{dg}(t)$ are average area density, average radius, and radius standard. The equations of impact probability for little, large, and linear constructions at any given time were developed basing on remote sensing data as initial information. The equations were verified at key areas of Western and Eastern Siberia, Caspian Lowland, and piedmont plains of Central Asia.

The mathematical models of landscape patterns give us *analytical decision for interrelations between different pattern metrics* and the problem of sufficient metrics including general information about landscape patterns. For example we can obtain a dependence between average (a) and standard (σ) of location density of karst depressions

$$\sigma=\sqrt{a} \quad (7)$$

The research branch dealing with the mathematical models of landscape patterns is named “the Mathematical Morphology of Landscape” (Victorov, 1998).

References

Ritters K.H., O’Neill R.V., Hunsaker C.T. *et al.* (1995) A factor of landscape pattern and structure metrics. *Landscape Ecology*, **v. 10**, №1, pp.23-39.

Victorov A. S. (2003) An integrated mathematical model for diffuse exogenous geological processes. *Proceedings of the 9th Annual Conference of the IAMG*, Portsmouth, GB, pp. 1600-1620.

Victorov A. S. (1998) Matematicheskaya morfologiya landshafta (Mathematical Morphology of Landscape). Tratek, Moscow

Statistical challenges integrating Landsat time series data with forest inventory data for characterizing forest disturbance and regrowth in the U.S.

G.G. Moisen[1], S.P. Healey [1], R.E. Kennedy [2], S.L. Powell [2], W.B. Cohen [2], S.N. Goward[3], J.G. Masek[4], C. Huang[3]

[1] US Forest Service – 507 25th Street, Ogden, UT 84401,USA.
e-mail: gmoisen@fs.fed.us
[2] U.S. Forest Service – Pacific Northwest Research Station, Corvallis, OR 97331, USA.
[3] Department of Geography, University of Maryland, College Park, MD 20742, USA.
[4] NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA.

Traditional forest inventories

The Forest Inventory and Analysis (FIA) program of the USDA Forest Service collects data annually on the status and trends in forested ecosystems across the U.S. (FIA, 2005.) Inventory is conducted via a network of ground-based plots which are located with an intensity of about one plot per 2,400 ha. Although the program historically collected data periodically, it recently shifted to an annual rotating panel system which samples 10 to 20% of each state's plot network annually (Reams et al., 2005.) These inventory data have traditionally been used to support estimates of forest population totals over large geographic areas.

Changing information needs

Recent emphasis has been placed on producing broad-scale maps of numerous forest characteristics to make these extensive forest resource data more accessible and useful to a larger and more diverse audience. Important applications of such maps include broad-scale mapping and assessment of wildlife habitat; documenting forest resources affected by fire, fragmentation, and urbanization; identifying land suitable for timber production; and locating areas at high risk for plant invasions, or insect or disease outbreaks. A variety of RS products are relied upon to improve precision in estimates of forest population parameters, construct meaningful small area estimates, enable rapid response to catastrophic change, etc.

An important component of monitoring is gaining a clear understanding of what has happened in the past. Reconstructing historical trends in forest disturbance using FIA data is hampered by inconsistent sampling schemes and plot designs, varying definitions, gaps in plot distributions, irregular and sometimes non-existent temporal sampling, and the list continues. FIA data alone cannot adequately tell the forest disturbance and recovery history. In contrast, disturbance maps generated from historic Landsat imagery communicate spatial and temporal disturbance trends in a straightforward manner (eg., Cohen et al., 2002.)

Collaboration under the North American Carbon Program

FIA is collaborating with NASA, the University of Maryland, and other Forest Service researchers to map historical disturbances across the country (Healey et al., In press.) Dense temporal stacks of 23 Landsat scenes have been sampled across the U.S. Forest biomass available on FIA plots is currently being modeled as empirical functions of Landsat spectral and ancillary data. These models are then being applied across the temporal stacks to develop a 30+ year historical record of forest disturbance and regrowth dynamics for North America.

Importance of local analyses

Five focal scenes are targeted for detailed analyses by FIA scientists, analysts, and clients for a variety of disturbance issues. Maps of disturbance can be used to identify harvest trends over time and across ownership boundaries; to track insect outbreaks; to support purely spatial analyses such as the estimation of edge effects or the revision of fuel or habitat maps; and to prioritise salvage and recovery efforts. Maps of biomass loss may be of use in any future carbon accounting framework. Re-growth trajectories can also be produced for each disturbance, enabling study of factors that affect forest recovery (Healey et al, 2006.) Leveraging of FIA data with satellite imagery in this way may open up open up new perspectives of how disturbance operates in our forests over both time and space. However, the statistical issues abound and here we describe the challenges in integrating design- and model-based paradigms to construct statistically defensible estimates of forest change parameters for both local and national analyses.

References

Cohen, W.B.; Spies, T.A.; Alig, R.J.; Oetter, D.R.; Maiersperger, T.K. & Fiorella, M. (2002.) Characterizing 23 years (1972-1995) of stand-replacing disturbance in western Oregon forest with Landsat imagery. Ecosystems 5: 122-137.

FIA, 2005. What is Forest Inventory and Analysis. FIA Fact Sheet Series, 3 February, 2005. Retrieved from http://fia.fs.fed.us/library/fact-sheets/, on Feb 1, 2007.

Healey, S.P.; Moisen, G., Masek; J., Cohen, W.; Goward, S.; Powell, S.; Nelson, M.; Jacobs, D.; Lister, A.; Kennedy, R. & Shaw, J. (In press.) Measurement of forest disturbance and re-growth with Landsat and FIA data: anticipated benefits from FIA's collaboration with NASA and University partners. In: McRoberts, R. (Ed.) Proceeding of the 7th FIA Science Symposium, Portland, ME.

Healey, S.P.; Yang, Z., Cohen; W.B.& Pierce, D.J. (2006.) Application of two regression-based methods to estimate the effects of partial harvest on forest structure using Landsat data. Remote Sensing of Environment 101: 115-126.

Reams, G.A.; Smith, W.D.; Hansen, M.H.; Bechtold, W.A.; Roesch, F.A.& Moisen, G.G. (2005.) The Forest Inventory and Analysis sampling frame. In W.A. Bechtold and P.L. Patterson, eds. The Enhanced Forest Inventory and Analysis Program – National Sampling Design and Estimation Procedures. US Department of Agriculture, Forest Service, Southern Research Station General Technical Report GTR-SRS-80. pp. 11-26.

Display of the basic functional properties of landscape cover on the basis of the remote information for maintenance of initial landscape planning stages

A.N. Krenke, Y.G.Puzachenko

Lomonosov Moscow State University Faculty of Geography, 119899, Moscow, Leninskiye Gory 1, Russia,
e-mail: By-his-divine-grace@yandex.ru

Landscape cover - the concept meaning display biophysical properties of a terrestrial surface. This concept is historically connected to the development of remote sensing by multispectral measurement of the condition of the land surface and eventually to the tasks connected to landscape planning.

Field work especially in northern regions incur high expenses; it is therefore necessary in the initial stages of design and exploration work to use to the maximum remote information available, in order to get a detailed overview of the current and past condition of the major properties of landscape cover.

For achievement of this purpose development of special algorithms for the analysis of the remote information are required, that provide not only allocation of the basic types of landscape cover, but display of spatial variation of its major properties such as: a hydrothermal mode, biological efficiency, character and a degree natural and anthropogenous disturbance.

In the present paper the algorithm of classification is used as a start, given both own values of brightness spectral channels is examined. These indexes are considered as a basis, which reliably reflect the certain physical properties of a terrestrial surface. The method used of dichotomizing hierarchical classification "from the general to the particular" accounts for both territorial position of selected types and values of indexes. They allow consistently defining their physical sense of selected classes of a landscape cover. On the basis of the classification and its discriminant analysis the main factors forming landscape structure are provided as well as a cartographic display of their values. The constructed maps of modern landscape cover, as a first approximation allow the estimation of problems which can enable the designer to estimate the vulnerability of territories, to allocate potential objects of protection and to develop the most economical and to make an effective avoidance of field research.

The basic factors are described which allow the construction of qualitative level models of vulnerability of territories to various impacts. In the study the estimation of fire danger of territory is shown. It is also possible to estimate engineering works which identify land which has increased risk of failures of non-production constructions. The most valuable land covers, the most productive large forests and pastures can be protected.

At the same time these results can be considered only as preliminary outcomes. Field research should be organized to check up the display of hypothetical landscapes and the definition of the geographical contents of the allocated types. The received set of optimum allocated field descriptions will then allow the application of multivariate methods to interpolate statistical models of landscape cover of territory.

Linking the remote information with a digital elevation model expands the opportunities of the analysis of structure of landscape cover and creates a basis for the preliminary design of a network of supervision of monitoring projects.

The landscape disparity index: an ecologically weighted measure of the landscape diversity.

P.K. Roche

CEMAGREF, Mediterranean Ecosystems Unit, 3275 Route Cezanne, 12182 Aix-en-Provence.
e-mail: philip.roche@univ-cezanne.fr

Introduction

Typically, the analysis of landscape patterns is based on a quantitative analysis of the composition or/and the spatial arrangements of categorical units mapped from aerial photographs, satellite images or land use maps using so-called landscape metrics (Gustafson, 1998).

Usually in landscape studies, authors assume that different landscape habitats or elements categorised in the mapping process are well defined, and equally different from each other (Forman 1995 and references therein). But, in most cases the landscape element types are often not really distinct or at least are not equally distinct from each other and the degree of dissimilarity between the mapped landscape elements is not usually considered.

In order to improve the ecological relevance of landscape diversity metrics some ecologically important features should be considered. An index should integrate the habitat number and their spatial arrangements (O'Neill et al., 1988). It should also have a low sensitivity to categorical resolution (Frohn, 1998) and/or should be able to handle degrees of thematic resolution (Loehle and Wein 1994). The two last points could be addressed by integrating a measure of the ecological contrast between the thematic categories – i.e. the disparity.

Methods

I propose a new landscape diversity metric: the Landscape Disparity Index (LDI) that takes into account both the landscape elements adjacencies frequencies and the patches ecological dissimilarities (1)

$$LDI = \frac{-\sum\sum \ln\left(p_{(i,j)}^2 \cdot d_{(i,j)}\right)}{\ln(2/(m \cdot (m+1)))} \qquad (1)$$

The LDI was tested using landscape maps from two sites in southern France. Environmental variables were used to compute the dissimilarity index between and within landscape element types. Highly autocorrelated variables like altitude and slope were eliminated. The remaining variables were tested using Kruskal-Wallis tests for significant differences between landscape elements. Non significant variables were removed. The remaining variables were used to compute the dissimilarity matrices.

The LDI was compared with eight other widely used landscape metrics using the Fragstats 3.1 software (McGarical and Marks, 1994).

Scale issues were analysed by computing the LDI and the eight other landscape metrics on our test area at 4 scales (30, 50, 70 and 90 m). Thematic resolution issues were assessed by computing the LDI and the other landscape metric on the 6 and 11 theme maps. In addition, for the LDI, the sensibility to the dissimilarity measure component using the two variants of the distance matrix for both 6 and 11 theme maps.

As a biological variable of interest we used the species richness at the landscape level using both modelled and field data.

If species richness is considered to increase when landscape heterogeneity increases (Duelli 1997), then landscape metrics measuring landscape heterogeneity indexes should be positively correlated with species richness at the landscape level.

Results and Discussion

The Landscape Disparity Index appeared to belong to the group of landscape diversity metrics with some interesting properties not shared by other diversity metrics: low sensibility to thematic resolution and ecologically significant weighting The Shannon index (SHDI) appears to be the more sensitive to thematic resolution effects with Diff% higher than 40% and four indexes have Diff% values under 10% (PLADJ, LDI, COHESION and AI). Two groups of metrics could be defined. The first one comprised the IJI, RPR, SHDI, LDI that could be defined as diversity metrics. The second group comprised the AI, PLADJ, COHESION, LPI and CONTAG indexes that are landscape compaction-aggregation metrics.

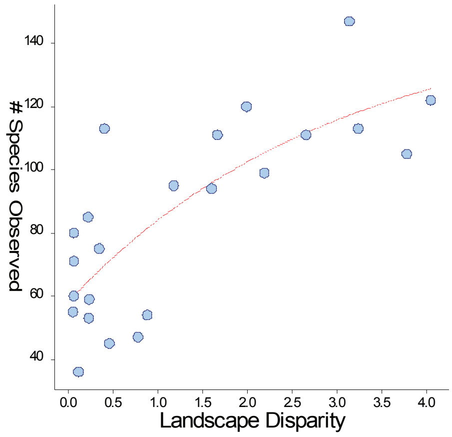


Fig. 1. Biplot of species richness and LDI. Each dot represents a landscape window of 90x90 m. The full line represents a GLM regression using a log link.

According to our results high LDI values are also related to high species richness at the landscape level (Fig1). High LDI values indicate that ecologically contrasted habitats are clustered together on the analysis scale. Traditionally used landscape diversity indexes such as the Shannon Index are not as coherent, because high values can be associated with low species richness. Thus, taking into account the degree of ecological contrast between landscape elements weights the spatial heterogeneity and improves correlation with biological patterns. These preliminary results indicate that the Landscape Disparity Index could be used to identify high diversity spots at the landscape level.

References

Duelli, P. 1997. Biodiversity evaluation in agricultural landscapes : an approach at two different scales. Agri. Ecos. Env., 62: 81-91.

Forman, R.T.T. 1995. Land mosaics. The ecology of landscapes and regions. Cambridge University Press, Cambridge, 622 pp.

Frohn, R. 1998. Remote sensing for landscape ecology. New metrics indicators for monitoring, modelling and assessment of ecosystems. Lewis publishers, Boca Raton.

Gustafson, E.J. 1998. Quantifying landscape spatial pattern: what is the state of the art ? Ecosystems, 1: 143-156.

McGarigal, K. and Marks, B.J. 1995. FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. General Technical Resport PNW-GTR-351. U.S. department of Agriculture, Forest service, Pacific Northwest Research station. Portland, OR. 122 pp.

O'Neill, R.V., Krummel, J.R., Gardner, R.H., Sugihara, G., Jackson, B., DeAngelis, D.L., Milne, B.T., Turner, M.G., Zigmunt, B., Christensen, S.W., Dayle, V.H. and Graham, R.L. 1988. Indices of landscape pattern. Land. Ecol., 1: 153-162.

Turner, M.G. 1989. Landscape ecology: the effect of pattern on process. Ann Rev Ecol Syst, 20: 171-197.

Are scaling functions for landscape pattern metrics really accurate and useful?

S. Saura and S. Castro

Departament d'Enginyeria Agroforestal. ETSEA. Universitat de Lleida. Av. Alcalde Rovira Roure, 191. 25198. Lleida. Spain.
e-mail: ssaura@eagrof.udl.es

Introduction

The availability of a wide variety of landscape data and remote sensors at multiple spatial scales urges the need for practical scaling techniques that allow comparing and transferring pattern estimates across different spatial resolutions. Different studies have found scaling functions (such as power laws) accurately describing the variations of several landscape pattern metrics with spatial resolution (Frohn, 1998; Frohn and Hao, 2006; Saura, 2001; Saura, 2004; Wu *et al.*, 2002; Wu, 2004). Considering the good apparent fit of these scaling functions to a wide set of landscape data, it has been suggested that the extrapolation and interpolation of the values of these metrics across different pixel sizes can be done simply and accurately (Wu *et al.*, 2002; Wu, 2004). However, Saura (2004) noted that the coefficients of the scaling functions (which are needed for the scaling process itself) cannot be known a priori for a certain image or landscape; rather they have to be determined empirically by previously fitting the scaling function to a set of metric values computed on the aggregated image at different spatial resolutions. For this reason, scaling functions seem to be of little aid for upscaling pattern estimates (i.e. obtaining metrics values at coarser spatial resolutions), since in fact they require as an input those metric values at broader pixel sizes. The major interest of these scaling functions may be obtaining subpixel estimates of pattern metrics, and in fact this may represent the only operational procedure to downscale spatial pattern characteristics (Saura, 2004), although no quantitative results have been provided yet on this respect, apart from a single forest class and range of spatial resolutions reported by García-Gigorro and Saura (2005).

