Developing Land Cover Scenarios in Metropolitan and Non-Metropolitan Michigan, USA: A Stochastic Simulation Approach

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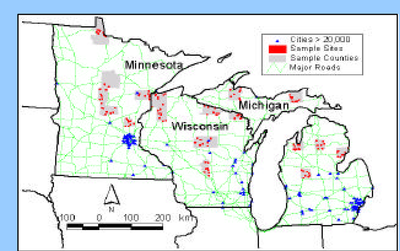
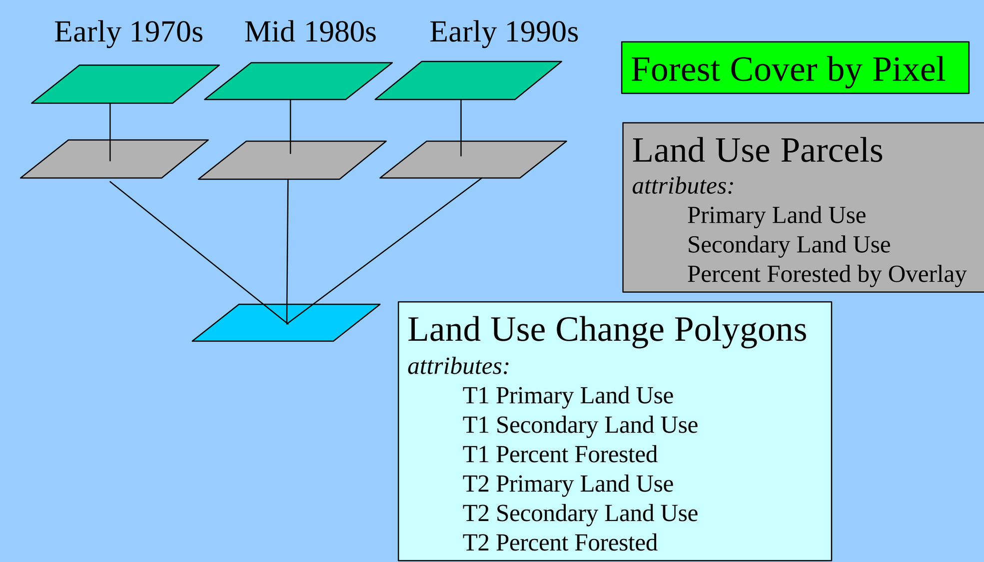
Previous Project

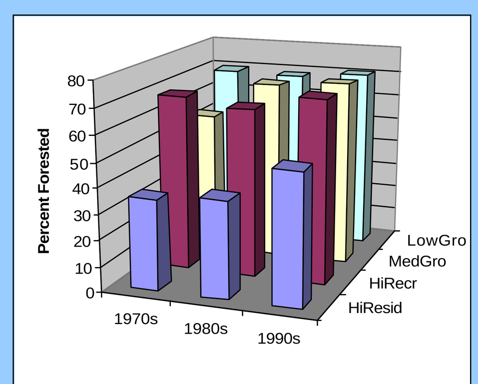
Methodology:

This project focused on the drivers of forest cover change in the Upper Midwest, USA. We compiled data on forest cover change from the North American Landscape Characterization (NALC) data set and data on land use change by interpreting aerial photographs and plat maps for 136 sample sites (2500 ha in size).





Forest Cover Change:



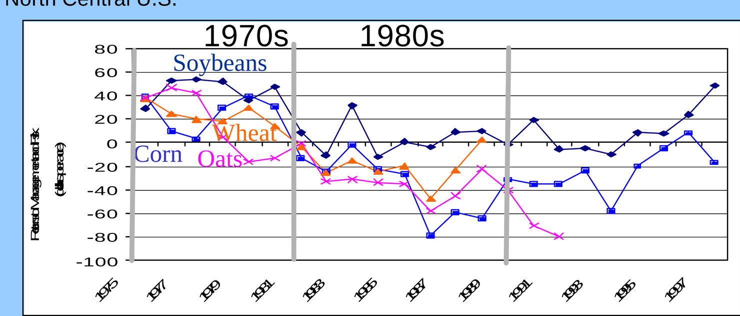
Our analysis of NALC-based forest cover classifications indicates an average of a 7 percent increase in forested area per decade within our sample sites. The most rapid increases were in counties experiencing the highest population growth rates.

