MODELING LAND USE CHANGE AND ITS ECOLOGICAL CONSEQUENCES IN THE PHOENIX METROPOLITAN REGION

CAP LTER
Central Arizona-Phoenix
Long-term Ecological Research

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INTRODUCTION

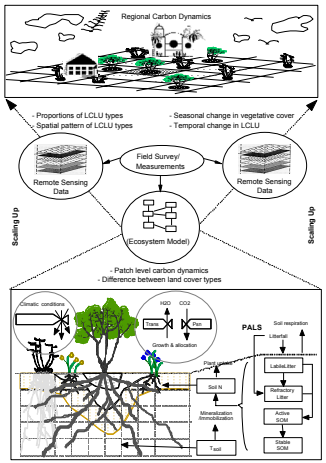
The modeling team has been conducting a series of multiple-scale landscape analyses and developing simulation models to quantify the landscape heterogeneity and its changes in time and space, simulate the pattern and process of urbanization, and link landscape pattern with ecological processes. The research activities of the modeling team include: (1) Landscape Pattern Analysis (urbanization gradient analysis, quantitative analysis of historical land use change, multiple-scale analysis of the current urban landscape, spatial ecological footprint), (2) Land Use and Land Cover Change Modeling (a CA-Markov-GA model, a rule-based urban growth model, a hierarchical land use and land cover change model), (3) Ecosystem Modeling, and (4) Development of the Hierarchical Modeling Platform that facilitates the development of and interface between land use change and ecosystem process models.

RESEARCH QUESTIONS

☐ **How does land use pattern in the Phoenix area change? What are the major factors controlling land use change in this area?**

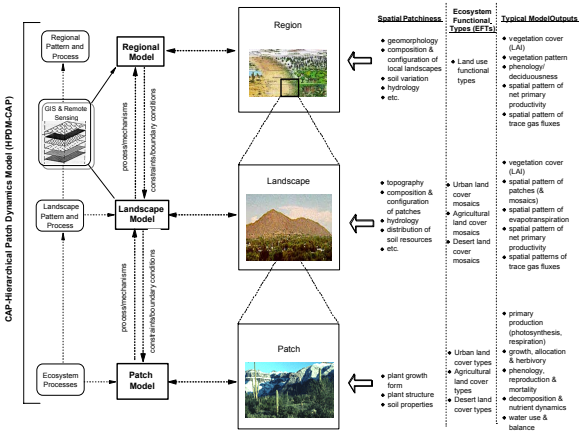
☐ **How does land use change interact with ecological conditions and processes (e.g., biodiversity measures, net primary productivity, biogeochemical cycles)?**

☐ **How do alternative land-use patterns possibly affect ecological conditions and processes, and what are the key factors for achieving ecological sustainability in this region?**



OVERVIEW OF MODELING APPROACH

HPDM-PHX is composed of linked models at different spatial scales. At the local scale, patch models relate patch characteristics to ecological and socioeconomic variables of interest. A family of ecosystem process models will be developed for different land cover types. These models will provide information that is necessary for understanding fine-scale interactions between urbanization and ecology as well as for constructing and parameterizing coarser-scale models. At the landscape level, natural vegetation dominated areas, agricultural fields, and urban areas are modeled with explicit consideration of their spatial variations. At the regional (CAP) scale, the hierarchical patch dynamics model (HPDM-PHX) incorporates land use change, socioeconomic driving factors, and ecological processes at different scales.



ON-GOING RESEARCH AND FUTURE DIRECTIONS

❑ **Refinement and validation of land use and land cover simulators**

❑ **Development and validation of ecosystem process models for different land cover types**

❑ **Coupling the land use and land cover change model with ecosystem process models**

❑ **Coupling urban growth/land use change models with other population and biodiversity models (e.g., metapopulation models, statistical models of biodiversity measures)**

❑ **Coupling urban growth/land use change models with regional climate and air quality models**

RESULTS

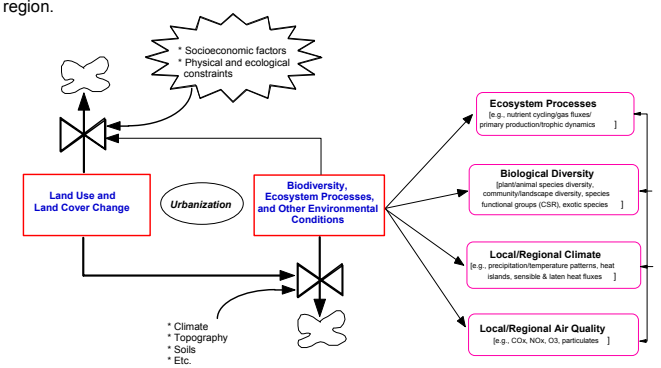
☐ With exponential urban expansion into the desert in the past several decades, the structural complexity and fragmentation of the Phoenix regional landscape have dramatically increased. The extent of urban area is linearly correlated with the population size, suggesting that human population may be, at least at the regional scale, used as a surrogate variable representing a suite of factors that have driven land use changes in the Phoenix metropolitan region in the past several decades.

☐ Areas of higher human impact are usually characterized by a higher degree of fragmentation (smaller patches and greater in number) and more regular patch shape (square or rectangular).

☐ Topography does not seem to have limited the urban expansion in the Phoenix region, meaning that while the city grows out, it also climbs up.

☐ Urbanization gradients in this region can be quantitatively defined using landscape metrics, and extensive spatial analyses suggest the existence of multiple-scale structure of the urban landscape.

☐ In addition, our research on pattern and scale analysis has generated insight into the following questions regarding the issue of pattern and scale: (i) How does changing extent affect the results of different landscape metrics? (ii) How does changing grain size affect the results of different landscape metrics? (iii) How does changing the direction (or orientation) of analysis affect the results of different landscape metrics? (iv) How do the responses of landscape metrics to scale changes resemble or differ from each other across scales and across landscapes, and are these changes predictable? In addition, we have developed and adapted three land use change models, which together provide numerous insights into the pattern and process of urbanization in the Phoenix metropolitan region.



Selected Publications
1. Wu, J. and Y. Qi. 2000. Dealing with scale in landscape analysis: An overview. Geographic Information Sciences 6(1):1-5.
2. Wu, J., D. E. Jelinski, M. Luck and P. T. Tueller. 2000. Multiscale analysis of landscape heterogeneity: Scale variance and pattern metrics. Geographic Information Sciences 6(1):6-19.
3. Zipperer, W. C., J. Wu, R. V. Pouyat, and S. T. A. Pickett. 2000. The application of ecological principles to urban and urbanizing landscapes. Ecological Applications 10(3): 685-688.
4. Wu, J. 1999. Hierarchy and scaling: Extrapolating information along a scaling ladder. Canadian Journal of Remote Sensing 25(4): 367-380.
5. Jenerette, G. D. and J. Wu. Analysis and simulation of land use change in the central Arizona - Phoenix region. Landscape Ecology (accepted)
6. Luck, M. and J. Wu. A Gradient Analysis of the Landscape Pattern of Urbanization in the Phoenix Metropolitan Area of USA. (submitted to Landscape Ecology)
7. Wu, J., J. L. David and D. Jenerette. Linking Land Use Change with Ecosystem Processes: A Hierarchical Patch Dynamics Model. (book chapter)
8. Wu, J. and J. L. David. Developing a hierarchical patch dynamics modeling platform. (Ecological Modelling)