Material and methods

To provide further insights into this scaling problem, we analysed a wide set of landscape data derived from remotely sensed images covering different study areas, sensor spatial resolutions, and classification approaches (pixel-based and object-based), which were aggregated to coarser spatial resolutions through majority filters. We considered a set of eight landscape pattern metrics (number of patches, mean patch size, patch size standard deviation, largest patch index, edge length, landscape shape index, area-weighted mean shape index, area-weighted mean patch fractal dimension) for which stable and predictable scaling functions at the class level had been previously reported (Frohn, 1998; Frohn and Hao, 2006; Saura, 2001; Saura, 2004; Wu *et al.*, 2002; Wu, 2004). We fitted these functions to the metrics values at different spatial resolutions (broader than the target resolution), comparing the resultant downscaled estimates (obtained through the scaling functions) with the true value of the pattern metrics at that target resolution.

Results and discussion

Even when all the eight metrics (and the corresponding scaling functions) have been previously reported as predictable in terms of their variations with spatial resolution, we found large differences in the actual accuracy of the resultant subpixel estimates among pattern metrics. For the mean patch size, the landscape shape index or the edge length, quite accurate subpixel estimates were achieved in all the datasets, while other metrics could not estimated accurately at finer resolutions through available scaling functions.

The most accurate subpixel estimates were obtained when only a narrow range of spatial resolutions (closest to the target resolution) was used to fit the scaling function, instead of the full range of spatial resolutions that can be obtained through aggregation, which agrees with García-Gigorro and Saura (2005). This suggests that the scale behaviour of the pattern metrics (as described by available scaling functions) is not really invariant across the full range of spatial resolutions; the rate of variation of the pattern metrics at increasingly broader scales diverges from the characteristic variation at subpixel resolutions.

We also found that the performance of available scaling functions was much lower in object-based data than in per-pixel classified data, particularly when scaling at spatial resolutions below the characteristic minimum mapping unit of the interpreted or segmented image. All the scaling functions for landscape pattern metrics reported so far have been based only on per-pixel classifications of remotely sensed data, and we suggest that other different scaling functions may be necessary to provide more accurate results when dealing with object-based data, which are increasingly common due to the important advantages that this classification approach presents for landscape pattern analysis.

Conclusions

Most of the previous research has not gone beyond a merely descriptive analysis of scale effects on pattern metrics. In this study we intended to go further by quantitatively assessing and validating the true accuracy and practical utility of available scaling functions for obtaining subpixel estimates of pattern metrics. We conclude that scaling functions may be useful and reasonably accurate for estimating the values of some pattern metrics at the subpixel level but only if the specific scaling recommendations and limitations reported in this study are conveniently taken into account.

References

Frohn, R.C. (1998) *Remote sensing for landscape ecology: new metric indicators for monitoring, modeling and assessment of ecosystems*. CRC-Lewis Publishers, Boca Raton, Florida, USA.

Frohn, R.C. & Hao, Y. (2006) Landscape metric performance in analyzing two decades of deforestation in the Amazon Basin of Rondonia, Brazil. *Remote Sensing of Environment* **100**: 237-251.

García-Gigorro, S. & Saura, S. (2005) Forest fragmentation estimated from remotely sensed data: is comparison across scales posible? *Forest Science* **51**: 51-63.

Saura, S. (2001) *Influencia de la escala en la configuración del paisaje: estudio mediante un nuevo método de simulación espacial, imágenes de satélite y cartografías temáticas*. Ph. D. Thesis, Universidad Politécnica de Madrid, Spain.

Saura, S. (2004) Effects of remote sensor spatial resolution and data aggregation on selected fragmentation indices. *Landscape Ecology* **19**: 197-209.

Wu, J.; Shen, W.; Sun, W. & Tueller, P.T. (2002) Empirical patterns of the effects of changing scale on landscape metrics. *Landscape Ecology* **17**: 761-782.

Wu, J. (2004) Effects of changing scale on landscape pattern analysis: scaling relations. *Landscape Ecology* **19**: 125-138.

AMOEBA algorithm to identify natural clusters of mixed forest in Poland using CLC2000 data

T. Edman

Swedish University of Agricultural Sciences, Forest Faculty, Department of South Swedish Forest Research, SE-230 53 Alnarp, Sweden.
e-mail: Tobias.Edman@ess.slu.se

Connectivity of habitats within and between landscapes and regions is of great importance for the persistence of viable populations in the landscapes and regions. There are several methods to establish the connectivity between separated habitats. These methods include grid based algorithms averaging the amount of habitats in an area, calculation of landscape metrics of different areas, k-mean clusters amongst others. Most of the methods are computing and data intensive.

The long history of land utilisation in Europe affects the potential for biodeversity and there are differences between regions due to variance in economic history, recent economical development and bio geographical conditions. These differences are recognised as an east-west gradient with low biodiversity in the Benelux area and high in the Baltic-states and in the Carpathian Mountains (Edman et al. manuscript). Poland (Figure 1) is a good arena for investigations of the relationship between landscape characteristics and biodiversity as it contains both high and low diversity areas. Poland consists mainly of agricultural plains with small forest patches and of forest landscapes in the northeast, southeast and in the northwest.

Mixed forests are of great importance for biodiversity as they often are less intensively managed and thus contain more suitable habitat for forest specialised species. Woodpeckers are connected with habitats that are common in the mixed forests of Europe (Martikainen et al., 1998) and the area of mixed forests are important for the functional diversity of forest vertebrates in temperate Europe (Edman and Angelstam, manuscript).

I used the AMOEBA algorithm proposed by Estivill-Castro and Lee (2000) as a less computing intensive cluster algorithm, to establish clusters of mixed forests in Poland. CORINE 2000 with resolution of 100m was used as land cover data (EEA, 2004). The geographic modifications of the CORINE 2000 raster was made with ArcWorcstation 8.2 Each delineable polygon was attributed with centre position, area, perimeter, land cover type, minor and major axes of the smallest ellipse that can be fitted over the polygon as well as the angle of the axis in relation to the x- and y-axis of the EUREF 99 coordinate system. According to the AMOEBA algorithm a Delaney triangulation table was established, the distances between all ellipses that are used as proxies for the actual land cover polygons were calculated and mean local (Lm) and global (Gm) segment length as well as global standard deviation (Gstd)of segment length. If a segment is shorter than Gm+Gstd*(Gm/Lm) the segment is considered to connect two patches that are part of a cluster, see Estivill-Castro and Lee (1999) for further elaboration of the algorithm. This procedure is repeated to obtain sub clusters of the first level clusters. All calsulations was made in Matlab 14.

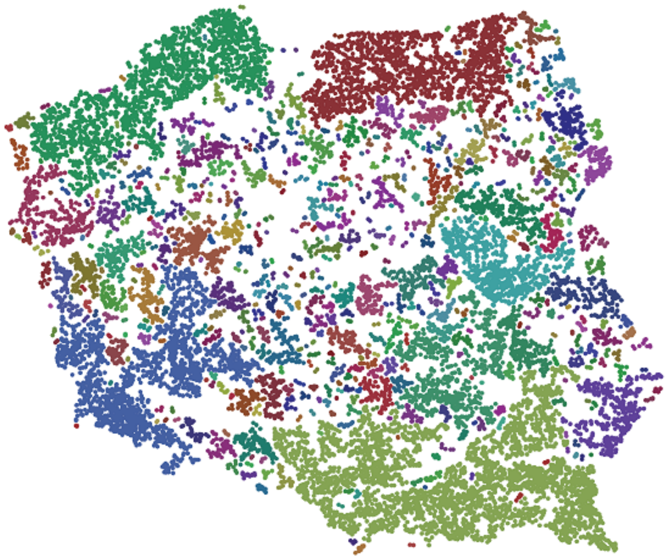


Figure 1 Map over Poland displaying the clusters of mixed forest, identified with the AMOEBA algorithm.

AMOEBA clustering proved to be a good way to explore networks of connected forest patches in Polish landscapes. As the cut off level for cluster belonging is adjustable and might be replaced with an ecologically based figure the AMOEBA clustering seems to have a good potential for further development and use in landscape ecological models, where species movements and connectivity between habitat patches is concerned.

References

EEA (2004) CORINE Land Cover 2000. pp.Landcover in Europe. EEA, Copenhagen.

Estivill-Castro, V. & Lee, I. (1999) AMOEBA: HIERARCHICAL CLUSTERING BASED ON SPATIAL PROXIMITY USING DELAUNATY DIAGRAM. *Proceedings of the 9th International Symposium on Spatial Data Handling (SDH2000)*.

Martikainen, P., Kaila, L. & Haila, Y. (1998) Threatened Beetles in White-Backed Woodpecker Habitats. *Conservation Biology,* 12, 293-301.

How important is the third dimension for the analysis of spatial patterns of landscape structure?

U. Walz, S. Hoechstetter, N.X. Thinh

Leibniz Institute of Ecological and Regional Development (IOER),
Weberplatz 1; D-01217 Dresden;
e-mail: u.walz@ioer.de

Introduction

The analysis and quantification of patterns of landscape structure are crucial for understanding ecological dynamics. In the Patch model ecologically meaningful 3D-features like terrain shape or elevation are not taken into account and valuable information is lost for the analysis. In a study financed by the German research foundation (DFG), several methods to include the third dimension in the analysis of landscape structure are developed, tested and customised.

3D-aspects can be integrated into structural analysis by the computation of "true" perimeter and area on the basis of digital elevation models (DEM) or by the consideration of actual surfaces on the basis of digital surface models (including vegetation and buildings). The latter includes the investigation of height differences between the landuse structures of individual patches or the characterisation of the surface texture within the landuse classes and/or individual patches.

Integration of "true" surface area and perimeter into landscape metrics

Most Geographic Information Systems (GIS) systematically underestimate the areas and perimeters of patches in a land mosaic and the distances between them because of the planimetric projection of land elements. As most of the commonly used landscape metrics utilise information about patch geometries as input parameters, this circumstance can lead to systematic errors in resulting index values. To improve this, we tested a method to approximate the realistic surface area from digital elevation models developed by Jenness (2004) and customised this method in order to calculate the true surface perimeters of each patch. For the analysis, we used a DEM from Airborne Laser Scanning and the digital vector data of the German ATKIS landuse data. The results of the computation of area and shape metrics for the planimetric and the 3D-situation with different spatial resolutions shows that there are distinct differences for the area metrics "Landscape Area" and "Patch Area", especially in steep terrain. Values tend to get closer to each other for the coarser resolution level, as differences in relief are levelled out when the elevation model is resampled to a larger grid size. On the other hand, metrics like Perimeter/Area-Ratio, Fractal Dimension Index and Shape-Index, which are based on fractions between patch perimeters and areas, exhibit only weak or no response at all to the inclusion of surface geometries into the calculation, especially for the coarse-grained landscape model. High-quality input data with a high spatial and thematic resolution appear to be a precondition for a meaningful implementation of 3D-approaches.

Three-dimensional landscape patterns

For the characterisation of surface patterns, modifications of fractal approaches like the determination of the three-dimensional box dimension and a new technique based on the lacunarity analysis of quantitative data, were developed. Besides that, parameters of surface metrology were used. Particularly the parameter „Average Surface Roughness" proved to be suitable as a straightforward approximation of the relief variability within individual landscape elements. The analysis of surface roughness may serve as a valuable instrument to provide highly condensed information about the topographic characteristics of patches. As the basic surface metrology-indices can easily be calculated and may be integrated into the patch mosaic model of landscapes, they appear to be a good extension of common landscape metrics towards the third spatial dimension.

Possible applications in landscape ecology

Our research showed that there is a need for the enhancement of landscape structure indices in terms of an integration of the third dimension. Especially in environmental planning, models and indicators are needed which can supply valid statements for the condition and the change of ecological systems caused by anthropogenic interferences. In this context, the landuse structure has a key position for the analysis and characterisation of functional correlations within the ecosystem. Furthermore, elevation and topography in reality act as “gradients” rather than “discrete structures”. Natural boundaries in the relief can rarely be detected. The attempt to integrate and to assess three-dimensional structures appears to be a promising way to take such ecological gradients into account (McGarigal and Cushman 2005).

The employment of 3D-indices in the context of environmental modelling or spatial planning leads to more precise results and may thus help to improve the basis of information. In particular in the following fields the application of 3D-indices of landscape structure appears to be relevant:

Methods of habitat connectivity and modelling of biodiversity (determination of isolation, size and neighbourhood relations; delineation of transition areas (ecotones));

Measures of landscape fragmentation. Currently used measures (e.g. effective mesh size) are based on surface computations. Including “real” area can thus lead to closer-to-reality results.

Distribution models of species frequently use structural descriptors as explanatory variables. One can expect that the consideration of three-dimensional surface properties leads to the improvement of such models.

Methods and models in forest sciences, in particular concerning height structures and surfaces of forest stands (e.g. information for forest stocktaking or estimation of horizontal and vertical diversity).

As a result, we can conclude that integrating elevation into the assessment of landscape structure principally seems to be an encouraging approach. Results indicate that 3D-analysis provides a great deal of additional information about the environment. Especially the comparison between standard landscape metrics and their corrected 3D-equivalents reveals significant differences between the index values. In combination with promising techniques such as lacunarity or surface metrology indices, which allow to capture ecological gradients and structure analysis over a range of scales, the proposed framework allows for a more realistic and accurate representation of landscapes. In particular when high-resolution data like for example digital terrain models from airborne laser scanning are available, the appliance of 3D- and gradient analysis techniques is appropriate.

References

Jenness, J.S. (2004): Calculating Landscape Surface Area from Digital Elevation Models. *Wildlife Society Bulletin* 32 (3): 829-839.

McGarigal, K. & Cushman, S.A. (2005): The Gradient Concept of Landscape Structure. In: Wiens, J., Moss, M. (eds.): Issues and Perspectives in Landscape Ecology. Cambridge University Press, Cambridge: 112-119.

Approaches to revealing landscape spatial pattern based on analysis of landscape between-component relations

K.A. Merekalova

Moscow Lomonosov State University, Geographical Faculty, Vorobyovy Gory, 119992, Moscow, Russia,
e-mail: merekalova@yandex.ru

Introduction

A specific character of landscape approach to nature investigation is the priority given to the study of relations between landscape components. The Russian landscape science school has traditionally relied on the concept of strictly determined interconnections between all landscape components (genetic model) when mapping natural landscapes (Vidina, 1962) (fig.1). Later, the idea of landscape multi-structural organization emerged, which assumed the simultaneous existence of spatially superposed but relatively independent partial landscape units generated by interaction between different geophysical fields (Solntsev, 1981). According to this concept, landscape spatial pattern at a certain scale level is an aggregate consisting of partial landscape units that are mostly evident in this scale. Lastly, nowadays there is a problem of translating geographical information from one scale level to another (upscaling and downscaling) (Marceau, 1999). Such a translation is possible only if the relationships type between landscape components are scale-independent and similar at all hierarchical levels in the area under study (Meentemeyer, 1989). Correspondingly, there is a need to reveal spatial landscape units with unified type of components interrelations at each scale level.

The purpose of this research is to apply the above approaches to reveal landscape spatial patterns within the boundaries of the focus region.