Drivers of Land Use Change:

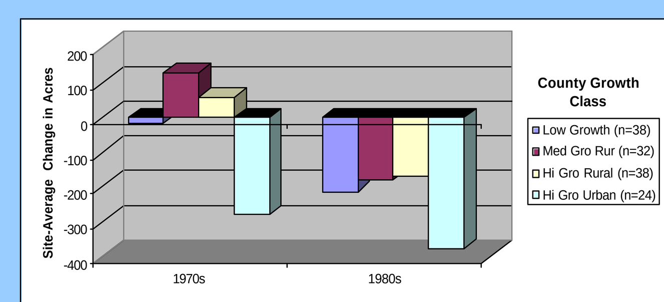
Agricultural conversion, driven largely by changing commodity prices and the marginality of the region, is a particularly important regional scale driver. Substantial development in the region, both residential and recreational, is driven by demographic and economic changes (and aging and wealthier population in the region).

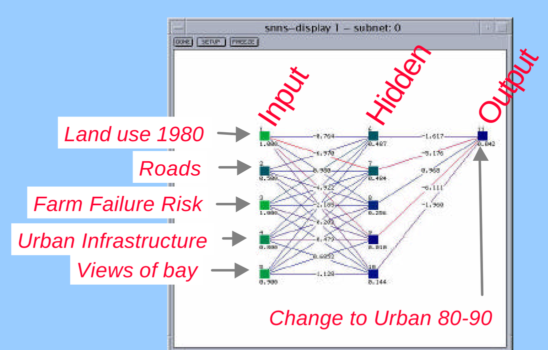
Declining Farm Profits and Ag Abandonment

North Central U.S.



Source: Economic Research Service, USDA

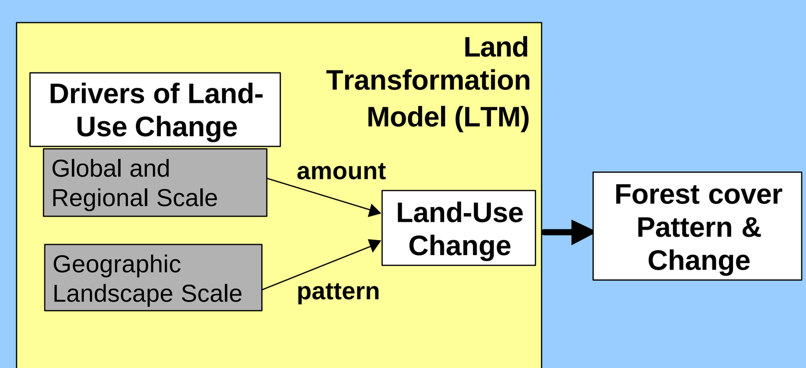


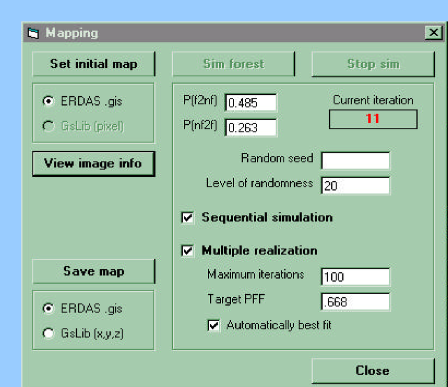


A neural net-based spatial model of land use change was used to evaluate relationships between landscape scale drivers and land use change. The model was applied to a pilot area (Pijanowski et al. In Press).

