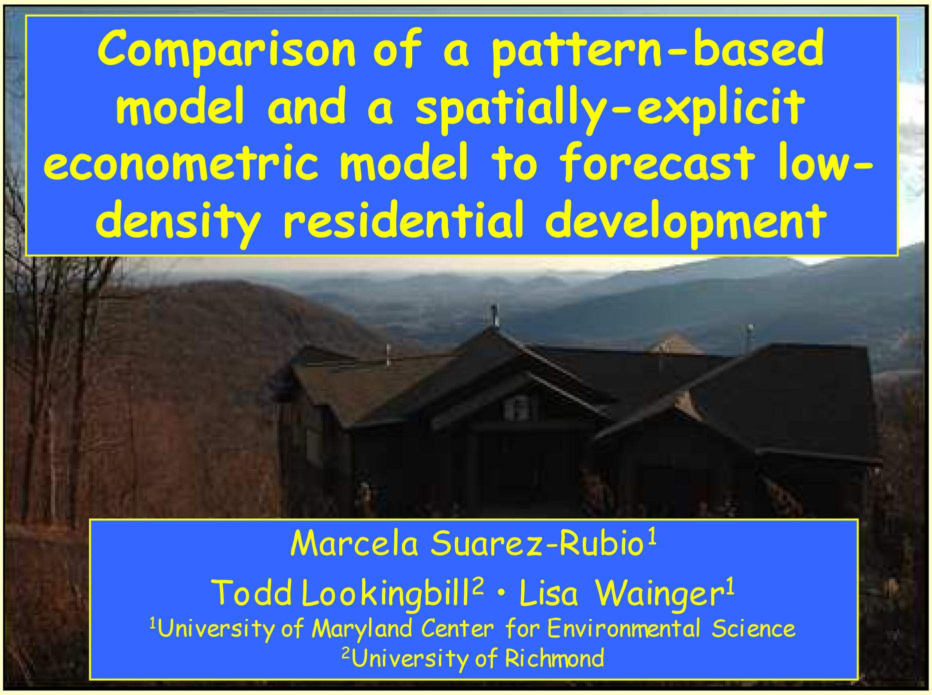

Comparison of a pattern-based model and a spatially-explicit econometric model to forecast low-density residential development

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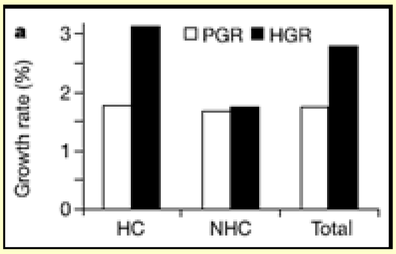
Land-use change

- Land use activities have transformed the planet's land surface

ecotope.org

- Housing development outpaced population growth

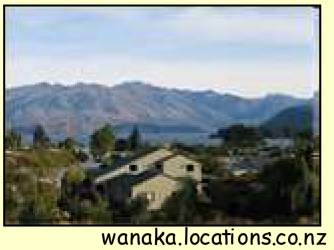
homeaway.com



Liu et al. 2003

Exurban development

- Low-density, scattered housing units
- Further away but within commuting distance to urban centers
- Natural and recreational amenities
- Nearby protected lands



wanaka.locations.co.nz

skyscrapercity.com

Theobald 2005, Hansen et al. 2005, Berube et al. 2006

Why are we concerned about exurbia?

- Biological effects
  - species composition
  - species density and abundance
- Spatial effects
  - fragmentation
  - connectivity and isolation
- Ecological effects
  - disturbance dynamics
  - nutrient cycling

Colorado

sciencepolicy.colorado.edu

Massachusetts

newenglandfutures.org

e.g., Hansen et al. 2005

Why should we model exurban development?