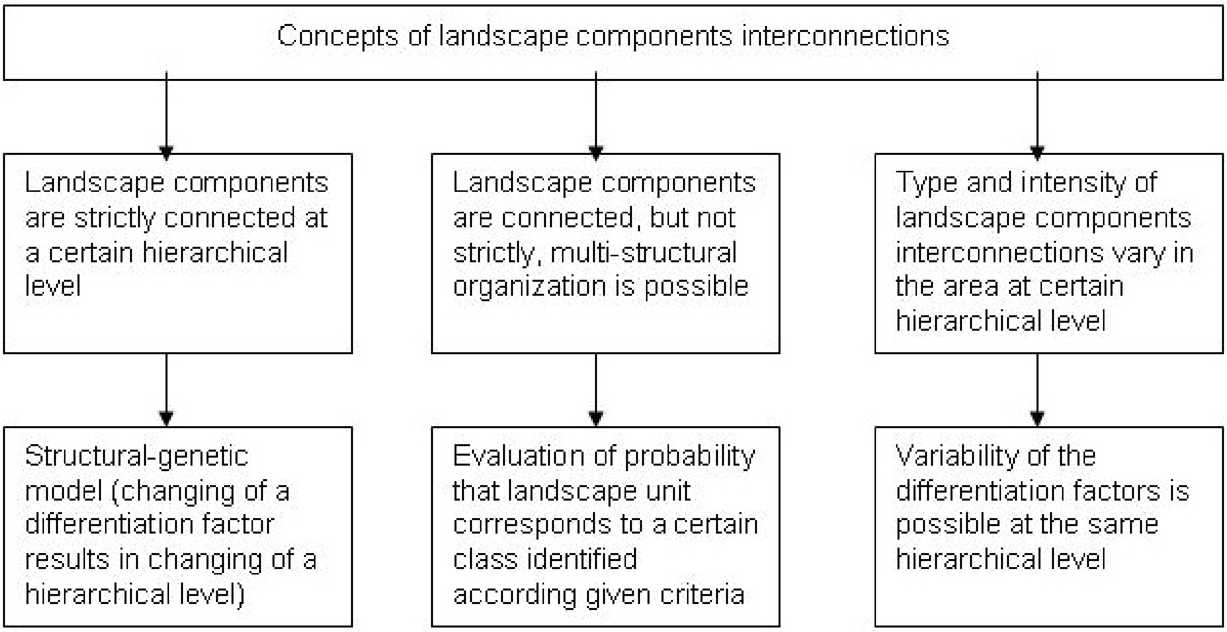


Figure 1. Concepts of landscape components interconnections

Region and material

The study area with an area of about 10 km^2 is located in middle taiga region of North European Russia. Research material includes: 1) digital elevation model (DEM) with resolution 30 m in pixel derived from topographic map with scale 1:10000; 2) space image Landsat 7 with resolution 30 m in pixel; 3) field landscape descriptions (more then 300 sample plots).

Results

The problems solved in the research are as follows:
1) Based on genetic approach a landscape map was created (scale 1:20000). The study area was divided into 3 localities that included 82 patch types.
2) Based on conception of multi-structure organization probabilistic approach was applied. Mutual adaptation of landscape components was evaluated and a map of partial landscape units was created (Khoroshev, Merekalova, 2006).
3) Linear multiple regression equations were computed for the system “landform-plant cover” in a moving window. As dependent variables we used factors of plant cover differentiation calculated using principal components analysis of Landsat 7 image. Relief characteristics based on DEM were chosen as independent variables (slope gradient, second derivative of elevation (Laplacian), distance to the closest waterway, vertical ruggedness (elevation variance in the area of certain radius) and horizontal ruggedness (total length of waterways in certain area)). Classification of the territory by regression coefficients revealed landscape units with unified type of components interrelations, with eight types in total. Comparison of the results achieved by using a different size of moving window made it possible to reveal the characteristic scales of landscape components interrelationships.

References

Khoroshev, A.V. & Merekalova, K.A. (2006) Uncertainty of relations between landscape components – a tool for modeling evolution of spatial pattern. *Ecology (Bratislava)*, **Vol. 25**, Supplement 1/2006, pp. 122-130.

Marceau, D.J. (1999) The scale issue in social and natural sciences. *Canadian Journal of Remote Sensing*, **Vol. 25**, No. 4, pp. 347-356.

Meentemeyer, V. (1989) Geographical perspectives of space, time, scale. *Landscape Ecology*, **Vol. 3**, No. 3/4, pp.163-173.

Solntsev, V.N. (1981) *Structural organization of landscapes* (in Russian). Science Press, Moscow.

Vidina, A.A. (1962) *Methodic of field large-scale landscape research* (in Russian). Moscow University Press, Moscow.

Use of a bioclimatic classification for a large-scale application of a biogeochemistry model

A.D. Shkaruba[1], V.V. Kireyeu[2], I.P. Usava[3]

[1]Central Research Institute for Integrative Use of Water Resources (CNIIKIWR), Slavinskaga 1/2, 220086 Minsk, Belarus.
e-mail: shkaruba@kth.se
[2]Central European University, Nador u. 9, 1051 Budapest, Hungary
[3]Belarus' State University, Ave. Skaryny 4, 220026 Minsk, Belarus

Knowledge of the spatial distribution of NPP, carbon and nitrogen fluxes is of increasing importance for a number of policy areas. As a result, large-scale applications of biogeochemical/geophysical models have become more common, and are also stimulated by open access to high-resolution spatial datasets and remote-sensed images. Accordingly, the quality and availability of field data have become a bottleneck for large-scale modelling applications. This is particularly true for process-based models, which are often preferred because of their broader applicability and robust extrapolations.

These problems have been faced when setting an application of one-dimensional CoupModel (coupled heat and mass transfer model for soil-plant-atmosphere systems (Jansson & Karlsberg, 2004)) for the Eastern Belarus Landscape Province (c.a. 22,000 km^2, 120-230 m, dominated by elevated moraine plains). The objective was to simulate actual and potential carbon stocks and sinks and make predictions in relation with baseline scenarios of climate change. For the reasons of data availability and computational efficiency, it was decided to run the model for environmental classes instead of grid meshes which would have been too coarse even at the highest resolution supported. Comparing to the grid meshes, classes of an environmental classification, believed ecologically homogeneous within their boundaries, can reproduce existing patterns of environmental gradients with a greater fidelity, while keeping within a reasonably low number of clusters. Hence, the specific objectives of this study were (1) to develop an environmental classification and (2) to propose procedures for preparing model inputs at a scale of these blocks (classes).

The underlying assumption of the classification is that the spatial diversity of ecological conditions and habitats primarily depends on the local distribution and re-distribution of the heat and water with significant contribution from land-use/cover. Other considerations were related to the input data requirements and design of the CoupModel, very much identical to those of many other process-based models. For this setup the model needed three kinds of input data: soil properties (mostly hydrothermic and biogeochemical), plant properties (biometry, physiology, phenology) and climate data series. Accordingly, the classification should be bioclimatic by its nature, which would allow the modeller to construct climate datasets for individual strata. Soil types should coincide with the bioclimatic units (this can be enhanced by adding to the classification the data on the conditions of saturation), which can be checked against local soil classifications (though quite impossible to validate by field data). Plant properties are mostly derived from the generis data and literature (though there are measured validating data available), but ideally they are also supposed to fit into the bioclimatic classes.

The method taken to produce the bioclimatic classification was a statistical stratification operating on quantitative data (Jongman *et al*, 1995). The technique is partly based on that employed in the Environmental Classification of Europe (Metzger *et al*, 2005). For the stratification we have selected variables (1) related to climate to account for the distribution of geophysical factors over the area and (2) related to topography to account for their local re-distribution. The spatial climate datasets have been downloaded from the CRU of the

University of East Anglia and included mean values for 1961-1990. The topographic variables have been extracted from USGS 3 arc-second Digital Terrain Elevation Data. They are elevation and TOPMODEL's topographical index (TopoIndex) used to account for topographically determined hydrological conditions (Kirkby & Weyman, 1974) and identify the meso-forms of local topography. The TopoIndex calculates as $\ln(\alpha/\mathrm{tg}\beta)$, where α is the area draining through a point from upslope and β is the local slope angle; high index values are likely to be more saturated. The stratification included (1) consequent Principal Component Analyses (PCA) to to remove redundancy and to reduce dimensionality within each category of environmental variables, (2) statistical classification and (3) post-processing. Several classifications with different number of classes has been generated and tested for the variability of input values within classes; 30-class stratification fit better the selection criteria.

As expected, the bioclimatic classification showed a good correspondence with the local soil classification, which is explained by the fact that the area's major topographic features coincide with the class boundaries, but often differ in the geological origin and, hence, in the underlying rocks. The main extent of the strata are always smaller in size than polygons of the soil classification, therefore, there was no need to subdivide strata massifs (separate groups of meshes) into smaller units with regard to soil classes. In contrast, land-use classification showed poor correlation with the strata boundaries, except the land-use classes strongly dependent on the physical environment, e.g. meadows, peat bogs or flooded forests. If requested by scenarios simulated, e.g. based on the current land-use, the strata can be subdivided by land-use boundaries into smaller parcels; if the issue is the potential vegetation, the strata can be subdivided by the classes of vegetation, which, however, again are likely to agree closely.

As discussed above, setting climate and vegetation input data to the CoupModel within this classification can be done in a straightforward manner. It is more difficult with soil data. The datasets available, coming from the National Land Survey, are not consistent, irregularly spaced, and have not been based on a accurate sampling design. It was concluded that the soil data available often are not statistically representative for particular landscapes, land-uses or strata and, therefore, cannot be subjected to aggregation. In the study the problem was solved by choosing representative soil samples within each block applying the expert knowledge of the area. Partly following the methodology suggested by Brus (1994), we tried to find an appropriate sample for each stratum, but also we took into consideration other factors of spatial variability (e.g. land-use) by taking more samples when the variability is higher. Additionally, the options and parameters of the CoupModel were analysed against abiotic ecological conditions (e.g. high saturation) and biocenoses expected within strata.

References

Brus D.J. (1994). Improving design-based estimation of spatial means by soil map stratification. A case study of phosphate saturation. *Geoderma* **62:** 233-246.

Jongman R.H.G.; Ter Braak C.J.F. & Van Tongeren O.F.M. (1995). *Data Analysis in Community and Landscape Ecology*, Cambridge University Press, Cambridge.

Kirkby, M. J. & Weyman, D. R. (1974). `Measurements of contributing area in very small drainage basins', *Seminar Series B*, No. 3, Department of Geography, University of Bristol, Bristol.

Metzger M.J.; Bunce R.G.H., Jongman R.H.G., Mücher C.A. & Watkins J.W. (2005). A climatic stratification of the environment of Europe. *Global Ecology and Biogeography,* **14:** 549-563.

5.5 Posters

How to recognize a landscape boundary? – Finding appropriate scale for the ecosystem management –

N. Tokiwa, J. Morimoto, F. Nakamura

Graduate School of Agriculture, Hokkaido University, JAPAN.
e-mail: t-nao@for.agr.hokudai.ac.jp

Introduction

Ecosystem functions can be maintained by keeping various ecological linkages between neighboring ecosystems, not by conserving an "isolated" target ecosystem from others (Meyer 1997). Landscape, a heterogeneous land mosaics composed of a cluster of ecosystems, and appropriate spatial scales for ecosystem management should be scientifically recognized. We developed a method to identify a landscape boundary by analogically applying species – area curves (Mueller-Dombois & Ellenberg 1974) to the relationships between the number of vegetation categories as ecosystems and management area in SHIRETOKO World Natural Heritage (WNH).

Methods

[Database] Actual Vegetation Map of 5th survey (MOE, 1999) and Environmental GIS database of latitude, elevation, relief, snow depth, degree of vegetation naturalness, and Warmth Index. [Software] ArcGIS9.0 (ESRI) and PC-ORD (MjM Software Design). [Analyses] 1. Ecosystem – Radius Curves: All data were converted into grid data. Assuming the northernmost SHIRETOKO Cape the center, concentric 80 circles with radius of 1,000m to 80,000m were made. The number of vegetation categories included in every circle was counted. With these data, a curve showing relations with the number of vegetation categories and concentric radius was delineated. 2. Ordination and Correlation Analysis: for understanding this curve, 20 sampling areas (5,000m in radius) that cover all SHIRETOKO WNH were arranged by Non-metric Multidimensional Scaling (NMS).

Results:

1. Ecosystem – Radius Curves: The range of a radius of 80,000m from SHIRETOKO Cape had two types of curves, i.e., intensively increasing part (fig.1-A,C,E) and relatively flat part (fig.1-B,D).
2. Ordination by NMS: Sampling areas in zone A and B were distributed over the approximately first quadrant in a 2 dimensional coordinate plane. In contrast the sampling areas in zone B, C and D were distributed widely. Vegetation categories appeared in zone A were distributed concentratedly near the origin. Whereas those appeared in zone C were distributed over the third quadrant. Vegetation categories which appeared in zone E distributed far from the origin in the third quadrant.
3. Correlation test: The relationships between the 1st axis score and 10 environmental variables revealed that 1st axis expresses steepness to the positive direction, and low level of naturalness to the negative direction. The relationships between the 2nd axis score and 10 environmental variables revealed that high altitudes to the positive direction, and low level of naturalness to the negative direction.

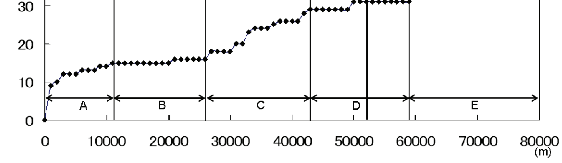


Fig1. Ecosystem - Radius Curves

Using graphs and graph theory to describe and analyze connectivity in linear habitat networks

A.Jellema[12], P.F.M. Opdam [2], W.A.H. Rossing [1]

[1] Biological Farming Systems Group, Marijkeweg 22, 6709 PG Wageningen, The Netherlands.
e-mail: andre.jellema@wur.nl
[3] Alterra Green World Research, P.O. Box 47, 6700 AA Wageningen, The Netherlands.

Introduction

Connectivity in a network of linear habitat elements, as found in agricultural or river landscapes, can not be described or analyzed adequately using traditional landscape ecological methods. We propose an alternative approach using mathematical graphs, as an efficient means to describe and analyze linear landscapes (Urban and Keitt 2001). A linear habitat network is described by a graph by breaking the linear elements in equal sized sections and representing each section by a node (point). The connections between the sections can be represented by a set of edges (lines). This methodology has been demonstrated in a case study on the hedgerow network of the Frisian Woodlands. A series of figures present the results in the poster.

Methodology

The methodology presented is based on two concepts from graph theory, the minimum spanning tree, the set of edges in a graph that connects all nodes of the graph at the least possible cost and the minimum cut, the set of edges with the minimum sum of edge weights that needs to be removed to break a graph into two sub graphs (Bondy and Murty 1977). We have used these concepts into a three step approach:

1. The definition of species dispersal groups based on the network configuration.
2. Analysis of the network structure per species group, revealing the backbone, the bottleneck and the core of the network.
3. Determination of the robustness of the network for habitat destruction.

Using the methodology a quick scan of the connectivity relations within a habitat network can be obtained for conservationists or spatial planners with limited effort. The concepts and method as presented can be generalized to patch networks and other ecological networks types.

Results

Case study results are presented on the poster in two figures.

References

Urban, D. & Keitt, T. (2001) Landscape connectivity: a graph-theoretic perspective. *Ecology* **82:** 1205-1218.

Bondy, J.A. & Murty, U.S.R. (1977) *Graph theory with applications.* American Elsevier Publishing Co., New York

ATLAS-Action for training in Land Use and Sustainability,

B. Pedroli, M. Bogers

Alterra Wageningen UR, Postbus 47 Wageninegn, The Netherlands
Bas.pedroli@wur.nl

The ATLAS project is an EU-funded Co-ordination Action (2005-2007) aimed to provide insights into delivering adequate types of education and training to decision-makers in the area of sustainable development and land use. They should be able to judge on the basis of sound policy analysis in a competent way about the effectiveness of different strategies.

ATLAS has brought together the expertise of the leading European research, education and training institutions in the area of land use and sustainability, combining innovative research efforts and practical experiences. It has led among others to a database of about 3000 courses related to sustainability and land use across Europe.