Linking Land Use and Forest Cover Change:

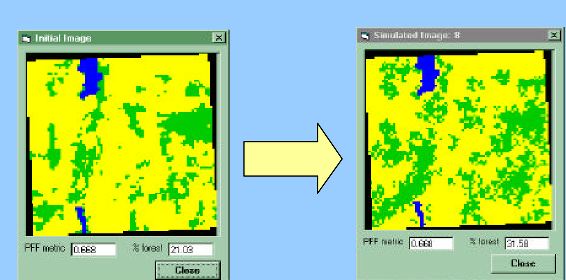
Because land use, and the processes that drive change in land use, and land cover, including forest cover, are linked but different, we use a generalized modeling framework that first models land use change, then develops an explicit link to land cover patterns and changes.





Prob. Of Forest Regrowth	t-statistic [P-value]
Initial Ag Amount	-11.7 [.000]
Initial Amount Developed	-3.72 [.000]
Rate of Development	-1.95 [.053]
Initial Ag Parcel Size	0.79 [.433]
Change in Ag Parcel Size	1.51 [.134]
C	24.56 [.000]
Adj. R^2 = 0.587	

Our empirical analysis, based on our sample sites, shows predictable relationships between land use in a site and transition probabilities among land cover types. The statistical analysis illustrated at left highlights the dependence of forest regrowth rate on both agricultural activity and development. Further analysis identified a time lag between agricultural abondonment and forest regrowth (Brown et al. 2000b).



Determining land cover transition probabilities allowed us to apply stochastic simulation methods to generate future landscape scenarios based on regional and landscape scale drivers of land use and the relationships between land use and land cover.

Referred Publications:

Brown, D.G., Duh, J.D., and Drzyzga, S. 2000a. Estimating error in an analysis of forest fragmentation change using North American Landscape Characterization (NALC) Data. *Remote Sensing of Environment,* 71: 106-117.

Brown, D.G., Pijanowski, B.C., and Duh, J.-D. 2000b. Modeling the Relationships between Land-Use and Land-Cover on Private Lands in the Upper Midwest, USA. *Journal of Environmental Management,* 59: 247-263.

Brown, D.G. and Duh, J.-D. 2001. Reply to Huber. *Journal of Environmental Management*, 62(2): 233-236.

Pijanowski, B.C., Brown, D.G., Shellito, B.A., and Manik, G.A. In Press. Using neural nets and GIS to forecast land use changes: a land transformation model. *Computers, Environment and Urban Systems.*

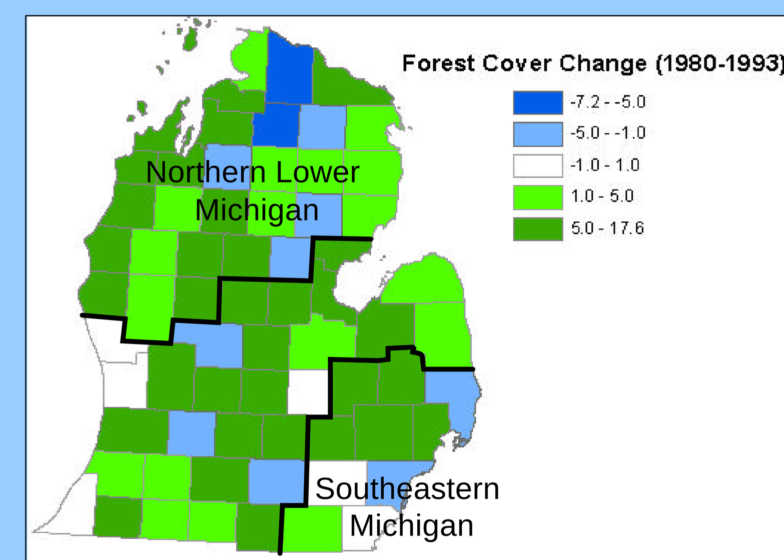
Drzyzga, S.A. and Brown, D.G. In Press. Spatial and Temporal Dynamics of Ownership Parcels and Forest Cover in Three Counties of Northern Lower Michigan USA, ca. 1970 to 1990. In S.J. Walsh and K.A. Crews-Meyer, Eds., *Remote Sensing and GIS Applications for Linking People, Place, and Policy*, Dordrecht: Kluwer.