- Recognize spatial and temporal patterns
- Understand causes and consequences of exurban development
- Establish which analytical tools make reliable projections
- Anticipate future exurban growth and its effects

Approaches to predict land-use change

Pattern-based models	**Econometric models**
• Objective: pattern matching	• Objective: profit maximization
• GIS based	• Drivers of land-use change
• Pixel	• Parcel

Irwin and Geoghegan 2001, Jantz et al. 2003, Wainger et al. 2007

Objective

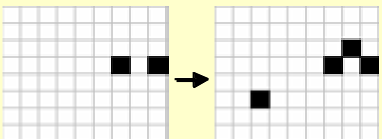
Evaluate a popular pattern-based model (SLEUTH) and a spatially explicit econometric model in predicting exurban development in north-central Virginia and western Maryland, USA

Hypothesis

Understanding exurban growth requires the consideration of individuals' decision-making process

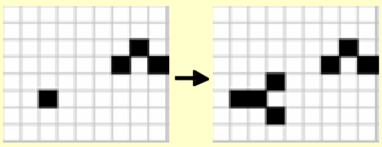
Pattern-based model: SLEUTH

Spontaneous growth



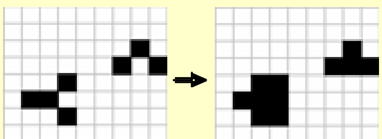
(Diffusion)

New spreading center growth



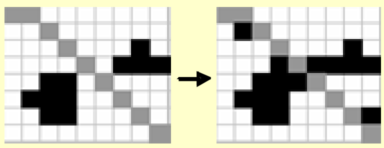
(Spread)

Edge growth



(Breed)

Road influence growth

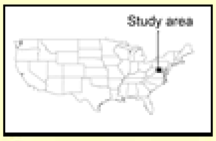


(Road gravity)

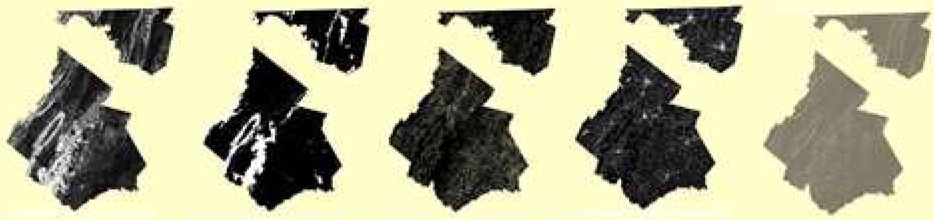
*Slope resistance applied to all growth types

Adapted from Clarke et al. 1997

SLEUTH



- Database development



Slope | Exclusion | Urban extent | Transportation | Hillshade

- Calibration and prediction
  - Diffusion multiplier and best-fit growth coefficients
  - Output: Development probabilities for 2009

Econometric model: Complementary log-log hazard model

- Estimate probability of land conversion as a function of site and location characteristics
- Returns from development – conversion cost ≥ returns from undeveloped land

$$\log[-\log(1-P_{i,t})] = a_t + \beta X_{i,t} + \varepsilon_i$$

$P_{i,t}$ = probability that development occurs
a_t = baseline hazard
$X_{i,t}$ = pixel attributes
β = coefficients
ε = unobserved factors

Iovanna and Vance 2007

Complementary log-log hazard model

- Databased development

Accessibility (4 variables) | Landscape configuration (4 variables) | Environmental amenities (8 variables) | Cost (7 variables) | Socio-economic (4 variables)

- Model estimation
  - Transformed the coefficients to risk ratios
  - Output: map of development pressure between 1986 and 2009

Calibration: SLEUTH

- Diffusion multiplier = 0.035
- Best-fit coefficients
  - diffusion = 100
  - breed = 25
  - spread = 15
  - slope = 100
  - road growth = 50

SLEUTH coefficients are in accordance to the characteristics of exurban development

