Paper presented at *New Generation Resource Policy for a Region in Transition: Land Use, Agriculture, Environment, and Health in the Great Lakes Region*, Oregon OH, May 12, 2004.

Land-Use and Land-Cover Trends in the Upper Midwest

Daniel G. Brown, School of Natural Resources & Environment, University of Michigan, danbrown@umich.edu

Introduction

This paper identifies broad trends in land-use and land-cover change across the Great Lakes region during the last half of the twentieth century. Before identifying trends it is important to offer clear definitions for *land use* and *land cover*, which can provide guidance about what data are helpful in identifying the trends and what the implications of the trends are.

Land use can be defined as the values that humans obtain from landscapes. What is it that people are actually doing on the landscape? Though remote sensing is often used for mapping land use and land cover over large areas, to actually map land use usually requires some careful human interpretation of the imagery or, better, surveying or interviewing people on the ground to identify their use of land. Land use can change without much visible change in the landscape, though land-use changes often have obvious land-cover effects. Land cover is the biophysical condition of a landscape. It is the sum total of all vegetation, structures, water and other materials that are exposed at the surface. Land cover can be fairly consistently identified with remote sensing. It is possible for land cover to change without changing land use (e.g., as agricultural fields are harvested or clear-cuts regrow to forest).

For this paper data on land use were obtained from Censuses of Population, Housing, and Agriculture and plat maps that identify land ownership. Related economic data were obtained from the Economic Research Service (ERS), USDA. Data on land cover from the Natural Resources Inventory (NRI) of the USDA NRCS, Forest Inventory and Analysis (FIA) of the USDA FS, Satellite images (MSS, AVHRR), and aerial photographs.

The rest of this paper outlines the broad trends that can be observed in the region. These include residential development, agricultural change, and land-cover, especially forest-cover, changes.

Residential Development

A variety of social trends play important roles in driving trends in residential development. In addition to demographic (e.g., an aging population and declining household size) and economic (e.g., increasing wealth) changes, technological developments in communications and transportation infrastructure have influenced residential development patterns. These changes include continued development of transportation infrastructure, including development of interstate highways and improvement of rural roads, and increased use of telecommuting given the importance of information in the economy and the availability of the internet. Policy choices about residential development are mostly available at the local level, e.g., counties, cities, and townships, given the importance of home rule in governing land-use decisions.

In order to understand residential growth, we might be tempted to examine population growth data from the census of population. However, there are some important trends in residential development that might be missed if we focused only on population data. In comparing the dynamics of population with those of housing units (Table 1), we find that during the 1980s and 1990s, the number of housing units grew at a rate 1.5 to 3 times faster than the number of people. This indicates two trends: first is an increase in the number of housing units per household, which reflects the growing number of seasonal homes in the region; second is an decrease in the average household size, which is a phenomenon that has been observed on a global scale (Liu et al. 2003). Comparing these trends with changes in the area of developed land (from the Natural Resources Inventory), we find that the area developed increased about two times faster than the number of housing units. This suggests that new housing units are both taking up more land area, because they and there lots are bigger, but also that there is more infrastructure (i.e., roads, utilities, commercial areas, etc.) per house than previously.

Table 1: Data on change in population, housing units, and area developed, based on Census of Population and Housing, and Natural Resources Inventory.

	1980s	1990s
Change in Population	+ 2.9%	+ 10.5%
Change in # of Housing Units	+ 9.7%	+ 14.2%
Change in Area Developed (1982-1997)	26.7% (10 yr equivalent is 16%)	

An important dimension on which development varies is density. In order to summarize broad trends in development patterns, we examined residential development at three levels of density: *urban* densities are defined as greater than 1 housing unit per acre; *exurban* densities are 1 housing unit per 1 to 40 acres; and rural densities are less than 1 housing unit per 40 acres. Though there are other ways to define these categories, the definitions give us a basis on which to summarize the census of housing for information about trends (Theobald 2001).

With these definitions in mind, we can examine trends in development at multiple densities. Trends in the amount of land developed at urban densities has increased three to four times over the period 1950 to 2000 (Figure 1). These trends are evidence of *urban sprawl* and have affected metropolitan counties much more than non-metropolitan counties.