The ATLAS project has designed an Interactive Roadmap to assist users in obtaining information regarding Sustainable Impact Assessment and Land use that is tailor-made for their respective needs. The Road-map is based on an analysis of strengths, weaknesses, opportunities and threats (SWOT) of the educational provision in this area in Europe and is tuned to the needs identified by the different target groups (students, policy makers, scientists) in sustainability impact assessment of land use policies. It aims to link the information needs of the different target groups to the required information. It not only includes the higher level education provision in this field but also informs about policies on National and EU level and provides links to the current state of the art within other EU projects (such as SENSOR, SEAMLESS, and others) and further reading and documents related to Sustainable Impact Assessment and Land use.

The poster session will be set up interactively[2] to show participants the function of the on-line roadmap and will ask for their feedback for future incorporation. This should provide better European organisation of the educational provision and lead to appropriate professional qualifications.

[2] for this poster session internet access and projection facilities are necessary

Landscape character assessment using region growing in GIS

A. Jellema[1,3], D.J. Stobbelaar[1,2,4], J.C.J. Groot[1,2], W.A.H. Rossing [1]

[1] Wageningen University & Research Centre, Biological Farming Systems Group, Marijkeweg 22, 6709 PG Wageningen, The Netherlands.
e-mail: andre.jellema@wur.nl.
[2]Plant Production Systems Group, [3] Alterra Green World Research [4] Rural Sociology Group.

Introduction

The character of a landscape can be defined as the arrangement, variety and intensity of different landscape features. Examples of such landscape features are the field pattern, types of land-use, the presence ponds, tree lines and hedgerows etc. The pattern of landscape features gives a landscape a specific quality and makes it stand out from its surrounding areas. We present a new methodology to delineate and analyze such landscapes using a region growing algorithm in spatial data. The methodology is demonstrated and evaluated in a case study in the Frisian Woodlands, using an expert map as a independent reference.

Methodology

Region growing is an iterative bottom-up optimization process, where iteratively the most similar neighbouring data elements are grouped creating spatially continuous clusters or regions (Baatz and Schaepe 2000). Each region in the spatial dataset represents a landscape characterized a data pattern of landscape features. The methodology consists of 4 steps: 1 building a spatial database, 2 Creating a regional adjacency graph representing the spatial elements (polygons or raster cells) as nodes and their neighbourhood relationship as edges, 3 delineating landscapes on the basis of the data patterns of the landscape features, 4 evaluation of the regions.

Results

Based on 7 landscape features, 132 landscapes are distinguished in the study area, using the region growing algorithm. When overlaying the original data with the region growing result, all regions and the exact location of most of the borders between regions can be explained. Also the resemblance with expert map is large; differences between the maps can be explained by the absence or presence of data. In comparison to the expert map, the region growing technique shows more consistent delineation of landscapes throughout the study area. The results are presented in figures in the poster.

Conclusion

Region growing provides a powerful means to delineate landscapes on the basis of a spatial data set. These landscapes can be used for planning discussions or further research. For example the quantitative description of the landscape pattern can be used to classify the landscapes or evaluate the landscape quality in comparison to a reference landscape. The methodology can be generalized to other scientific disciplines.

References

Baatz, M. & Schaepe, A. (2000). In: J. Strobel and T. Blaschke (Eds.). Multiresolution Segmentation: an Optimization approach for high quality image segmentation, Angewandte Geographische Informationsverarbeitung 12. Wichmann-Verlag, Heidelberg, pp.12-23.

The use of remote sensing data for modeling differing levels of grassland improvement within the Welsh landscape

J. Breyer[1], K. Medcalf[2]

[1]Institute of Geography and Earth Science, University of Wales, Aberystwyth, Ceredigion, UK.
e-mail: jfb06@aber.ac.uk
[2]Environment Systems, 8G Cefn Llan Science Park, Aberystwyth, Ceredigion, UK.

Unimproved and semi-improved grassland habitats are an important repository of biodiversity within the Welsh landscape. This poster examines the use of space and airborne remote sensing data to identify areas of species rich unimproved and semi-improved grassland. The technique potentially represents a readily available tool for monitoring and evaluating biodiversity networks relating to these important grassland habitats.

The method was developed using 1 m spatial resolution hyperspectral Compact Airborne Spectrographic Imager (CASI) data acquired over two upland and lowland long term experimental sites. Each site contained a number of grassland plots representing a range of improved to unimproved sward types that are typical to the Welsh landscape, which has been under traditional agricultural long term management. Fieldwork undertaken coincidentally with the CASI imagery acquisition indicated that the spectral properties (specifically mean Near Infrared (NIR) reflectance and NIR variance) of fields at varying levels of improvement differ and can be related to ecological factors such as species composition, species richness and biomass.

These relationships were then utilized within a rule-based classification developed within eCogniton software to classify 10 m spatial resolution multispectral SPOT 5 HRVIR imagery. The NEXTMap DTM was used to evaluate altitude and slope within the landscape, supporting conclusions on particularly the drainage conditions in the uplands, which can determine the prevalent grassland type. To further aid the classification, linear spectral unmixing techniques within ENVI imaging processing software were utilized to generate endmember fraction images for shade/moisture, photosynthetic and non-photosynthetic vegetation.

To reduce error during classification the landscape was initially segmented into objects (segments) within eCognition software using the Land Parcel Identification System (LPIS) unit boundaries as a thematic layer, which provides all field boundaries within the lowlands. The upland was defined as areas above the upper limit of agricultural enclosure again using the LPIS boundary vector layer. To further increase accuracy, all non grassland habitat areas were identified and excluded from the classification process. Prior to image classification, accurate registration of the satellite data was essential, as well as reliable atmospheric correction to surface reflectance to be able to directly compare between different images.

The resulting map of semi-improved and unimproved grasslands areas within selected areas of the Welsh landscape is presented in this poster. Maps like these, generated from remote sensing data, would be a valuable aid to conservation efforts such as UK Biodiversity Action Plans, particularly in view of maintaining and restoring biodiversity networks and preventing further isolation of valuable grassland species populations and communities. They would also support policy decision processes particularly in relation to the effects of the European Common Agricultural Policy (CAP) reform.

Application of System Approach towards Small-Scale Mapping and Classification of Geographical Landscapes for the Purposes of Melioration and Agriculture

A.A. Nikiforova

Moscow Lomonosov State University, Soil Science Department, Moscow, Leninskiye Gory, , Russian Federation.
e-mail: nikifsoil@mail.ru

It is evident that efficient and environmentally safe agricultural soil use is impossible without a system approach. In its turn successful practical realization of a system approach under agricultural ecosystem exploitation is impossible without small-scale mapping. "*Agroecological Soil-Reclamative Map of the Nechernozemnaya Zone of the European Russia*"* in scale 1:1 500 000 is an attempt to apply a system approach towards small-scale mapping and classification of geographical landscapes for the purposes of agriculture.

Since a system approach in geography is a landscape approach, the map was compiled using a landscape base. Geographical landscapes are regarded as hierarchically superordinate natural territorial complexes of different levels composed of interdependent and associated natural components. Thus soils are only one of the natural components of geographical landscapes and cannot be considered out of context. The map does not give integral cartographical representation of geographical landscapes, i.e. it is not "a map-conclusion". Due to the layer by layer cartographical representation of the landscapes components and their characteristics, the map is, in fact, a Geographical Information System (GIS). It contains: 1) spatial distribution of natural and agricultural geographical landscapes (agrolandscapes) of different levels and characteristics of their natural components (in other words, climatic and natural conditions); 2) agroecological alternatives of soil use; 3) reclamative and erosion control measures; 4) factors complicating the carrying out of reclamative and erosion control measures; 5) spatial distribution of land areas inadaptable and restrictedly inadaptable for agricultural use, derelict lands and forest fund.

There are seven hierarchical levels of the geographical landscapes on the map, the bases of division of which are characteristics of their natural components. Notations of geographical landscapes of concrete hierarchical level are formed by banding of notations of characteristics of their natural components which are the bases of division of this and all higher levels.

Application of a system approach towards small-scale mapping and classification of geographical landscapes for the purposes of melioration and agriculture has enhanced the following conclusions to be draw:

1. The validity of landscape classifications cannot be checked up with using a small-scale landscape "maps-conclusions" with one type boundaries for all subdivisions.
2. Small-scale agroecological maps cannot be "maps-conclusions" because of insufficiency of graphic arts for cartographical representation of the information held on them.
3. Subdivisions of "intrazonal" geographical landscapes are of no classification value and do not fill well into an integrated hierarchically superordinate classification system.
4. Morphologic (horizontal) structure of geographical landscapes cannot be used as the basis of their division because of subjectiveness and ambiguousness in the way they were constructed.

* The map covers ~2.5 m sq. km (27 constituent entities of the Russian Federation) and has been prepared for publication in two versions – in the form of bound album and as a wall chart.

Biophysical surveys integration and multifunctional gis management for running sustainability-conscious agro-based projects of the millennium challenge account programs.

E. Amamoo-Otchere[1], F. Mensah[2]

[1]Centre for Remote Sensing and Geographic Information Services (CERSGIS), University of Ghana, Legon;
e-mail: eamamoo@ug.edu.gh
[2]Principal Applications Specialist, Centre for Remote Sensing and Geographic Information Services (CERSGIS), University of Ghana, Legon

Reportedly, Ghana is to benefit from United States Government special grant "MILLENNIUM CHALLENGE ACCOUNT (MCA), which is basically for implementation of rural-based agriculture, transportation and community-based agro-related social infrastructure. It is intended to benefit some of the poorest rural districts where poverty rates range between 40 and 90% of the national standard. It is supposed to raise the income potentials of farmers through increased production of high-value cash crops along side basic food crops, improve transportation network and integrate food processing industries and produce export handling facilities. Twenty-three districts are to benefit from the programme. The components enhancement of profitability of commercial agriculture among small-scale farmers, improvement of land tenure to facilitate security of small-scale holdings, improvement of the Volta Lake transport in order to open the Afram Basin to the outside market, and improvement of small-scale irrigation.

One of the pre-project challenging tasks is development of comprehensive, community-level databases for the project. The current data sets on the Biophysical Environment, Land use/Land ownership, Community's Social, Economic and Cultural Profiles are not ready for use. Collection and processing of essential data will take some considerable time. Timeliness will be essential in data provision for critical decision in the project planning stages. Robust geographic databases on all the spatial and non-spatial data sets are basic requirements that the initial phase should give priority to.

Some community-based social infrastructure facilities are being compiled for each administrative district. However, the biophysical and land use/land land tenure databases are not yet tackled. The surveys for establishing the requisite databases need to be commenced in time to facilitate availability of the essential land-related data in user-friendly formats. The existing datasets do not have the quality and quantity required for the project. An initial integrated survey should target high resolution database building for soils, hydro-geology, agro-meteorology, vegetation (at plant species level including ethno-botany), and habitats of endemic parasitic animal/human disease vectors.

Remote Sensing tools will be used as part of the surveillance technology. Past, current and future aerospace images and GPS-based point-data acquisition will form part of the GIS-database building processes. The database will require that all data sets are geo-referenced to the common base map, the 1/50,000 scale topographic map with coordinates compatible with GPS values, in turn referenced to the satellite images. All other existing spatial data (soil, vegetation, water, hydrology/ hydrogeology, agro-climate, among others) will be a set of baseline data processed and linked to the base map. The database organization will have to recognize the administrative structures of the district assemblies since the assemblies will play the implementing role of the projects.The paper utilizes satellite images, other existing environmental data sets converted to GIS-format to illustrate aspects of the survey integration GIS-database building processes.

Structural thresholds at landscapes, across different habitat amount and aggregation levels

M.C. Ribeiro, J.P. Metzger, A.C. Martensen

Laboratório de Ecologia da Paisagem e Conservação – LEPAC, Instituto de Biociências, Universidade de São Paulo, Rua do Matão - travessa 14 n° 321, São Paulo, Brazil.
e-mail: miltinho_astronauta@yahoo.com.br

Thresholds can be understood as a state-and-transition point or zone below or above, which abrupt changes can be observed in the response variables. Despite some studies investigating landscape metrics and their relationship with gradients of area and aggregation (Neel et al, 2004), structural thresholds above which cover and configuration could vary independently are still unknown. We have investigated the behavior of landscape metrics across habitat amount and configuration gradients, in order to identify cover thresholds about which the spatial arrangement of habitat patches presents little or none importance. Neutral habitat and non-habitat landscapes were generated using the RULE program. Nineteen levels of habitat amount (P= 5% to 95%, with steps of 5%) and ten levels of aggregation (H= 0.1 to 1, with steps of 0.1) were used as input parameters. Neutral landscapes were simulated combining P and H, with 100 replicates, in a total of 19,000 binary maps. Landscape metrics (n= 59) were computed at class-level for the following metric groups: area, shape, core area, isolation, proximity, contagious and connectivity. As many of class-metrics are correlated, we select only those that present complimentary information, i.e. poorly correlated. Linear, Logarithm and Piece-wise regressions were applied to habitat amount and class-level landscape metrics, for each aggregation levels. Metric selection was carried out using Principal Component Analysis (PC). Akima´s method for bivariate interpolation and smooth surface fitting was used to generate 3-D surfaces for selected metrics (as Z-axis), having P and H levels as X and Y-axis. We accounted 86.2% of total variance in the first five components (PC1 to PC5). PC scores for these five PC´s helped the selection of following landscape metrics: PROX_MN (mean proximity index), DCORE_MN (mean disjunct core distribution), MESH (relative measure of patch structure) and SPLIT (cumulative patch area distribution). Piece-wise regression between PROX_MN and P levels showed highest r^2 values (from 0.74 to 0.95) when compared to linear and logarithm models. It suggests a structural threshold between PROX_MN and P. It was also noticed that each aggregation (H) levels changed the amount of habitat thresholds (P_th), with negative slope. The thresholds for PROX_MN ranged from P_th=55.6% for H=0.1 (disperse) to P_th=45.6% for H=1 (aggregated). Piece-wise models were also better for MESH (mean r^2 = 0.989), when compared to linear (mean r^2=0.901) and logarithm (mean r^2=0.868). Again we observe that exit structural thresholds were between P and MESH index. The P_th for MESH were 47.3% for H=0.1 and ranging between 50.3% and 51.1% for H$\geq$0.2 to 1. When analyzing DCORE_MN and SPLIT, log models were better than Piece-wise, so no thresholds were identified. The results found in this study emphasise the existence of structural thresholds on landscape metric behaviors, and that depending on H levels, these thresholds can change slightly. Almost for PROX_MN and MESH metrics, the P_th appear to be between 45% and 56% of the amount of habitat. Our findings could be helpful in species persistence studies.

Reference

Neel, M.C., McGarigal, K. & Cushman, S.A. 2004. Behavior of class-level landscape metrics across gradients of class aggregation and area. Landscape Ecology 19: 435-455.

Incorporating Local Landscape Knowledge into the Cultural Heritage Mapping Process

E.A. Moylan

School of Geosciences, University of Sydney, Sydney, 2006, Australia
e-mail: emoy4644@mail.usyd.edu.au

Introduction

A challenge faced by managers of heritage landscapes is the incorporation of local knowledge into the cultural heritage mapping process. This poster presents cultural heritage mapping at the World Heritage site of Angkor, in Cambodia. Angkor is best known for its historically significant temples. However, management of the site involves more than the conservation of archaeological structures because it is also home to over 100,000 people. The history of the people living at the site constitutes a cultural landscape, but one on a different level to that associated with the temples.

Using Map Biographies to identify Local Knowledge

Development of community maps that document cultural heritage in the context of the landscape is an important step towards the inclusion of the local people in the management of that community (Fox et al 2005). This poster presents community mapping activities at Angkor that combine landscape ecology principles with ethno-cartographic techniques. The map biography approach was used in a series interviews with the local community.

