Study Plan

ECOLOGIC DRIVERS OF POPULATION AND HOUSING DENSITY CHANGE IN THE NORTH CENTRAL REGION

Study FS-NC-4153 (02-01)

Lead Unit: RWU-NC-4153
North Central Research Station
5985 Highway K
Rhinelander, WI 54501

Eric Gustafson, Lead Scientist (NC-4153)
Robert Potts (NC-4153)
Dan Brown and Kathleen Bergen (University of Michigan)
Volker Radeloff (University of Wisconsin)

RWU-NC-4153 Problem: 1 – The ecological consequences of changes in landscape composition and structure created through resource management and other land uses, natural disturbances and their interactions.

Research issue

Virtually all aspects of the natural and social landscape are characterized by change. These changes are the result of complex interactions between physical, biological and social factors, and are not randomly distributed across a region. The configuration of land use / land cover and the distribution and impacts of people are so interrelated that it is difficult to distinguish between cause and effect (Wear and Bolstad 1998). However, to predict future changes, and to develop policies to guide future change, it is imperative to discover the factors that lead to changes (Gobster et al 2000). This can be accomplished by studying recent changes to identify the factors that appear to be associated with change that has already occurred. This knowledge can be used to develop predictive models that can be tested against changes that are now occurring.

Some changes in land use and development patterns are undoubtedly caused by socio-economic factors (Wear and Bolstad 1998, Ahn et al 2000, Gobster et al 2000). The economic causes (drivers) of change may include increased disposable income levels, tax policies, improved transportation options, and declining economic viability of historic land uses. Social factors leading to land use change may include regional increases in population size, cultural shifts in the norms for housing and lot size, changing demand for recreation and vacation destinations and activities, and changing ownership patterns (Stynes et al 1997). However, this study focuses on the ecologic factors that may contribute to the location of landscape change within the 7 states that comprise the North Central region (Minnesota, Wisconsin, Michigan, Iowa, Missouri, Illinois and Indiana). These factors may include the natural resource amenities that enhance quality of life, the mix of natural and developed elements in the landscape, and the characteristics and spatial arrangement of the natural features found in an area. A study of the interaction of the economic, social and ecologic factors could be developed in the future, where the predictor variables identified in similar studies of economic and social factors will be combined to study interactions and the relative importance of factors.

Natural resource amenities are thought to be an important factor considered by some people when they decide where they will live, or where they will invest in vacation or retirement property (Stewart and Stynes 1994). This appears to be particularly true in the northern and southern portions of the North Central region, where lakes and forests serve as a powerful attractor, providing scenic beauty, abundant recreational opportunities and a clean environment. However, it is not clear to what extent each of these features is driving population and housing density increases, nor if the drivers of change are constant across the region. Furthermore, it is not now possible to predict how changes occurring in the characteristics of these natural amenities may influence the spatial pattern of future landscape change, or how future change might be managed by manipulation of ecological conditions.

Objectives

1. Test the hypothesis that the change in population density, housing density, and the proportion of houses that are not primary residences in a county is related to the ecological conditions found there.
2. Assess the relative importance of various ecological factors for attracting people to live (primary or secondary residence) in an area.
3. Determine if the importance of specific ecological drivers of change varies by ecological Province.
4. Develop models to predict future change in population density, housing density, and 2nd home development for each ecological Province in the NC region.
5. Test the models.
6. Use the models to assess the impact of ecological change (degradation or restoration) on the spatial location of future landscape change.

Methods

The study area will be the 7 states of the North Central region (Minnesota, Wisconsin, Michigan, Iowa, Missouri, Illinois and Indiana). The study area will be stratified by the three Ecological Provinces (Keys et al 1995) of the region. The Laurentian Mixed-Forest Ecological Province covers the northern portions of Minnesota, Wisconsin and Michigan, the Prairie Parkland Province is roughly synonymous with the 'corn belt' region of Iowa, and Illinois, and the Eastern Broadleaf Forest Province covers the remainder of the region. The unit of analysis will be the county (n≈650). We will assign each county to the Province containing the greatest proportion of its area. The counties in the 'bootheel' of Missouri falling primarily in the Lower Mississippi Riverine Forest Province will be excluded from the study.

For each Province, we will test the hypothesis that physiographic, forest (composition and spatial pattern), and forest ownership characteristics can be used to predict changes in population density, housing density, and 2nd home development over a 10-year interval (1980-1990). We will construct multivariate linear models (transforming variables if necessary to straighten non-linear relationships or create variables with a normal distribution), and test for slopes significantly different from zero. The relative proportion of the variability explained by each factor will be used to assess the relative importance of the factors for attracting people to live (primary or secondary residence) in an area. The R-square values of the models will provide an indication of the importance of ecological factors in determining population and housing change, compared to economic, social and other factors not modeled.