Current Project

Goals:

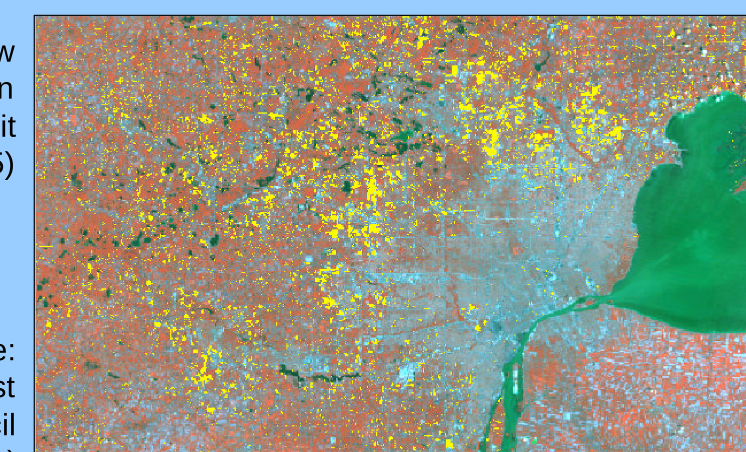
We will develop a stochastic LCLUC modeling approach and apply it to both metropolitan and non-metropolitan counties in Michigan.

We will apply a geostatistical simulation approach to predict land cover in 2010 and 2020 at the pixel level within each of our two regions using a four-stage process that:
(1) generates future land use proportions within each county using demographic and economic projections in an econometric modeling framework;
(2) generates a sub-county map of land use change probabilities for development and agricultural abandonment,
(3) determines the resulting probabilities of changes in tree cover (i.e., regrowth and clearing), conditioned on biophysical site attributes, and
(4) applies stochastic simulation to generate multiple plausible realizations of future tree cover.



According to the USDA Forest Service forest inventory (FIA), forest cover is increasing throughout much of the US. The driving processes, including interactions between development and agricultural abandonment, is likely different in rural areas (like Northern Lower Mich.) than in metropolitan areas (like Southeastern Mich.).