The Significance of Local Knowledge in the Identification of Cultural Heritage

Incorporating a traditional Asian landscape knowledge system into a fundamentally scientific approach, such as landscape ecology, required a reappraisal of standard mapping techniques. Some of the issues raised from the reappraisal include the development of local landscape classification systems, the spatial representation of intangible heritage, and the significance of place names as indicators of land use history. Local descriptions of landscape types were encouraged, thereby reducing the influence of preconceived classification systems. This approach resulted in the identification of subtle differences in landscape types, an improved understanding of landscape changes, and information to analysis patterns due to current land use restrictions. The inclusion of intangible heritage into cultural heritage management is a relatively new approach to heritage management in Asia. The nature of intangible heritage makes it difficult to identify and define. Mapping spatial attachment to the landscape from a cultural perspective offers a way to identify and represent heritage features in it (Byrne & Nugent, 2005). The adoption of this approach resulted in some cases where archaeologically significant temples were demoted in value over local contemporary religious structures. Additionally, the significance of place names was found to vary between formal administrative names, and historical local names. Research indicates that local gazetteers are an important part of cultural heritage mapping.

References

Byrne, D, Nugent, M. (2005) *Mapping Attachment: A spatial approach to Aboriginal post-contact heritage*.Department of Environment and Conservation (NSW), Sydney

Fox, J., Suryanata, K & Hershock, P. Eds (2005) *Mapping Communities: Ethics, Values, Practice.* East-West Center, Hawaii.

Identification of Functional Landscapes in Catalonia (NE Spain). A case-study for the High Pyrenees Natural Park.

J.M. Serra[1], M. Ninyerola[2], J. Cristóbal[1]

[1] Autonomous University of Barcelona. Department of Geography, 08193 Barcelona, Spain.
e-mail: josep.serra@uab.cat
[2] Autonomous University of Barcelona. Department of Animal Biology, Plant Biology and Ecology, 08193 Barcelona, Spain.

Introduction

Many attempts have been made in order to define ecological boundaries (Bryan, 2006; Mora and Iverson, 2002) by defining regions with similar ecological characteristics. In the present research, *Functional Landscapes* (FL) are identified for the High Pyrenees Natural Park. The concept of FL relates to the physical forces driving the ecological behavior of the study area through topographic and climatic variables. Those FL are areas that have the same characteristics, hence the same potential to develop similar ecological regions.

Metodology

Topoclimatic data

Topographic and climatic variables have been obtained from Catalonian Digital Climatic Atlas (Ninyerola *et al*., 2000) in a 180 meters spatial resolution, wisely transformed and aggregated.

Cluster analysis

A Principal Component Analysis (PCA) has been first performed among climatic and topographic variables in order to reduce redundancy. Subsequently, a semi-automatic non-supervised iterative *clustering* method using IsoData algorithm (Duda & Hart,1973) created 10 clusters, which divided the Natural Park in homogeneous environmental areas. A second cluster analysis using Ward's method has been performed for the centroid of each cluster, establishing similarities between each FL and therefore enabling a creation of a hierarchical legend that groups FLs at a different scale.

Functional landscapes map evaluation

Map evaluation has been performed using former landscape cartography (Chevalier, 1929), actual vegetation maps, forestry suitability maps and field surveys.

References

Bryan, B.A. (2006) Synergistic techniques for better understanding and classifying the environmental structure of landscapes. *Environmental Management* **37**: 126-140.

Chevalier, M. (1929) *Les Paysages catalans: leurs aspects, leur structure et leur évolution*, Librairie scientifique Albert Blanchard, Paris.

Duda, R.D. & Hart, P.E. (1973) *Pattern classification and scene analysis*, John Wiley & Sons, New York.

Mora, F. & Iverson, L. (2002) A spatially constrained ecological classification: rationale, methodology and implementation. Plant Ecology **158**: 153-169.

Ninyerola, M; Pons, X. & Roure, J.M. (2000) A methodological approach of climatological modelling of air temperature and precipitation through GIS techniques. *International Journal of Climatology* **20**: 1823-1841.

Application of BioHab in the Israeli mediterranean zone: a test of the habitat sampling method

L. Olsvig-Whittaker[1], M. Walczak[1], D. Rotem[1], Y. Magal[1], S. Amir[1], A. Perevolotsky[2], I. Tauber[3], R. Einav[4,] A. Zahavi[5], Y. Carmel[6], M. Sternberg[7], R. Frumkin[8], T. Achiron-Frumkin[8]

[1]Science Division, Israel Nature and Parks Authority, 3 Am Ve Olamo Street, Jerusalem 95463, Israel.
email: Linda.Whittaker@npa.org.il.
[2] Dept. of Agronomy and Natural Resources, ARO, the Volcani Center, P.O. Box 6, Bet Dagan 50250, Israel. [3] Keren Kayemit Leumi, Forest Dept, PO Box 45, Kiryat Hayim, 26103, Israel. [4]Blue-Ecosystems Environmental Consulting, Hagat 177, Zichron Yaakov, 30900, Israel. [5] Beit Berl College, Doar Beit Berl, 44905, Israel. [6] Faculty of Civil and Environmental Engineering,Technion -- Israel Institute of Technology, Haifa 32000 Israel. [7] Department of Plant Sciences, Wise Faculty of Life Sciences, Tel Aviv University, Tel Aviv 69978, Israel. [8] Environmental Consultants. P.O. Box 2444, Mevasseret Zion 90805, Israel.

Introduction

BioHab is a landscape oriented, species-independent method for habitat description and classification which has been developed for use in Europe (Bunce et al. 2005, see also www.biohab.alterra.nl). Several organizations in Israel with responsibility for land management have expressed an interest in application of this method in our country. In March 2006, we held a workshop on the subject in Israel with instructors Bob Bunce and Marc Metzger from Alterra, home base of BioHab in the Netherlands. The result of this workshop was an agreement to continue trials and assessment of the method. We translated the coding forms to Hebrew, eliminated those codes irrelevant to Israel, and added some terms peculiar to our country, in preparation for a second field experiment.

Field trial at Park Britannia

In this stage, we explored the possible use of this method in a field trial conducted in February 2007. Our study site, Park Britannia, was a 4,000 ha area with a mixture of planted forest and natural shrub land, in Israel's Mediterranean-Arid transition zone. Participants from several interest groups (conservation, rangeland, forestry, academic ecological research, regional planning, environmental impact assessment, and education) did joint sampling and assessed the field sampling from their professional perspectives.

Conclusion

It seems that BioHab can be used outside the habitat range of Europe, with real advantages where the taxonomic description used in classic habitat classification is weak or irrelevant. However, adaptations of the method must be made to incorporate new conditions not found in Europe. A simplification of the method needs to be developed for use by beginners and groups with limited time and resources. Analytical approaches after data collection will also become very important.

References

Bunce, R.G. H., G.B. Groom, R.H.G. Jongman, and E. Padoa-Schioppa (eds.) 2005 Handbook for Surveillance and Monitoring of European Habitats. Alterra report 1219, ISSN 1566-7197. EU FP5 project EVK2-CT-2002-20018. Alterra, Wageningen, the Netherlands.

Landscape Types of the Czech Republic

D. Romportl, T. Chuman, Z. Lipský

[1] Department of Physical Geography and Geoecology, Faculty of Science, Charles University in Prague, Albertov 6, Praha 2, 128 43,
e-mail: dusan@natur.cuni.cz

Landscape classification and typology represents one the most important subject of study for landscape sciences in the Czech Republic. Although different landscape typologies were developed in the Czech Republic in the past, none of them is applicable to the recent situation. The present poster introduces a new methodological system of complex landscape typology. The basic difference is that the typology presented here is based on exact, easily quantified data covering both natural and cultural landscape conditions, which can be classified in GIS.

In a first step, critical review of available environmental data has been undertaken in order to select the following suitable data sources for the delineation of the major natural landscape units:

- climate
- relief
- parent material

All data inputs were firstly generalized and converted to raster datasets with the same pixel size. These raster datasets were analyzed by statistical functions implemented in a Spatial Analyst extension for ArcGIS. In next step, these three layers were stacked into one RGB colour composite as a TIFF file, which was segmented in a specific way using the eCognition software. This object-oriented image classification software allows delineation of polygons represented natural landscape types in various scale levels.

Additionally, the following data about anthropogenic influences on the landscape were examined in a Spatial Analyst extension for ArcGIS:

1. land use/land cover
2. secondary landscape heterogeneity

By combining chosen raster datasets a new unique raster dataset was created where each pixel has a unique combination of selected characteristics. All pixels of the same summary characteristics represent a particular landscape type. The unique landscape types were generalized and combined with similar ones in polygons defined by eCognition segmentation process. The output of the used methodology is a map representing a preliminary landscape typology of the contemporary Czech landscape that will be the subject of further modifications and interpretations.

Habitat Guide of the Landscape Ecological Habitat Mapping of Hungary

J. Bölöni[1], A. Kun[2], Z. Molnar[1], E. Illyés[1]

[1] Institute of Ecology and Botany of HAS – 2163, Vácrátót, Alkotmány 2-4., Hungary
e-mail: jboloni@botanika.hu
[2] 1037, Budapest, Kolostor 2. Hungary

Introduction

To conserve our natural heritage and for developing sustainable landscape management strategies, it is essential to know on country level what kind of landscapes do we have with what kind of habitats and in what state are they in. To fulfill these demands actual data on the distribution and conservation status of the Hungarian habitats were needed, since so far there was no map of the actual vegetation of Hungary. Therefore a satellite image supported field mapping of (semi)natural habitats of all Hungary (MÉTA) was carried out in a hexagonal grid of 35 hectares. List and area proportions of habitats in each hexagon, and 17 other attributes including naturalness, threats, presence of invasive species, land use and landscape-ecological attributes were documented. The Habitat Guide presented here was compiled especially for the purposes of this survey.

The aim and structure of the Habitat Guide

The aim of the Habitat Guide was to serve as a comprehensive basis for the habitat survey and to ensure the equal quality of the mapping, since nearly 200 mappers were involved in this project. However, the Habitat Guide is very suitable for other habitat surveys beyond the MÉTA project as well.

The Habitat Guide is generally based on the Hungarian National Habitat Classification System (Á-NÉR) developed in 1997 and used successfully in many vegetation surveys so far, but it was modified and extended considerably. The habitat classification system of the Habitat Guide reflects the traditional phytosociological views while the emphasis is put more on the physiognomical approach and the site conditions. It contains 86 habitat types, with detailed descriptions of the 81 semi-natural habitats and 5 degraded habitat complexes.

The Habitat Guide describes each habitat type in 1500-2000 words in the following chapters: definition, site conditions, typical stand structure, characteristic species, vegetation context in which the habitat type occurs, subtypes (with short descriptions), types not belonging here (the correct category is given), patterns on the satellite image characteristic for the certain habitat type, naturalness-based habitat quality and regeneration potential. There are many examples and explanation given on characteristic and specific situations seen on the field by experianced mappers.

Uniqueness of the Habitat Guide

The uniqueness of the guide stands in the fact that besides the 21 authors, all of the 200 MÉTA mappers contributed to its compilation in two steps. Firstly, they had to review at least 10 habitat types from the Habitat Giude and report in writing before they started the mapping, and secondly, during the discussions on the compulsury three-day-long field-trips as preparation for the mapping they raised their questions and added their comments, which were inbedded in the final version of the Habitat Guide.

Programme for planned biodiversity studies: ecologically robust and cost-effective site-based ecological data for multi-purpose research and management

J-M Hero [1], W.E. Magnusson [2], B.E. Lawson [3]

[1] Centre for Innovative Conservation Strategies, School of Environment, Griffith University, Gold Coast Qld 9726, Australia.
e-mail: m.hero@griffith.edu.au
[2] Instituto Nacional de Pesquisas da Amazonia (INPA), 2.936, Petrópolis, Manaus, Amazonas, CEP 69060-001, Brazil.
[3] School of Natural and Rural Systems Management, The University of Queensland, Gatton Qld 4343, Australia.

Nationally and internationally, long-term site-based datasets are integral to natural resource management for purposes including condition assessment, impact assessment, population estimation, planning and modelling. The Programme for Planned Biodiversity (PPBio) project involves integrated, standardised long-term ecological survey grid based on a meso-scale grid of survey trails (5km x 5km), with 30 permanent terrestrial plots (Fig. 1) and permanent aquatic plots as required.

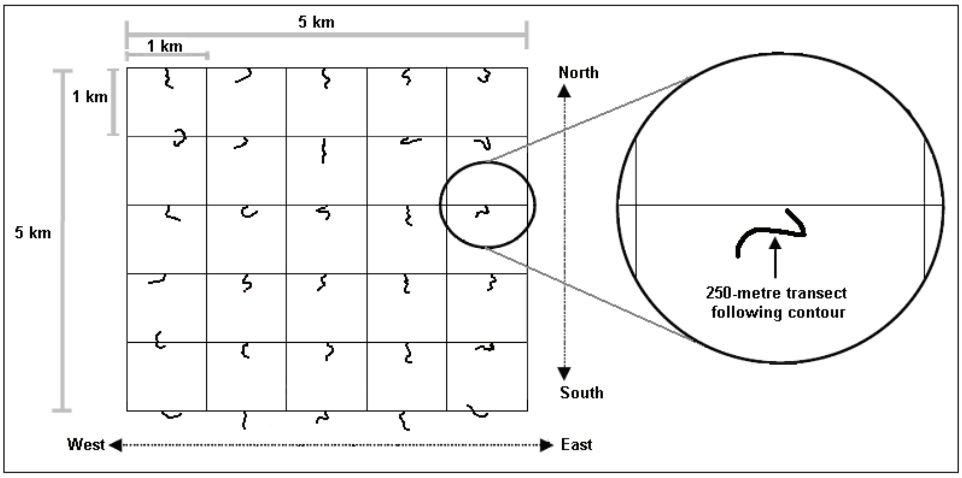


Figure 1. The layout and design of a standard PPBio long-term ecological survey grid with 30 plots of 250m length and varying in width depending on the taxon measured.

The PPBio programme was developed in Amazonas Province, Brazil, for baseline ecological monitoring and research. The resultant ecological understanding and cost-effective design has seen its rapid expansion across Brazil, with substantial interest from conservation agencies across the globe.

One such project is the PPBio Australasia consortium which has recently established a survey grid in south-east Queensland, Australia. This consortium includes local government and natural resource management bodies which are eager for a survey methodology that can efficiently and effectively integrate ecological research at the site-level to achieve long-term ecological monitoring in addition to one-off ecological studies by demand. The PPBio design offers a unique program for multi-purpose and multi-scale biodiversity research, and excellent opportunities for applied management outcomes.

This poster describes the history, design and applications of the PPBio approach, with specific focus on the Brazilian and Australian programmes.

Evaluation of the vulnerability to floods on the state of Tabasco, Mexico

L. Gama[1], C. Zequeira-Larios[1], L. Giddings[2], M. Soto-Esparza[2], A. Galindo-Alcantara[1], A. Hernadez-Moralez[1]

[1] Universidad Juarez Autonoma de Tabasco Km. 0.5 Carretera Villahermosa-Cardenas, Entronque a Bosques de Saloya, 86030 Villahermosa, Tabasco, Mexico
e-mail: lillygama@yahoo.com
[2] Instituto de Ecologia, A. C. Km. 2.5 Carretera Antigua a Coatepec 351, Congregación El Haya, 91000 Xalapa, Veracruz, Mexico

According to the information recorded by the Mexican Secretary of Environment and Natural Resources, floods constitute the most important type of disaster in Southern Mexico. The damages resulting from floods have the largest economic, social, and environmental consequences. Although it is impossible to eliminate floods; it is possible to minimize their effects via projects, and activities based on data regarding vulnerability areas that will protect the economic and social infrastructure. Tabasco has undergo important land cover changes due to agricultural, cattle raising activities and petroleum extraction, that affected natural landscapes. Climate change is also expected to be a cause of important changes because of the geographical conditions of the state. An analysis of the vulnerability to floods due to the physical condition of the area, the changes on the coastal line and the increase on precipitations was done to configure a map.
Precipitation data from the Global Historical Climatology Network (GHCN) and additional Mexican data from Eric II (compact disk produced by the Mexican National Water Commission), data were assembled from stations in southern Mexico. Monthly precipitation data were converted to SPI and interpolated to form monthly contour maps of SPI of the region. The Standardized Precipitation Index (SPI) developed by McKee et al. (1993) categorizes the observed rainfall as a standardized departure with respect to a rainfall probability distribution function. that compares the precipitation of one month with the entire record of precipitation was applied to individual months of a reporting station as well as to longer periods.