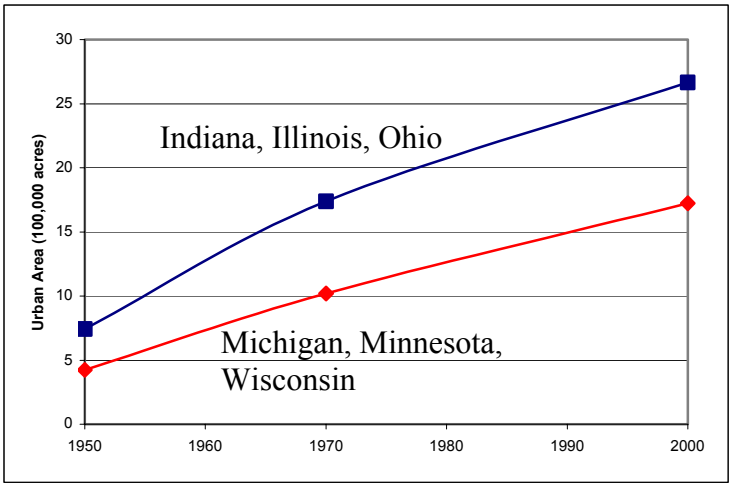

Figure 1. Amount of urban area in northern and southern Great Lakes regions, 1950-2000 (data from Theobald, 2001).

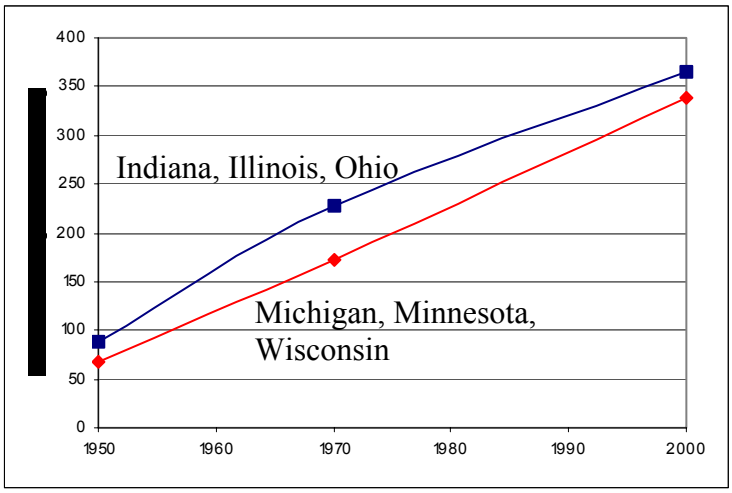

Figure 2. Amount of exurban area in northern and southern Great Lakes regions, 1950-2000 (Data from Theobald, 2001)

In addition to the expansion of areas developed at urban densities, the amount of area settled at exurban densities has increased substantially throughout the region (Figure 2). Though the northern Great Lakes have not urbanized to the same extent, and at the same rate, as the southern Great Lakes, the exurbanization has been more rapid, and in both regions covers a much larger area. This trend is not necessarily associated with outward expansion of existing urban areas, but is associated with the population growth of broad regions of rural areas through the region and nation (Johnson 1999), and might be called *exurban smear*.

An important component of this development in the region is the development of seasonal homes. The Upper Midwest (especially MI, MN, and WI) is one of a handful of regions in the country with a high concentration of seasonal homes. In addition to driving land-use changes and fragmentation of ownership (e.g., parcelization), these changes could have long-term implications for rural communities struggling to provide services. A survey of second-home owners (Stewart 1994) found that ~40% cited possible retirement destination as a reason to purchase their second home.

Other implications of these widespread and increasingly dispersed settlement patterns include: increased commute times, up about 15 % from 1990-2000 in MI, MN and WI (~11% in IL, IN, OH) according to the US census; increased use of septic systems and wells for water and sewage, increased traffic volumes, fragmentation of landscapes by more dispersed development and some surprising land-cover changes (which is addressed later).

Agriculture Change

Change in agriculture in the region has been affected by demographics (including an aging population) and economics with a strong policy influence. Policies affecting agriculture include price supports, subsidies, and trade policy, among others. Given a variety of changes in the national and international contexts within which the region rests, economic returns to investments in various crops have declined over time. Based on data from the USDA Economic Research Service, returns to investment in corn production declined by a factor of three between 1975 and their low point in the late 1980s. Though they have rebounded somewhat since then, the economic equation that drives crop production has generally turned against agriculture in the region. Though there are many dimensions to agriculture, for the purposes of examining land-use change I focus here on area in crops. The total amount of cropland includes harvested cropland, cropland used only for pasture or grazing, cropland on which all crops failed, cropland in cover crops, cropland in cultivated summer fallow, idle cropland and land under conservation reserve or wetland reserve programs (Waisenan and Bliss, 2002).