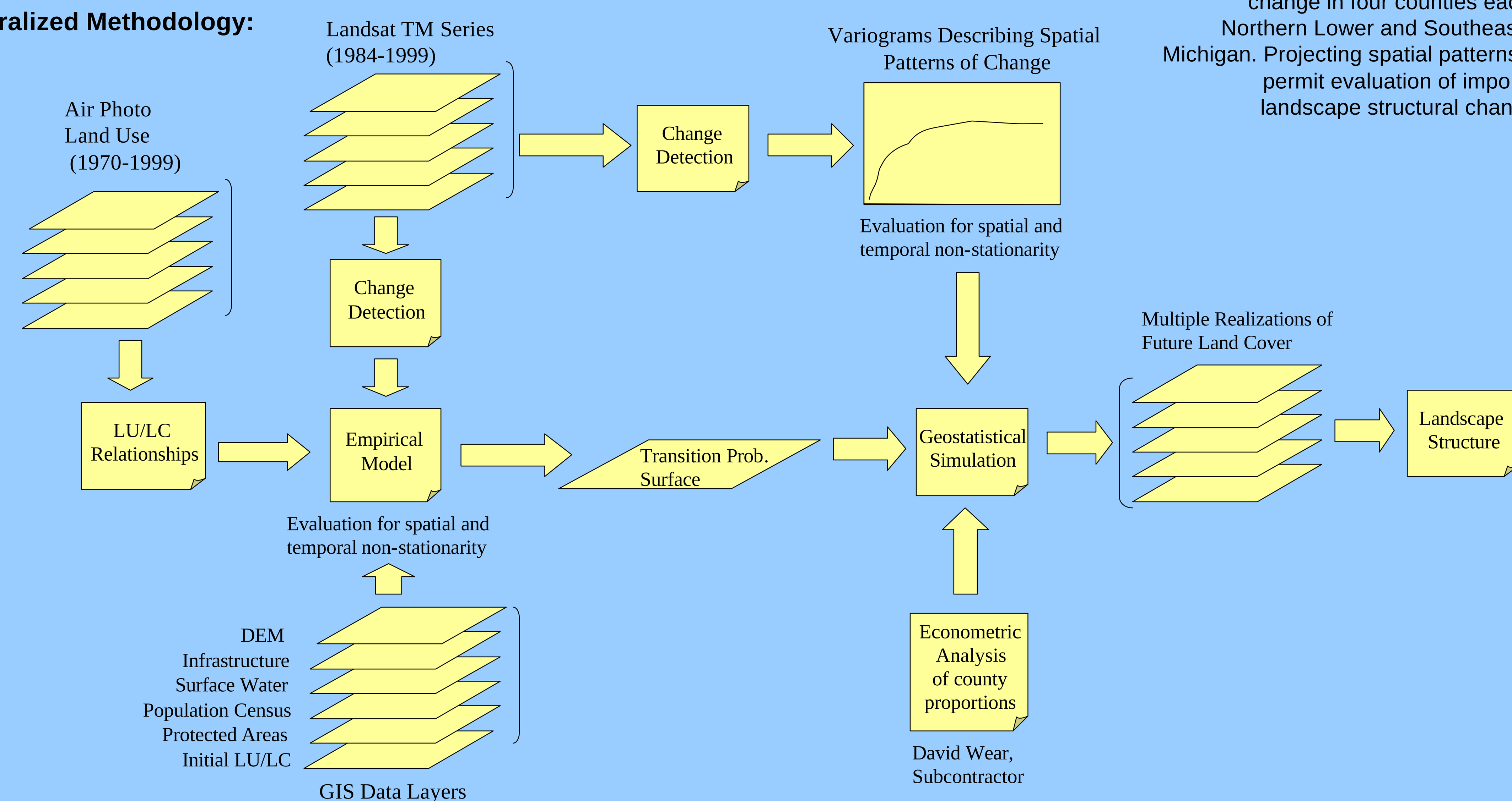
Locations of new development in Metro Detroit (1978-1995)



(Source: Southeast Michigan Council of Governments)

We will develop spatial projections of land cover and pattern based on remote observations of recent change and projected agricultural and development change in four counties each in Northern Lower and Southeastern Michigan. Projecting spatial patterns will permit evaluation of important landscape structural changes.

Generalized Methodology:



Geostatistical simulation permits incorporation of several constraints to produce mapped predictions that reproduce several important characteristics of the data. Our projections will be constrained to reproduce (a) county-wide proportions of land-use types, estimated using econometric projection, (b) spatial patterns of change observed through change detection, and (c) a surface of local transition probabilities that represents the spatial drivers of change. Statistical and geostatistical relationships will be evaluated over-time and between regions to describe potential non-stationarities.

NSF Biocomplexity Project: Spatial Land Use Change and Ecological Effects:

This LCLUC project will be conducted concurrently with a a new NSF-funded Biocomplexity project (Brown, PI) that will develop agent-based models (ABMs) of land use change. Whereas the LCLUC project will produce rich descriptions of the patterns and dynamics of land change, the Biocomplexity project will investigate the specific human decision-making processes that are driving and generating those patterns and dynamics. Predicted dynamics from the agent-based models will be compared against the changes observed, described, and modeled through this project.