Aerial photos and a historical review were performed to evaluate changes on the coast line during the last 20 years (Ortiz Perez, et al. 2006). A great Coastal lost of between 5 to 20 meters each year as well as damage to infrastructure shows that a monitoring system has to be implemented to evaluate the future impact on the rest of the state. Both factor increase on precipitation and changes on coastal lines are risk factors for an important amount of population of the state that have to be monitored.

References

McKee, T. B., Doesken, N. J. & Kleist, J. (1993). *Drought monitoring with multiple timescales.* Paper presented at the Preprints, Eighth Conference on Applied Climatology, Anaheim, California.

Ortiz Perez, M. A., A. P., Mendez Linares & J. R., Hernandez Santana, (2006), *Sea level rise and vulnerability of coastal low-land in the Mexican area of the Gulf of México and the Caribbean Sea* (Chapter 14). In: Ecosystem-Based Management in the Gulf Of Mexico (eds. J. W. Day & A. Yañez-Arencibia), multi-volume series “The Gulf of Mexico: Its Origins, Waters, Biota Human Impacts”. Texas A & M University Pres.

Evaluation of farm woodlands as agri-environmental schemes in rural landscapes

M. Sigura, A. Marelli

University of Udine. Department of Agricultural and Environmental Sciences, via delle Scienze 208, 33100 Udine, Italy.
e-mail: maurizia.sigura@uniud.it

Introduction

Several agri-environmental schemes funded by the European Union have been aimed at increasing the amount of woodland on formerly agricultural land (EEC Regulation 2080/92 and 1257/99) and the evaluation of their effects on biodiversity is required.

The aims of this paper were to assess the value of that new woodland in preserving biodiversity, using bird species richness as an indicator, and to evaluate the relations between landscape pattern and bird species richness

Methods and Results

The study was carried out in lowlands of Friuli Venezia Giulia, North-eastern Italy. Bird species richness in 28 farm woodland was compared with the one in 26 control habitats, the latter being patches of semi-natural woods and shrubs within 1 kilometre. Bird survey was based on one point count (10 minutes, no fixed radius) carried out monthly in each farm woodland and control habitat between February and June 2005. The habitat was analysed by the Index of Vegetation Complexity (MacArthur & Horn, 1969, Bibby et al, 2000 and Radtke & Bolstad, 2001 modified) that describes structural complexity of vegetation for both farm woodlands and control habitats.

The analysis of landscape pattern was based on the land use of a 2 km buffer around the habitats, as landscape metrics we consider: at the patch level (farm woodland and control habitats) the patch area, patch perimeters, shape factor, at different spatial scales (500 m, 1000 m, 2000 m) the relative presence of land use classes. The overall list of species recorded in farm woodlands doesn't differ greatly from that in control habitats, but frequency of each species is usually lower in farm woodlands. On average you are likely to encounter 2.6 species in a given farm woodland vs. 8.7 species in a control habitat. Best regression model (best sub-set method) includes 8 variable, fits in well with observed data and shows a high degree of significance (R^2 = 0.745, $F_{8.42}$ =15.35, p<<0.001). The most important contributions to regression model are by vegetation complexity index, perimeter and presence of farm woodland in surrounding landscape. Important are also the presence of edges, woodland and arboreal cultivation but with a different weight at the different spatial scales. The results show that the variable which best explains low species richness is the poor vegetation structure of farm woods: vegetation complexity index is strongly correlated with species richness and is systematically lower in farm woods. The trend of landscape variables at different spatial scale could indicate that in fragmented landscapes, like the agricultural landscape, the birds need landscape diversity as number of different patches in order to satisfy their needs and maintaining one vital population.

References

Bibby C. J., Burgess N. D., Hill A. H., Mustoe S. (2000) Bird census techniques – Second edition. Academic Press, London.

MacArthur R.H. & Horn H.S. (1969) Foliage profile by vertical measurements. Ecology, 50 (5) : 802-804.

Radtke P.J. & Bolstad P.V. (2001) Laser point-quadrat sampling for estimating foliage-height profile in broad-leaved forest. Can. J. For. Res., 31: 410-418.

Characterisation of the rural landscape. Application in a case study of the plain of North Eastern Italy

M. Sigura, A. Treleani, P. Bonfanti

University of Udine, Department of Agricultural and Environmental Sciences, Via delle Scienze, 208_33100_ Udine_ ITALY
e-mail: maurizia.sigura@uniud.it

Introduction

In the modern age the changes in land use and land cover modified quickly the rural landscape with sudden and wide effects that produced visual uniformity and anonymity with threats to social identity and quality of life, loss in environmental heterogeneity and biodiversity as well as cultural heritage. It is necessary to study the proprieties of landscape changes at different levels (Bastian O. et al, 2006). This paper wants to analyse the changing of visual characters of the rural landscape in different conditions of land use with the focus on the rural landscape as perceived by people. The aim was to develop and test a methodology for the application of visual character analysis, not only qualitative, applied with a multiscale approach to a plain of a single municipality (Friuli Venezia Giulia, Italy) that presents inside two specific landscape patterns. From the analysis it was revealed that the first one is correlated to a land consolidation of the second half of XX century with strong simplification effects of landscape and environment, while the second keeps clear marks of the stratification of land use of the past with a larger level of landscape and environmental heterogeneity.

Methods and results

In this study, indicators (related to *diversity* and *complexity*) in the two different areas at two distinct scales were measured and, subsequently, dates achieved were integrated with a common derivate index. At the macro scale the photograph relief was developed playing visual shots related to vantage points (bell towers) and separating the whole diorama in 4 view cones in correspondence with cardinal points. With a common process the photos were standardized and analyzed referring to 7 classes of visual factors elements (*intensive agriculture, meadows, edges, private green belt, streets/paths, dwellings, factories*). At the detail scale for every macro view cones several foreground points (rural streets) were selected. They are matched with the global character of the area. The indices calculated were: the MSIEI at the macro scale, the *Normalized Index of Linear Complexity* (NILC) at detail scale, as the medium value of linear structures perceived (normalized to scale 0-1), and the *Derivate Diversity Index* (DDI) as the sum of MSIDI and NILC to integrate both scales. In the DDI the NILC is an incremental factor that adjusts the diversity value calculated at the macro scale with the complexity value surveyed at the detail scale of the perceived landscape. MSIEI shows a general simplification of the pattern of both considered areas, but the values of NILC show different levels of complexity derived from the perception of linear structures at the detail scale that are higher in the area whole land consolidation has no interest. We can notice that at the increasing of the IDD values the visual *diversity* of the landscape pattern and the linear *complexity* of the visual units grows. This scale integration method has integrated the landscape diversity of the two areas providing a further visual survey instrument to the landscape diagnosis.

References

Bastian O., Krönert R., Lipsky Zdeněk (2006), Landscape diagnosis on different space and time scales_ a challenge for landscape planning, *Landscape Ecology*: **374** -pp.359-374

Analysis of spatial structure of landscape cover classes of sub-basin Balsas, south of Maranhão state, Brazil

L. Barreto[1], M.C. Ribeiro[2], E. Pontes[3], A. Veldkamp[4]

[1]Federal University of Maranhão, Oceanography and Limnology Department, Portugueses Avenue, s/n., 65080-040, São Luís, MA-Brazil.
e-mail: laraufma@yahoo.com.br
[2] University of São Paulo, Landscape Ecology and Conservation Laboratory, São Paulo, SP-Brazil
[3] State University of Maranhão, Lansat Laboratory, 65055-970, São Luís, MA-Brazil
[4] Wageningen Agricultural University, Lab. Soil Science and Geology, The Netherlands

Recent studies suggest that land use and land cover change dynamics are also relevant for site selection when one is are aiming for conservation and restoration of natural ecosystems (Veldkamp *et al*., 2001; Verburg *et al*., 2004). Several metrics such as spatial configuration, connectivity, can be computed for patches, classes and landscapes, helping the analysis task. Combination of some of them can express the fragmentation status of an interest region. Also multi-scale analyses are essential to improve de understanding of the role of regional scale on the local scale processes.

We analyzed the spatial structure of remaining patches of Balsa's sub-basin, south of Maranhão state of Brazil. As a consequence of arable land expansion, natural habitats suffered severely, causing significant impacts on regional flora and fauna. Understanding how the remaining habitats are spatial distributed and configured is essential for developing an effective Conservation Area Network definition. In this work we derived a cover map from Landsat/TM 5 images acquired in 2000, with the classes: *cerrado* (brazilian savanna) and riparian forests; open fields (*campo cerrado*) and pasture; human activities (crops and buildings) and d) water body.

The whole region was subdivided into 322 hexagonal cells (planning unit - PU) of analyses, each with 10,000 hectares. Several structural landscape metrics were computed for the cells (MacGarigal & Marks 1995), only the metric percentage of native *cerrado* and riparian forests (PLAND) are discussed here. The metric was computed for two spatial scales: a) local scale which included the amount of native forests within the cells; b) regional scale, computed the amount of native forest in a virtual hexagonal cell of about 50,000 hectares, centered on the midpoint of each local (10,000 hectare) cells.

Our preliminary results shows that when considering only a local scale, about 22% of the total number of P.U. presented good PLAND values ($\geq$60%), 18% presented intermediate PLAND ($\geq$40-60%) and 60% of the regional have low PLAND (<40%). But when we analyzed the regional scale over the local scale, we noticed that some PU´s shift for both lower and higher PLAND values. Taking in account our two scales of analyses, local and regional, we classified the PU´s and suggested some preliminary management actions. We believe that a multi-scale approach of analyses could provide good information to help the first steps of the definition of a CAN.

References

Mcgarigal, K. & Marks, B. J. (1995) FRAGSTATS: spatial pattern analysis program for quantify landscape strucure. USDA. *Forest Service Pacific Northhwest Research Station,* Portland, OR.

Veldkamp, A.; Verburg, P. H.; Kok, K.; de Koning, G. H. J.; Priess, J. & Bergsma, A. R. (2001) The need for scale sensitive approaches in spatially explicit land use change modeling. *Environmental Modelinmg and Assesment* **6**: 111 –121.

Velburg, P. H.; Schot, P. P., Dijst, M. J. & Veldkamp, A. (2004) Land use change modelling: current practice and research priorities. *Geojournal* **61**: 309-324

Assessment of a land change model using a three-dimensional matrix at multiple scales

S. Peethambaram, .G. Pontius Jr

Clark University, 950 Main Street, Worcester MA 01610, USA.
e-mail: smitha.peethambaram@gmail.com

This paper proposes a novel statistical method to assess the mapped output from a spatially-explicit model that simulates change over time among land categories. This paper allows each pixel in the map to have partial membership to more than one category. Therefore it is possible to compute the statistics at multiple scales. The technique considers three maps: 1) a reference map of time 1, 2) a reference map of time 2, and 3) a prediction map of time 2 from a model that predicts the land change between times 1 and 2. The three maps derive from an application of the SAMBA modelling project in Vietnam (Castella *et al.* 2005). Figure 1 shows that there is more error than correctly predicted change at the 30-meter resolution of the raw data, which is common for land change models (Pontius *et al.* in press). Two of the three types of errors shrink substantially as resolution becomes coarser.

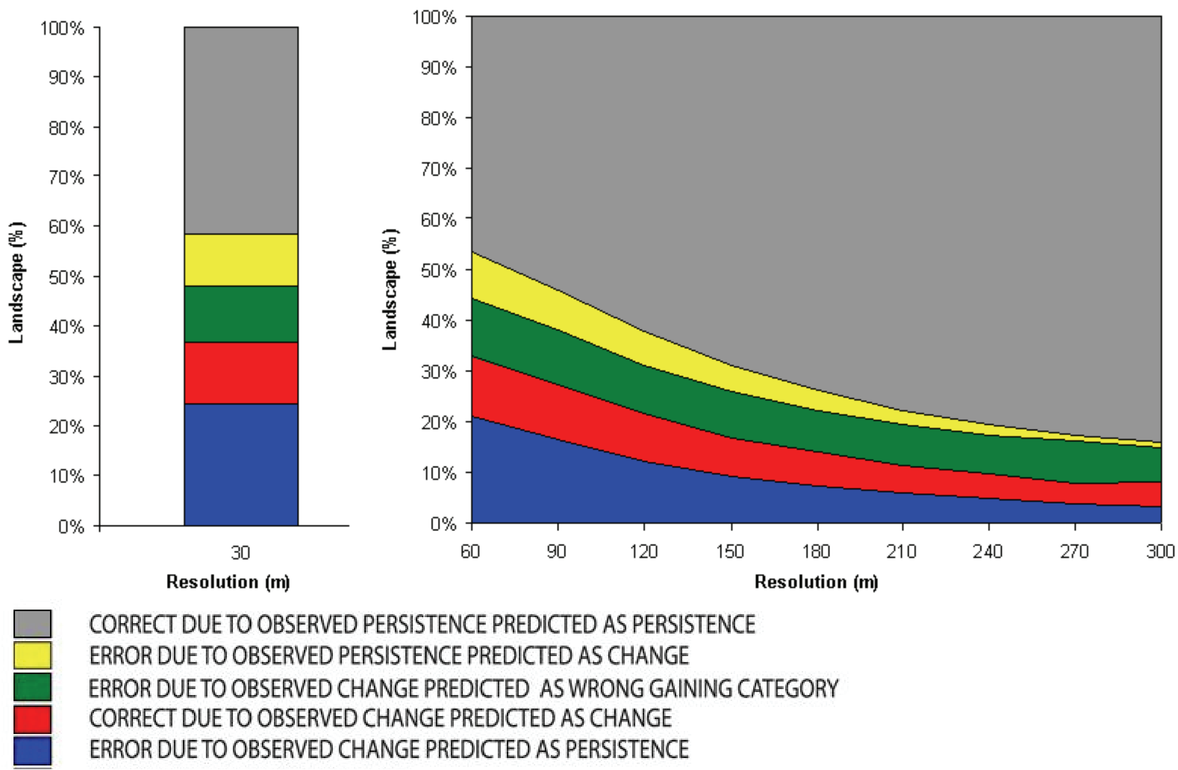


Figure 1. Percent of landscape categorized as correct and erroneous at multiple scales.

References

Castella, J.-C., Boissau, S., Trung, T.N., & Quang, D.D. (2005) Agrarian transition and lowland-upland interactions in mountain areas in northern Vietnam: Application of a multi-agent simulation model. *Agricultural Systems* **86(3):** 312-332.

Pontius Jr, R.G., Boersma, W., Castella, J.-C., Clarke, K., de Nijs, T., Dietzel, C., Zengqiang, D., Fotsing, E., Goldstein, N., Kok, K., Koomen, E., Lippitt, C.D., McConnell, W., Pijanowski, B., Pithadia, S., Mohd Sood, A., Sweeney, S, Ngoc Trung, T., Veldkamp, A.T. & Verburg, P.H.. 2007. Comparing the input, output, and validation maps for several models of land change. *Annals of Regional Science* **(available at www.clarku.edu/~rpontius)**.

Delineation of landscape units at diverse scales using moving windows for heterogeneity analysis

E. Diaz-Varela[1], R. Crecente-Maseda [2]

[1] LaboraTe. Escola Politécnica Superior- Campus Universitario s/n. 27002-Lugo (Spain). Er-mail: ediazv@lugo.usc.es
[2] LaboraTe. Escola Politécnica Superior- Campus Universitario s/n. 27002-Lugo (Spain).