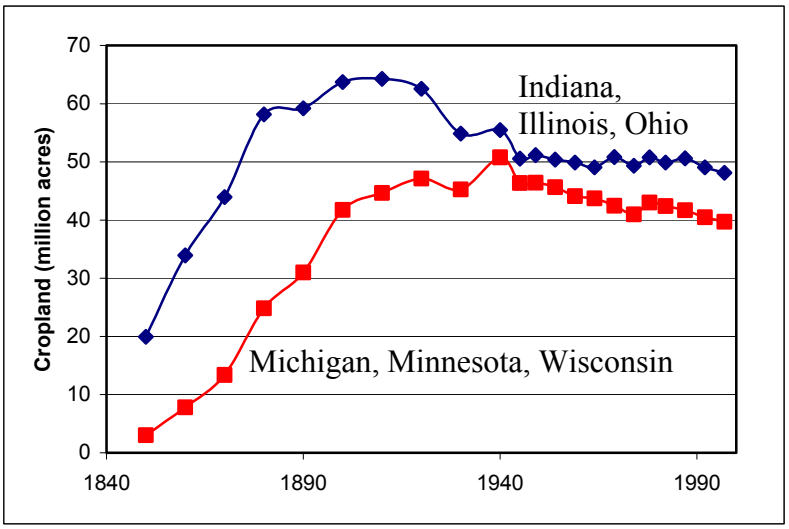

Figure 3. Amount of land in cropland in the northern and southern Great Lakes regions, 1950-1997 (from Waisanen and Bliss, 2002)

After an extensive period of agriculture expansion that ended during the 1920s and 1930s, cropland area has declined. The amount of cropland in the southern Great Lakes region was steady from 1940 to the mid-1980s, but declined after that. The northern Great Lakes, with its shorter growing season and less productive soils has seen declines in all decades since 1940.

Land-Cover Trends

The land-use trends identified, i.e., declining land in agricultural production and increasing dispersion of residential development, have implications for land cover. Though they are not identical, land use and land cover are clearly linked. Land cover includes all physical components of the landscapes; perhaps the easiest to study is forest/tree cover.

Data on trends in forestland can be obtained from the USDA Forest Service Forest Inventory and Analysis (FIA). The definition of forest land used in the inventories was "Land at least 16.7 percent stocked by forest trees…, or formerly having had such tree cover, and not currently developed for nonforest use. The minimum area for classification of forest land is 1 acre, (though) roadside, streamside, and shelterbelt strips (that) have a crown width of at least 120 feet … qualify as forest land." (Leatherberry and Spencer, 1996, p. 21). It is important to recognize that this is largely a land-use definition, any forest or tree cover on land that is also used for other purposes is not included in this definition. Nonetheless, a general trend of increasing forest land can be observed, especially in the southern Great Lakes and in recent decades (Figure 4). Independent analysis of satellite images reveals that the rates of increase are much higher if all areas with greater than 40% tree cover are included (Brown 2003).

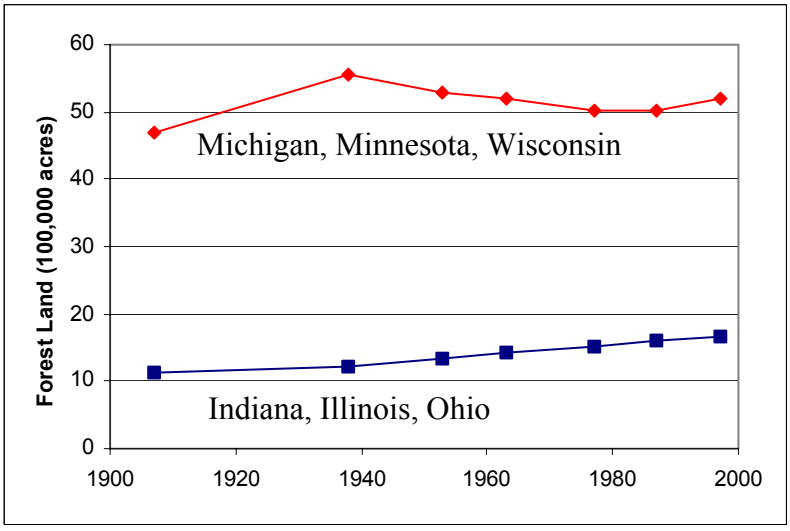

Figure 4. Total amount of forestland in the northern and southern Great Lakes regions, 1907 to 1997 (data from USDA Forest Service FIA)

Relating Land-Use and Forest Cover

In a study to examine the relationship between forest cover and land use on private lands in rural areas of Upper Midwest (northern MI, MN, and WI), remotely sensed data (aerial photos and satellite images) were used to identify land-use by parcel from 1970-1990, and forest cover by pixel (Brown et al., 2000; Brown 2003). A total of 136 sample sites, 3 by 3 miles in size, were selected to represent predominantly private, rural land areas in the Northern forested portions of Michigan, Minnesota, and Wisconsin.