Dependent variables, and the data source:

- Percent change in population density (1980-1990, Census data)
- Percent change in housing density (1980-1990, Census data)
- Percent change in density of non-primary residences (1980-1990, Census data)

Potential independent variables, the data source, the rationale for including the variable, and the hypothesis to be tested concerning the variable:

- % of county area in water (static value, LUDA) –[need objective way to include water in counties adjacent to a Great Lake or other, very large lakes)]. People may be attracted to water. Hypothesis: change will be greater as % water increases.
- Density of shoreline (lakes and rivers) (static value, EPA hydrology data?). People may be attracted to water. Hypothesis: change will be greater as density of shoreline increases.
- % of county area in forest, including forested wetlands (in 1980, LUDA or FIA). People may be attracted to forested landscapes. Hypothesis: change will be greater as forested area increases. (There may be an interaction with ownership or reserved status of forested lands, because some heavily forested areas are not available for development.)
- % of county area in wetlands (in 1980, LUDA or National Wetlands Inventory). People may be attracted to areas with open, undeveloped wetlands, or may avoid them because they believe biting insects breed there. Hypothesis: change will be related to % wetlands, but the sign of the relationship is unknown (conduct 2-tailed test).
- ratio of forest to agriculture (area) in county (in 1980, from LUDA). People may be attracted to areas with a certain mix of forested and pastoral land uses. Hypothesis: change will be greater as forest:ag ratio increases.
- GISfrag forest fragmentation index (in 1980, LUDA) [do study to determine effect of grain size on index. Use distance units rather than pixel units.] People may be attracted to large blocks of forest. Hypothesis: change will be greater in less fragmented counties.
- % of county area in sawtimber size class (ca. 1980, FIA). People may be attracted to forests that appear mature. Hypothesis: change will be greater as % of the sawtimber size class increases.
- % of county area in seedling/sapling size class (ca. 1980, FIA). People may avoid areas with a lot of logging. Hypothesis: change will be less as % of the seedling/sapling size class increases.
- average potential productivity of forestland (or ag land) in county (ca. 1980, FIA, STATSGO, NRI soil capability class). Conversion of land use to 'developed' may be related to primary (soil) productivity. Hypothesis: change will be greater on less productive land.
- % of county owned by timber industry (ca. 1980, FIA). People may or may not be attracted to areas likely to remain undeveloped, but with frequent logging activity. Hypothesis: change will be related to the % of county owned by timber companies decreases (conduct 2-tailed test).
- % of county owned by government entities or tribes (ca. 1980, FIA). People may be attracted to areas likely to remain undeveloped. Hypothesis: change will be greater as % of county owned by government entities increases. Caveat: this may be true up to a point. Look for non-linear relationship.

- % of county in reserved status (ca. 1980, FIA, ag data?). People may be attracted to areas likely to remain undeveloped. Hypothesis: change will be greater as % of county in reserved status increases.
- % of land in adjacent counties in reserved status (ca. 1980, FIA, ag data?). People may be attracted to places near areas likely to remain undeveloped. Hypothesis: change will be greater as % of adjacent counties in reserved status increases.
- index of topographic relief (static value, DEM). Standard deviation of elevations within the county calculated from a 1:250,000 DEM. People may prefer landscapes with vistas and varied terrain. Hypothesis: change will be greater as topographic relief increases.
- distance (hours by car) from nearest metropolitan county (as defined by Census?). People may be attracted to areas that are more easily accessible than others. While not an ecological variable, distance is expected to be an important covariate. Hypothesis: change will be greater in counties closer to a metropolitan center.
- existing population density (in 1980, census). Future change may be related to current conditions (which may reflect past change). While not an ecological variable, existing population may be an important covariate. Hypothesis: change will be greater in counties with larger existing populations.

The following landscape pattern metrics are subject to edge effects (created by county boundaries) and scale effects:

- interspersion and juxtaposition index (in 1980, LUDA). People may prefer landscapes with interspersed land uses, or conversely, those with large contiguous blocks of a preferred land use. Hypothesis: change will be greater as the interspersion and juxtaposition index increases.
- contagion might be better – no edge effects, but need common resolution between model-building and testing data sets (in 1980, LUDA) Hypothesis: change will be greater as the contagion index increases.
- edge density of all land cover types (forest, ag, urban, water) (in 1980, LUDA). People may be attracted to the interfaces between land uses and cover types. Hypothesis: change will be greater as edge density decreases.