Delineation of landscape units should reflect the spatial variation of the heterogeneity of landscapes and their hierarchical organization in spatial levels, according to their functional and structural characteristics. In this work, a method involving the use of moving window analysis at multiple scales was developed, as a simple but straight-forward approach to the delineation of landscape units at several scales. The use of moving windows for calculation of landscape metrics (see e.g. Eiden et al., 2000; Riitters et al., 2000) can provide useful information on the spatial distribution of landscape heterogeneity, whereas the variation on window size can be used to emulate different scale levels. The different domains of scale thus identified can be interpreted as building up a hierarchy in the complexity of space (Zonneveld, 1995), and each of them can be considered as landscape units.

As landscape heterogeneity is conditioned at intermediate levels by the spatial distribution of vegetation, animal populations, and land forms (Meisel & Turner, 1998), digital data on distribution of land cover (raster map, 10x10m pixel resolution, obtained from photo-interpretation) and physiographic characteristics (slope map derived from 1:5.000 digital cartography) were used for the analysis. Analyses were made using window capabilities of FRAGSTATS software (McGarigal et al., 2002), using windows of 250, 500, 750, 1000, 1250 and 1500 m of diameter. Then, majority filtering was done on the slope map using ArcGIS, following a similar array of scales of analysis than in the land cover map.

Results obtained from the analysis of the land cover map allowed distinguishing areas in which the level of heterogeneity was constant against other with scale-dependent changes. Such areas were afterwards overlaid with the results for the slope map allowing the differentiation among several landscape units. Such units were then organized in a nested-hierarchical structure, obtaining a final land-unit, multiscale defined map. A subsequent study of the composition and configuration of the landscape structure in the delineated units verified differences among their characteristics.

References

Eiden, G.; Kayadjanian, M.; Vidal, C. (2000): *Quantifying Landscape Structures: spatial and temporal dimensions*. Retrieved on date 12-18-2006, from: http://ec.europa.eu/agriculture/publi/landscape/ch2.htm#2.

Meisel, J. E. & Turner, M. G. (1998) Scale detection in real and artificial landscapes using semivariance analysis. *Landscape ecology* **13**: 347-362.

Riitters, K.H.; Wickham, J.D.; Vogelmann, J.E.; Jones, K.B. (2000): National land-cover pattern data. Ecology, 81(2): 604-604. Retrieved on date 12-18-2006, from: http://www.esapubs.org/archive/ecol/E081/004/metadata.htm

Zonneveld, I.S. (1995) *Land Ecology: an introduction of landscape ecology as a base for land evaluation, land management and conservation.* SPB Academic Publishing, Amsterdam, The Netherlands

McGarigal, K.; Cushman, S.A.; Neel, M.C.; Ene, E. (2002) FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps. Retrieved on date 12-18-2006, from: www.umass.edu/landeco/research/fragstats/fragstats.html.

Prediction of soil properties in paddy rice landscapes using terrain data and satellite information as indicators

K. Sumfleth[1], R. Duttmann[1]

[1] Institute of Geography, Department of Landscape Ecology and Geoinformation Sciences, University of Kiel, Ludewig-Meyn-Str. 14, 24098 Kiel, Germany.
e-mail: sumfleth@geographie.uni-kiel.de

Abstract

Sustainable land management and land use planning require reliable information about the spatial distribution of physical and chemical soil properties affecting landscape processes and services as well. Although many studies have been conducted to identify the spatial patterns of soil property distribution on various scales and landscapes, only less is known about the relationships underlying the spatial distribution of soil properties in intensively used paddy soil landscapes in southeast of China. In order to provide adequate soil information needed for the modelling of landscape processes, such as soil water movement, nutrient leaching, soil erosion and plant growth, this study investigates to what extend the use of cheap and readily available ancillary information, derived from digital elevation models and remote sensing data is suited to support soil mapping and to indicate soil characteristics on the landscape scale. This investigation focuses on the spatial prediction of the total carbon content as well as to soil physical soil properties such as topsoil silt, sand and clay content, topsoil depth and plough pan thickness. Correlation analyses indicate that the distribution of carbon and silt contents is quite well related to the NDVI (SPOT 5, ASTER and Landsat ETM+) of vegetated surfaces on the one hand side and corresponds significantly to terrain attributes such as relative elevation, elevation above nearest drainage channel and topographical wetness index on the other. Geostatistical analyses furthermore reflect a moderately structured spatial correlation of these soil variables. The combined use of the above mentioned terrain variables and the NDVI in a multiple linear regression accounted for 29% (silt) to 41% (total C) of the variance of these soil properties. The spatial distribution of variables as topsoil depth and plough pan thickness is mainly affected by the long term history of land use and recent land and soil management practices (e.g. intensity of ploughing, puddling, rice straw management), so that no and less narrow relationships and structured spatial dependencies could be recognized here. In order to select the best prediction method to accurately map soil property distribution, we compared the performance of different regionalization techniques, as multi linear regression, simple kriging, inverse distance to a power, ordinary kriging and regression kriging. Except the prediction of topsoil clay content, in all other cases regression kriging model “C” performed best. The regression kriging model “C” is assumed to be suited to reduce soil sampling density and to contribute to a time and cost saving soil mapping on the landscape scale even in intensively used paddy soil landscapes.

References

Herbst, M.; Diekkrüger, B. & Vereecken, H. (2006) Geostatistical co-regionalization of soil hydraulic properties in a micro-scale catchement using terrain attributes *Geoderma* **132:** 206-221

Odeh, I.O.A.; McBratney, A.B. & Chittleborough, D.J. (1995) Further results on prediction of soil properties from terrain attributes: heterotopic cokriging and regression-kriging. *Geoderma* **67:** 215-226

Simbahan, G.C.; Dobermann, A.; Goovaerts, P.; Ping, J.; & Haddix, M.L. (2006) Fine-resolution mapping of soil organic carbon based on multivariate secondary data. *Geoderma* **132:** 417-489.

Yanai, J; Lee, C.; Kaho, T.; Iida, M.; Matsui, T.; Umeda, M. & Kosaki, T. (2001) Geostatistical analysis of soil chemical properties and rice yield in a paddy field and application to the analysis of yield-determining factors. *Soil Science and Plant Nutrition* **42:** 291-301.

Object-based classification of rural landscapes using remotely sensed data of various resolutions

K. Hara[1], N. Kamagata[2], T. Ishitsuka[3], M. Tomita[4]

[1,4] Faculty of Information Sciences, Tokyo University of Information Sciences, 1200-2 Yatoh-cho, Wakaba-ku, Chiba 265-8501, Japan.
e-mail: hara@rsch.tuis.ac.jp
[2,3]Graduate School of Informatics, Tokyo University of Information Sciences, 1200-2 Yatoh-cho, Wakaba-ku, Chiba 265-8501, Japan.

Introduction

Effectiveness of object-based classification of land-cover using very high resolution (VHR) data such as IKONOS has been demonstrated in recent research (eg., Burnett & Blaschke, 2003, Kamagata *et al.*, 2006, etc.). We examined the effectiveness of object-based classification for rural landscapes in central Japan, where small-scale agricultural practices and complex topography produce a complicated pattern of landscape. In object-based classification, the target area is divided by segmentation processing, and each segment identified is considered to be one image object. The segmentation of an image allows for groups of pixels to be considered as a single unit, or an object, within the image.

Study Sites and Methods

This research was conducted at experimental plots located in agricultural areas of Sakura City and Sosa City, located in Chiba Prefecture, central Japan. These areas consist of narrow, highly-branched alluvial valleys, called 'Yatsu', which are cut deeply into flat-topped, plateau-like uplands. Definiens Ver.5 was employed for the object-based classification, and classification results based on IKONOS (spatial resolution (SR): 4m), ASTER (SR: 15m) and multi-temporal TM/ETM+ (SR: 30m) images, as well as results from aerial photograph (SR: 0.6m) were compared. Initial segmentation was a multi-resolution, bottom-up system based on the method of Baatz and Schape (2000).

Results and Discussion

The research results showed that aerial photograph and IKONOS data were capable of extracting small patches such as fragmented forests and small irrigation ponds, and narrow corridors such as roads and streams. On the other hand, the lower resolution satellite data, especially the multi-temporal TM/ETM+ data, proved suitable for identifying and mapping basic landscape types (such as irrigated paddies and dry fields) over a wider region. These results indicate that object-based classifications using remotely sensed data of various resolutions can be effective tools in classifying and mapping rural landscapes.

References

Baatz, M. & Schape, A. (2000) Multiresolution Segmentation – an optimization approach for high quality multi-scale image segmentation. Strobl, J. & Blaschke, T. (Eds). *Angewandte Geographische Informations Verarbeitung XII*. Wichmann-Verlag, Heidelberg, pp.12-23.

Burnett, C. & Blaschke, T. (2003) A multi-scale segmentation/object relationship modelling methodology for landscape analysis. *Ecological Modelling* **168:** pp233-249.

Kamagata, N., Hara, K., Mori, M., Akamatsu, Y., Li, Y. & Hoshino, Y. (2006) A new method of vegetation mapping by object-based classification using high resolution satellite data. *Proc. 1st Int. Conf. Object-based Image Analysis*, 5pp. CD-ROM, Salzburg, Austria.

Stewardship and monitoring of conservation lands

P. August[1], J. Coit[2], D. Gregg[3], R. Friday[4]

[1] Department of Natural Resources Science, University of Rhode Island, Kingston, Rhode Island, USA.
e-mail pete@edc.uri.edu
[2] The Nature Conservancy, Rhode Island Field Office, 159 Waterman Street, Providence, Rhode Island USA
[3] The Rhode Island Natural History Survey, Coastal Institute in Kingston, Kingston, 1 USA
[4] The Land Trust Council, The Nature Conservancy, Rhode Island Field Office, 159 Waterman Street, Providence, Rhode Island USA

Over 400 square kilometers of the state of Rhode Island have been acquired to protect fauna, flora, and ecosystem services. The major institutional owners of conservation land are the State of Rhode Island, United States Department of the Interior Fish and Wildlife Service, the Audubon Society of Rhode Island, The Nature Conservancy, and small land trusts and conservancies. The viability of any single parcel of land to support healthy populations of native plants and animals is a function of the condition of the parcel (site-scale) and the condition of the land around it (landscape-scale). Threats to the integrity of land that has been purchased for conservation include invasion by pests, pathogens, and non-native organisms; inappropriate human activities (dumping, cutting vegetation) within or near a property; degradation of landscape context such as loss of critical dispersal corridors to/from a property; ecological changes resulting from declines in water quality or quantity; and succession into habitat states that do not support target species or ecological communities. Few of the owners of conservation land in Rhode Island have the technical or staff capacity to monitor and steward their properties. Moreover, there are no standards, guidelines, or protocols that are universally followed in conservation land management in RI. The consequences of not monitoring and stewarding conservation lands are the loss of their ability to support target habitats and perform desired ecosystem services.

We are developing a framework for conservation land stewardship that consists of the following steps: 1) Site assessment, 2) Development of stewardship goals and plan, 3) Implementation of a stewardship plan for each property, 4) Monitoring, and 5) Synthesis, reflection, and adaptive stewardship. Stewardship and monitoring activities draw from and contribute to a common database on the biota of Rhode Island. Local land trusts are an essential participant in the program as they are the portal to volunteer land stewards who have the capacity to perform site surveys and monitoring. Landscape ecological assessment is an integral element of the framework as it provides a regional context for conservation and provides insight in gains/losses of dispersal corridors, upwatershed threats that would jeopardize site-level habitats or species, and land use changes on nearby properties that might enhance or diminish the conservation value of a particular parcel.

Multi-scale landscape pattern analysis for h-resolution imagery of tropical dry forest: integration of object-oriented approach and topographic data

J.A. Gallardo-Cruz, J.A. Meave

Departamento de Ecología y Recursos Naturales, Facultad de Ciencias, Universidad Nacional Autónoma de México, Circuito Exterior s/n, Ciudad Universitaria, México, D.F., Mexico.
e-mail: jagc@ciencias.unam.mx

Introduction

Landscape complexity must be addressed at multiple scales when evaluating the various levels of heterogeneity in a system (Burnett and Blaschke, 2003). This evaluation may be based on the use of landscape indices computed for the elements recognized in a satellite image (Turner and Gardner, 1991). The information enclosed in very high resolution imagery sets the basis for the identification of landscape elements. However, to fully exploit this information the spatial characteristics of the image must be used by the adequate classification methodologies.

In this study we aimed at evaluating landscape pattern at different scales in a tropical dry forest region. We used an object oriented classification approach to produce categorical maps from which landscape indices were calculated. The final goal was to explore the relationship between landscape pattern and scale in the system.

Methods

The data used come from an 8 × 8 km Quickbird image acquired in December 2005. The image represents a region of low elevation hills (< 500 m) located in the southern part of the Isthmus of Tehuantepec (Oaxaca), México. Land cover combines vast portions of seasonally dry tropical forest and savanna intermingled with other plant communities and human influenced areas (Pérez-García *et al*., 2001). The orthorectified and pansharpened image was classified using an object-oriented approach. This technique allows obtaining different size objects through an image segmentation procedure (Blaschke and Strobl, 2001). The objects where then classified according to their spectral, textural, spatial and topographical properties, to generate three categorical maps of the area representing landscape elements of different scales. A set of landscape metrics were computed and compared between scales.

Conclusions

This pattern analysis increased our understanding and improved the characterization of related processes through a wide range of scales that constitute a landscape, and allow perceiving a complexity of this landscape and its changes across scales that would otherwise remain unnoticed.

References

Blaschke, T. & Strobl, J. (2001) What's wrong with pixels? Some recent developments interfacing remote sensing and GIS. *GIS – Zeitschrift für Geoinformationssysteme* **6:** 12-17.

Burnett, C. & Blaschke, T. (2003) A multi-scale segmentation/object relationship modelling methodology for landscape analysis. *Ecological Modelling* **168:** 233-249.

Pérez- García, E.A; Meave, J. & Gallardo, C. (2001) Vegetación y flora de la región de Nizanda, Istmo de Tehuantepec, Oaxaca, México. *Acta Botanica Mexicana* **56:** 19-88.

Turner, M.G. & Gardner R.H. (1991) *Quantitative Methods in Landscape Ecology: The Analysis and Interpretation of Landscape Heterogeneity*. Springer-Verlag, New York.

Evaluation of landscape characteristics derived from digital elevation models

M.V. Ravibabu, P. Negi, K. Jain

Geomatics Engineering Section, Department of Civil Engineering,
Indian Institute of Technology (IIT), Roorkee-24766, Uttaranchal, India.
e-mail: ravi.mandla@gmail.com

In Geographic Information Sciences (GIS), digital elevation model (DEM) is one of the important input parameter for studying landform changes. DEM derives are frequently employed throughout physical geography for applications ranging from geomorphometry to hydrological modeling and the physiographic correction of digital satellite images. In this present paper, DEM generated from various data sources such as topographic maps, surveyed data and stereo satellite images (ASTER) are utilized to derived topographic parameters like slope, aspects and shaded map to analyze landscape variations in study area. The main objective of this paper is to evaluate landscape/terrain changes from various DEMs. Also we will address the effects of interpolation techniques, scaling and quality of the terrain in the study area.

Using conditional transit cost to identify multiple dispersal routes: an example from the Brazilian Atlantic forest

N. Pinto

Section of Integrative Biology, University of Texas at Austin, Austin, TX, 78712, USA.
email: naiara@mail.utexas.edu

Introduction

The identification of dispersal routes using friction layers and shortest-path algorithms provides the opportunity for scaling up from individual behavior to landscape pattern. Shortest-path algorithms are most often used in landscape ecology to obtain the optimum route between two points, but in practice the establishment of corridors profits from the identification of redundant routes. Here, I use a new graph-theoretical approach named Conditional Transit Cost (CTC), which uses the shortest-path algorithm to output all possible paths between two points along with their relative quality.