This data set allows us to inquire about the direct linkages between land-use change and land-cover change. For example, it was determined that, of the total amount of agriculture within the study sites, about 2 percent converted to developed during the 1970s and during the 1980s. However, 7 percent (in the 1970s) and about 10 percent (in the 1980s) of agriculture land was converted to undeveloped land, with a large potential of being reforested.

A statistical model relating land use and land-use change variables to the probability of forest regrowth (Brown et al., 2000), revealed that the probability of forest regrowth was greatest in study sites with less initial agriculture and development and less new development over time. The strongest relationship was with the amount of initial agriculture, begging the question why sites with more agriculture had less forest regrowth. A separate statistical model revealed that sites with more agriculture tended to have more prime soils (based on the NRCS STATSGO dataset) and to undergo less conversion to undeveloped uses. This finding indicates that forest regrowth was most frequently observed on sites with more marginal soils, and which, therefore, had less agriculture to begin with. Abandonment of agriculture on marginal lands during the 1970s and 1980s, appears to be an important factor in explaining forest regrowth within the region.

Other results of this study suggest that (a) land-use changes are consistent with regional trends observed in census data, i.e., low-density residential land use increased from 1% to 4% of the area within study sites and agriculture declined from 44% to 39%; (b) average forest cover increased on parcels of all land-use type, but most rapidly on low-density residential parcels (from 37% in 1970 to 53% in 1990), and (d) forest cover was higher on parcels of all land-use types in counties that were most recreationally oriented, as opposed to the agriculturally oriented counties.

The results of the study describes suggest a strong trend toward forest regrowth in the rural forested areas of the Upper Midwest. However, given the strong trend of residential development in the agricultural and metropolitan areas in the southern parts of the region might be expected to result in the opposite trend in forest cover. On the contrary, FIA data suggest increasing forest cover in metropolitan areas like Detroit as well. Preliminary unpublished data on land use and land cover, similar to that described above, for Scio Township, near Ann Arbor MI, indicate a 50 percent increase in tree cover during the period 1960-2000, a period that also saw a more than doubling of the population. Clearly, the conversion of agricultural land is resulting in increased forest/tree cover throughout the region, even in areas with substantial residential development.

Conclusions

The broad conclusions to be drawn from the data presented here are that there are consistent and dominant trends in land-use across the Great Lakes region that include increased and increasingly dispersed development and declining land area in agricultural production. These trends are driven by a complex of demographic, economic, policy and social factors, which, though alluded to, this paper does not address directly. Both trends can be invoked to understand forest- and tree-cover dynamics, mostly increasing in recent decades. One result is an increasing intermixing of people and natural land cover in the region and a possible trend toward the "New Englandization" of the region, i.e., declining parcel sizes, continued decline of agriculture, an increase in dispersed, recreationally driven development.

Acknowledgements

This work was supported by the USDA Forest Service, North Central Research Station, the NASA Land Cover and Land Use Change Program, the National Wildlife Federation, and the National Science Foundation Program on Biocomplexity in the Environment.

References

Brown, D.G. 2003. Land use and forest cover in private parcels in the Upper Midwest USA, 1970-1990. *Landscape Ecology*, 18(8): 777-790.

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

Johnson, K.M. 1999. The Rural Rebound. *PRB Reports on America*. 1(3): 1-20. Washington, DC: Population Reference Bureau.

Leatherberry, E.C. and Spencer, J.S. 1996. *Michigan Forest Statistics, 1993.* Resource Bulletin NC-170. St Paul, MN: USDA Forest Service, North Central Forest Experiment Station.

Liu, J., Dailey, G.C., Ehrlich, P.R., Luck, P.R., 2003. Effects of household dynamics on resource consumption and biodiversity. *Nature*, published online.

Stewart, S. I., 1994. The Seasonal Home Location Decision Process: Toward a Dynamic Model. Ph.D. Dissertation. Department of Parks and Recreation, Michigan State University, East Lansing, MI.

Theobald, D.M. 2001. Land-use dynamics beyond the American urban fringe. *Geographical Review* 91(3): 544-564.

Waisanen, P.J. and Bliss, N.B. 2002. Changes in population and agricultural land in conterminous United States counties, 1790 to 1997. *Global Biogeochemical Cycles*. 16(4): 1137.