Landscape pattern metrics will be calculated using Fragstats v3.0 (McGarigal and Marks 1995, McGarigal et al 2002). We will screen related independent variables, and select those most correlated with the dependent variables, that also minimizes collinearity within the model.

The final models for each ecological Province will be compared. We will specifically look for variables that are significant in all Provinces, and for variables for which the sign varies by Province.

Testing the models.

We will test the models by generating predictions of change (between 1990 and 2000) in housing density and density of non-primary residences based on ownership and ecological conditions in

1990-1992 (FIA and TM land cover data). The amount of water, shoreline, and topographic relief are static, and these values will be unchanged from the model development phase. Forest and landscape pattern characteristics ca. 1990 will be derived from existing land cover data derived from TM imagery collected ca. 1992 (NLCD, http://edcwww.cr.usgs.gov/pub/data/landcover/states/ or GAP). Forest characteristics and ownership patterns will be derived from 1990 census data, or ca. 1990 FIA data. We will plot the observed housing density (in 2000, US Census data) against predicted housing density, and test the joint hypotheses that the intercept = 0.0 and the slope = 1.0. Because the data used to estimate independent variables will be derived from sources of different resolution and data structure (model development vs. model testing), some prediction error will result from measurement error of the input values. Tests of model significance will therefore be conservative (i.e., if the models have predictive value even in the face of this error, they can be considered relatively robust).

We will compare the models among Provinces to determine the generality of the relationships. We will look for factors and coefficients that are similar between models, and for those that are dissimilar between models. The R-square values of the models will provide an indication of the importance of ecological factors in determining population and housing change, compared to economic, social and other factors not modeled. These analyses should help us understand how the drivers of change may differ between sub-regions within the study area, and if differences exist, suggest new studies to determine why they differ by region.

Data sources:

Census (US Bureau of Census). Data collected in 1980, 1990 and 2000.

LUDA ca. 1978-1980. Land cover data derived by interpretation of aerial photography. Minimum mapping unit = 10 acres for urban, 40 acres for all others. Classes =1) urban and built-up, 2) agricultural land, 3) forest land, 4) water, 5) wetland, and 6) barren land.

FIA (NCRS Forest Inventory and Analysis). Ca. 1980 data were collected as follows: MN=1977 WI=1983 MI=1980 IL=1985, IN=1967/1986, IA=1974/1990, MO=1976/1989. Ca. 1990 data were collected as follows: MN=1990, WI=1996, MI=1993, MO=1989/1999, IL=1985/1998, IN=1986/1998, IA=1990. We will derive estimates for 1980 and 1990 by interpolating between inventories as necessary. This assumes linear change, which is reasonable given the relatively slow and continuous rates of change in forest characteristics across the region (Tom Schmidt, *personal communication*). Most estimates will require interpolations of less than 5 years from a nominal inventory date. We will investigate FIA models used to project years-year change on plots (Ron McRoberts).

DEM (Digital Elevation Model, USGS). 1:250,000.
http://edcwww.cr.usgs.gov/glis/hyper/guide/1_dgr_dem

EPA hydrologic Units.

Ag land productivity data – To be determined. NRI? USDA SCS? STATSGO? FIA?

Outcomes

This study will determine if ecological conditions serve as a driver of landscape change across the North Central region, providing insight into how people value the natural environment in which they desire to live. The research will also result in a predictive model to assess how current and future ecological changes (restoration or degradation) might affect future population growth patterns. Such knowledge and capabilities could be useful to set policy about protecting the resources that bring people to an area, but that may be jeopardized by the influx of large numbers of new residents.

Timetable

June 2002	Hire technician, begin to assemble required data.
September 2002	Begin hypothesis testing and model development.
February 2003	Begin model testing.
September 2003	Submit manuscripts, initiate other tech transfer.

Safety and Health

Work on this study will be conducted in an office setting. Some travel to meetings will be required. Employees performing office work and travel related to this study will review and follow the attached job hazard analyses for office work and vehicular travel.

Environmental Considerations

This is a research activity consisting of data collection and analysis. Actions are of limited environmental scope and intensity and are therefore categorically excluded from the need for any further documentation in an EIS or EA (FSH 1909.15 ch. 31.1a3).

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Reviewers

John Dwyer (RWU-NC-4902)
Robert Haight (RWU-NC-4803)
Louis Iverson (RWU-NE-4153)