Methods

The method is illustrated with data from a 2000-Km^2 region in the Brazilian Atlantic forest (-24.3, -47.3). The area of interest is a complex landscape mosaic composed of urban centers, farms, roads, pastures, and isolated forest patches. The goal was to model animal movement between two conservation units, assuming species display a preference for primary forest but can also move through secondary forest. Thus, the quality for each 50 x 50 m pixel was a function of the percent tree cover weighted by a value that was highest for primary forest, intermediate for secondary forest, and lowest for non-forested areas.

I explored the use of two friction layers: F1 and F2, which assumed different relative quality values for secondary forest. Each friction layer is used to build four graphs: G1, G2, G3, and G4. For G1, I used a 8-cell neighbourhood, to obtain results similar to commercial GIS packages such as Spatial Analyst within ArcGIS. For G2, G3, and G4, I increased the neighbourhood to cover a radius of 100, 200 and 400 m respectively. This was done to simulate the behavior of species that can take large jumps over habitat patches. Last, the Conditional Transit Cost was calculated for all eight scenarios. The CTC for pixel C considering a route between A and B is the cost to move from A to B conditional on passing through C, using Dijktra's shortest path algorithm. The analyses were done using the Java graph library Jung 1.7.4.

Results

As predicted, the choice of different neighbourhoods gave different results. When the species is assumed to take large steps and the graph is built with a larger neighbourhood, the movement routes are almost straight-lines. But in all eight cases, it was possible to identify more than one route between the two conservation units.

Applications

By using the CTC model on different scenarios, it is possible to explore how one's assumptions about species' movement can affect the number and quality of dispersal routes between two points. The CTC model can also be used to produce hypotheses about animal movement that can be tested in the field.

Classification of spatial unites for the forested Korean mountainous landscape using DEM: Comparison of GIS analyzed data with landscape and memory of people

J. Kwon, J.H. Oh, J.H. Shin, Y.K. Kim, C.Y. Park

Korea Forest Research Institute, Division of Forest Ecology, Cheongyangni 2-dong, Dongdaemun-gu, Seoul, 130-712, Korea.
e-mail: alp96jk@foa.go.kr

Introduction

The character of Korean landscape is a mountain-based forested landscape which covers 65% of Korean land. In history, there were traditional ecological approaches including the Korean peninsula into a topography-based structure. The traditional approach would be described as 'The land is not flat, it is fluctuating (Ch'oe, 1994). The shape of surrounding was a key factor to understand Korean nature. However, since the experience of major landscape change during last half of the century due to war and rapid urbanization, the traditional character has been weakened, and it is now necessary for a reconsideration of the traditional ecological approaches to improve the landscape for the future.

What is the spatial units & how it developed?

<u>Nine prototype landscapes</u>

Illustrated concepts of Korean landscape patterns have been tested since 2002 (Kwon, 2002), and nine types of prototype landscape have been defined both using GIS tools and people's memory of Korean landscape. Aerial photographs, DEM and ArcScene with a modified AML have been applied to classify the nine landscapes. The key issues are; can the prototypes be classified by DEM? How big are they? Can they be useful as a vehicle which contains various ecological data of Korean peninsula? The hypotheses are; land-use patterns, forest types and habitats of wildlife can be influenced by the nine types, because people use the land based on a traditional landscape concept. For example, some types are strongly related to farming in history and topographical elements which could cause regional micro-climate differences.

<u>Prime spatial units & traditional forests and landscape</u>

In previous research (2002, Kwon), the nine types were summarized as follows; *Cultivated, Basin, Basin Holy, Corridor Cultivated, Cul-de-sac Holy, Crescent Valley, Enclosed Cultivation, Large Scale-Open Cultivation, Mountainous Settlement* and *Landmark Landscape*. As the results of classification using GIS tools, the three types of landscape which are the most readily identified are *Corridor Cultivated, Cul-de-sac Holy* and *Enclosed Cultivation Landscape.* Locations and shapes of Korean traditional village groves (*MAEULSOOP*) have different characters based on the nine types. In a national park area (Mt. Jiri), the landscape types are, in order: *Cul-de-sac Holy* and *Enclosed Cultivation* landscape.

References

Ch'oe, C.J. (1994) HAN'GUK ŬI P'UNGSU SASANG (A Conception of 'P'UNGSU' in Korea). Minumsa, Seoul.

Kwon, J. (2002) Sense of place – A concept of Korean prototype landscape with reference to a new policy of urban fringe forest. Unpublished Ph.D. thesis of Department of Landscape. The university of Sheffield. UK. pp174-186.

Decision tree and vegetation indices assisting land use classification in a heterogeneous landscape, a case study in Brazil -

S. Weel[1], M.E. Schaepman [2], J.G.P.W. Clevers[2]

[1] EarthCollective – FSD, PO box 570, 6700AN Wageningen, The Netherlands
e-mail: silvia.weel@wur.nl
[2] Centre for Geo-Information, Wageningen University, P.O. Box 47, 6700 AA Wageningen, The Netherlands

Introduction

The depiction of landscape indicators, through the assessment of land cover patterns and processes, provides spatial information to assist a more balanced approach in the planning and sustainable management of natural resources. Remote sensing data are the basis for the depiction of these indicators, through classification techniques and conversion analysis. However, the traditionally used Maximum Likelihood (ML) rule can misestimate landscape units due to the assumption of normal distribution of the data (not true for heterogeneous scenes). The potential of multivariate methods and the integration of spectral vegetation indices in the recognition of vegetation units may be assessed (DeFries and Townshend, 1994). The objective of this study was to evaluate the Decision Tree (DT) algorithm and vegetation indices in terms of their contribution to landscape assessment, seeking for more reliable classification techniques of heterogeneous conditions in the south-east of Brazil.

Methodology

Campinas is a municipality requiring a suitable and strategic environmental policy, due to intense anthropogenic influences on the original landscape composition. Classes of land cover and plant functional types were depicted from Landsat TM 5 images from 1988 and 2004, through ML and DT algorithms, in order to derive the landscape pattern. Different band compositions were considered for each classifier, where the ML used original bands and the DT took several vegetation indices (NDVI, MVI and TCT). A conversion analysis was based on post-classification comparison of the classified images; deriving indicators of human induced changes and natural processes, such as expansion of human activities, degradation and regeneration of natural vegetation.

Results and Conclusion

The results of the classification procedure indicated that the ML and DT had similar performance, considering the bands used in each model. However, some classes had a low accuracy due to the functions of the algorithm, biophysical variations and qualities of the sensor. The result of the DT presents the MVI as the most important index in the data splitting process. However, statistical analysis may be performed through a method presented by Xu *et al.* (2005). The conversion matrix proved to be very useful in delivering information for understanding the overall processes occurring within the landscape as well as providing an insight on the best technique and variables to be used for deriving more specific processes. The planning and management perspectives of this landscape analysis are dependent on the goal and scale of the approach of each administrative institution acting at the regional, municipal, and local level.

References

DeFries R. and Townshend J.R.G. (1994). NDVI-derived land cover classification at a global scale. *International Journal of Remote Sensing,* **15**:3567-3586.

Xu M., Watanachaturaporn P., Varshney P.K., Arora M.J. (2005). Decision tree regression for soft classification of remote sensing data. *Remote Sensing of Environment*, **97**:322-336.

Classification of the landscape of Huelva (Andalusia, Spain) using multivariate methods

J. Alcántara Manzanares[1], J. M. Muñoz Álvarez[1], J. Quijada Muñoz[2], J. M. Moreira Madueño[2]

[1]Department of Botany, Ecology and Plant Physiology. University of Córdoba. Campus Rabanales. Ed. Celestino Mutis. 14014. Córdoba. Spain. b62almaj@uco.es
[2]Environmental Department. Andalusian Regional Council. C/ Manuel Siurot, 50. 41013. Sevilla. Spain

Introduction

This study was conducted in the province of Huelva (Andalucía, Spain), which has a surface area of 10,128 Km^2. It comprises four structural sectors: (1) the *Sierra*, in the North of the province (up to 1000 m),; (2) the *Campiña*, in the middle of the province, with low hills, loamy soils and rainfed crops; to the South lie (3) the Coast, with dunes, expanses of sand, forestry (pine and eucalyptus groves), crops and housing developments, and (4) the Marshes, flat areas with limestone soils and characteristic vegetation. The climate is Mediterranean Oceanic, with mild winters and hot summers;.

The aim of the study was to classify the landscape of Huelva using multivariate methods and GIS tools.

Method

The province was divided into grid squares of 1Km x 1Km to which information was associated on visually-perceivable variables: soil use, plant cover, lithology and relief.

Multivariate Classification Analysis.TWINSPAN: This approach offers an advantage over other classification techniques: it allows grouping of elements and simultaneously provision of an ecological interpretation of how groups differ (McGarigal *et al*., 2000).

Multivariate ordination analysis. DCA: Enables visual analysis of the position occupied by squares in the ordination space, corroboration of classification analysis groups and establishment of degrees of difference between groups according to the distance between them (Kent and Coker, 1992).

Multivariate Classification-Validation Analysis. Discriminant Analysis: For a meaningful validation, the set of elements classified must be different from that subjected to Discriminant Analysis (Legendre and Legendre, 1998).

Results

Analysis of results of TWINSPAN classification yielded 8 major landscape types, from North to South: High Sierras; Low Sierras; Peneplains and Piedmonts; Slopes and Hills; Campiñas; Coastal and Pre-coastal Dunes; Sands; Marshes. DCA results for the first two axes reveal that the distance between groups in the ordination space is is lower for groups belonging to the same hierarchical division (except for Campiñas); the greatest distance was that between High Sierras and Dunes. The classification was checked by Discriminant Analysis, which yielded an 80% match with the TWINSPAN estimate.

References

Kent, M. & Coker, M. (1992). Vegetation Description and Analysis. A Practical Approach. CRC Press, Inc., Corporate Blvd., N.W., Boca Raton, Florida.

Legendre, P. & Legendre, L. (1998). Numerical Ecology. Second English Edition Elsevier Science B.V., Amsterdam.

McGarigal, K; Cushman, S & Stafford, S. (2000). Multivariate Statistics for Wildlife and Ecology Research. Springer-Verlag. New York.

Environmental Impact Monitoring Based on Ecological Carrying Capacity

W.C. Su, C.Y. Chang, K.C. Sung

Landscape Architecture Group, Department of Horticulture, National Taiwan University, 138 Keelung Rd. 10673 Taipei, Taiwan.
e-mail: d95628011@ntu.edu.tw

Introduction

Taiwan has faced a critical problem for several decades. Tourists are seriously impacting natural conservation areas, especially by the traffic problem (Reijnen, *et al*., 1995; Forman & Deblinger, 2000). Once the environment is damaged, it can only be regenerated by time, if at all. Some protected areas limit the number of tourists allowed to ensure environmental quality. However, the restriction of quantity is more likely based on facility capacity. In other words, a regular volume of traffic enters these protected areas. In fact, Bowles (1995) has pointed out that each "normal" sound which affects natural ecology is noise. This study aims to measure the current effect on the environment and avoid future damage.

Method and material

This study was carried out in the highland farm of National Taiwan University. We monitored the birds and measured the noise in 12 sites near the highland farm in holiday and non-holiday areas. In order to understand the correlation between noise and bird species, we carried out Spearman Analysis with SPSS 13.0.

Result and discussion

Table 1 shows that when the Lmax increases, the bird volumes near highland farm have a dramatic decrease. It means the effect is not different on all species. Out of the holiday period, it is more significant because the surroundings are very quiet. This result agrees with research showing that recreation activities affect ecology directly (Riffell *et al*., 1996). Therefore, the more recreational activities there are, the more impacts they cause. Limiting the facilities or the social carrying capacity does not work to control the damage. Therefore the buffer zones should be regulated in land use plans to improve ideal habitats for wild birds.

Table 1. The Spearman Analysis between measured noise and bird species indices

		species	volume	diversity	evenness
Lmax(dB)	Spearman	-0.282	**-0.622***	0.301	0.301
	p	0.375	0.031	0.342	0.342
Lmin(dB)	Spearman	-0.211	-0.224	-0.049	-0.049
	p	0.510	0.484	0.880	0.880
Leq(dB)	Spearman	-0.176	-0.049	-0.350	-0.350
	p	0.584	0.880	0.265	0.265

References

Bowles, A. E. (1995) Response of wildlife to noise. *Wildlife and Recreationists: Coexistence through Management and Research*. Island Press, Washington, D.C.

Forman R. T. T. & Deblinger, R. D. (2000) The Ecological Road-effect Zone of a Massachusetts (U.S.A) Suburban Highway. *Conservation Biology* **14**: 36-46.

Reijnen, R., Foppen, R., Braak, C. T. & Thissen, J. (1995) The Effects of Car Traffic on Breeding Bird Populations in Woodland. III. Reduction of Density in Relation to the Proximity of Main Roads. The Journal of Applied Ecology **1**: 187-202.

Riffell, S. K., Gutzwiller, K. J. & Anderson, S.H. (1996) Does Repeated Human Intrusion Cause Cumulative Declines in Avian Richness and Abundance? *Ecological Applications* **2**: 492–505.

Satellite remote sensing for monitoring ecological integrity of Canada's national parks

D. Pouliot[1], I. Olthof[1], R. Fraser*[1], A. Clouston[2], S. Wang[1], W. Chen[1], J. Poitevin[3], D. McLennan[3], J. Kerr[4], M. Sawada[5]

[1]Canada Centre for Remote Sensing, Earth Sciences Sector, Natural Resources Canada, 588 Booth St, Ottawa, ON, Canada K1A 0Y7.
e-mail: Robert.Fraser@NRCan.gc.ca
[2]Noetix Research Inc., on contract with the Canada Centre for Remote Sensing, 588 Booth St, Ottawa, ON, Canada K1A 0Y7
[3]Parks Canada Agency, National Parks Directorate, Ottawa, ON, Canada K1A 0M5
[4]University of Ottawa, Department of Biology, Ottawa, ON, Canada K1N 6N5
[5]University of Ottawa, Department of Geography, Ottawa, ON, Canada K1N 6N5

Canada's national parks system includes 42 parks covering 3% (276,275 sq km) of the country's landmass and representing the full diversity of natural regions. The Panel on the Ecological Integrity of Canada's National Parks concluded in 2000 that the Ecological Integrity (EI) of virtually all of Canada's national parks is threatened from a variety of internal and external stresses. In response, the *Canada National Parks Act* was amended to make EI the 'first priority' in parks management and for reporting the state of Canada's national parks to all Canadians.

Considering the vast and often remote areas under protection, Parks Canada Agency (PCA) considers Earth Observation (EO) technology to be an integral component of a national park EI monitoring program. A multi-agency initiative is underway to develop operational EO based methods that use Landsat class imagery to monitor and report the EI of parks and their greater park ecosystems. This poster describes four types of landscape scale EI measures that correspond to Landscape Pattern, Succession and Retrogression, Net Primary Productivity (NPP), and Focal Species Distributions. The measures and processing methodologies are demonstrated for three pilot study parks (La Mauricie NP, Quebec; St. Lawrence Islands NP, Ontario; and Pacific Rim NP, British Columbia) that represent a range of ecological characteristics, using time series of Landsat TM and ETM+ imagery ranging from 1985-2005.

Landscape pattern analyses are discussed in relation to landscape metric selection, temporal stability, and spatial scaling. Major vegetation disturbances impacting Succession and Retrogression patterns were identified using a hybrid change detection technique that combines vegetation index differencing and constrained spectral signature extension from a baseline land cover product. Ecosystem productivity, as an integrated measure of ecosystem health, was tracked using a remote sensing-based modeling approach known as EALCO (Ecological Assimilation of Land and Climate Observations). Finally, changes in the distribution of focal species were modeled using Genetic Algorithm for Rule Set Production (GARP) with the temporal remote sensing products and field observations of species presences serving as inputs.

Author list