Complementary log-log hazard model

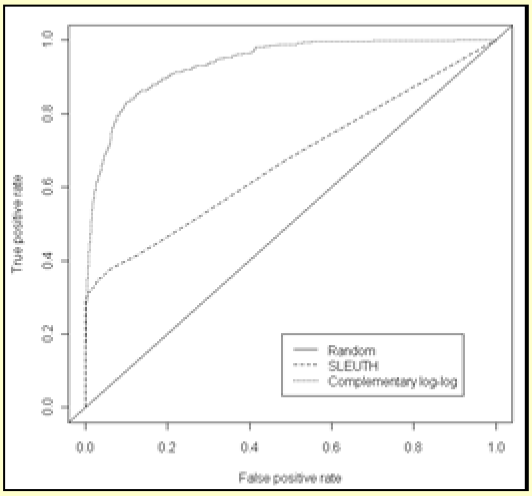
Explanatory variables	Likelihood -ratio X^2	Risk ratio
Fragmentation index (0.15 km)	15.23	1688.93
Percent exurban (0.15 km)	1269.09	13.33
Percent forest (0.15 km)	478.29	5.15
Distance to forest	66.75	-100.00
Distance to water	7.03	-11.55
Percent water (0.15-1 km)	8.61	-6.90
Slope	10.47	2.44

People's preference for certain attributes are important drivers of land conversion

Models' performance

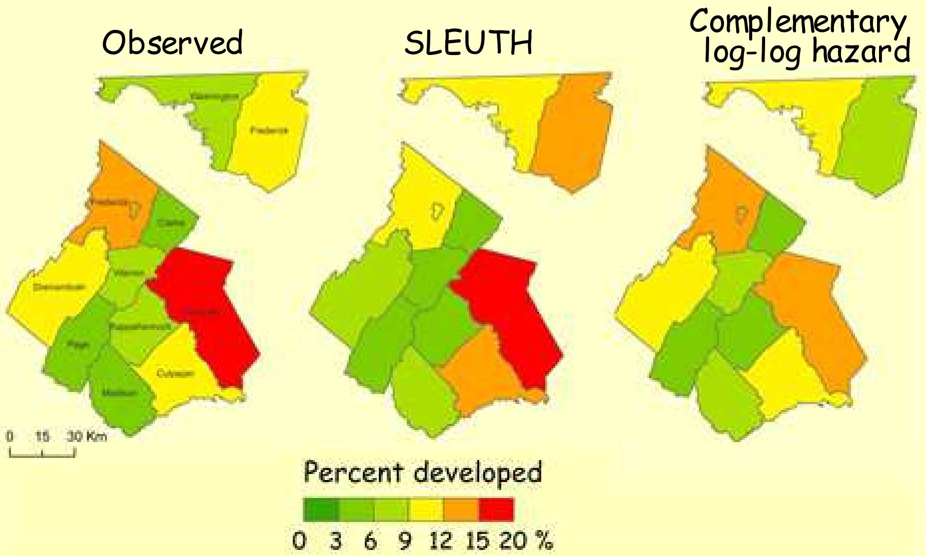
Goodman and Kruskal's gamma
SLEUTH = 0.47
CLLH = 0.90

Area under ROC
SLEUTH = 0.67
CLLH = 0.94



The CLLH model performed significantly better than SLEUTH

Comparison at county scale (2009)

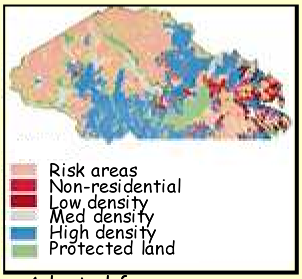


Conclusions

- SLEUTH did not capture appropriately the observed exurban pattern at the local scale but performed better when results were aggregated to the county level
- CLLH model effectively estimated land conversion to exurban development at both local and county scales
- Individuals' decisions play a major role for modeling exurban growth

Implications

- Pattern-based models can serve to forewarn potential coarse-scale losses of natural resources



Adapted from
Bockstael and Irwin 2003

- Econometric models can be used for assessing potential consequences of land-use policy on people's behavior

independencejournal.com

Acknowledgements

- S. Guinn for his assistance with the travel cost layer
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Thank you!
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