PROCEEDINGS

GREAT LAKES
GREAT FORESTS

of the

Society of American Foresters

1998 NATIONAL CONVENTION

Traverse City, Michigan

September 19–23, 1998

Society of American Foresters
5400 Grosvenor Lane
Bethesda, MD 20814-2198
www.safnet.org

SAF Publication SAF 99-01
ISBN 0-939970-77-5

Not Available

LAND PARCELIZATION AND FOREST COVER FRAGMENTATION IN THREE FORESTED COUNTIES IN NORTHERN LOWER MICHIGAN

Scott A. Drzyzga and Daniel G. Brown

ABSTRACT

Many northern Michigan counties have grown in permanent residents and seasonal homes over the past several decades. Forest managers have observed that this influx of new forest owners affects public expectations and the range of socially acceptable forest management options. This shift in settlement and ownership patterns affects the landscape and has important ecological and economic implications. Information regarding landscape and ownership changes is necessary to make management and policy decisions. Changing patterns of land ownership and land parcelization were studied in three adjacent Michigan counties -- Grand Traverse, Kalkaska and Crawford. Historical parcel maps were analyzed for each county at three points in time (approximately 1970, 1980, and 1990). Parcels were digitized into a geographic information system in vector format using five categories: private large parcels, private small parcels, public lands, built-up areas, and water features. Parcelization was calculated as the change in average parcel size between each time period. Average parcel size declined in all three counties while rates of parcelization varied. Forest cover patterns were quantified, for three dates, using classified Landsat MSS data and spatial pattern analysis. This research describes the link between land ownership parcelization and changes in forest cover at multiple spatial scales.

INTRODUCTION

In Michigan, land use planning is a local decision process that is directed by local (city, village, or township) legislation. Under the County Zoning Act (MI PA 183 of 1943) and the Township Zoning Act (MI PA 184 of 1943) township planning boards are given the authority to develop ordinances that provide for the regulation of land use, the protection of natural resources, and the ability to limit the congestion of human populations. Since basic land-use regulation occurs at the township level, townships are important organizational units for ecological planning.

In Michigan's Northern Lower Peninsula (NLP), a large portion of idle or abandoned farm lands are naturally regenerating into young forest conditions. These new forests may become incorporated into proximate forest habitats or may exist as island habitats within a sea of anthropogenic land covers. If these newly forested areas are subjected to development pressures or are overlooked by local forest managers, then the monies spent on conservation efforts may not be efficiently applied. Also, intense development on forested lands may ultimately destroy the natural amenities that now make such lands attractive to new property owners and the region's tourist economy. Participation among township entities is necessary if public, private, and protected forest areas are to coalesce into a biologically meaningful and self-sustaining ecological network.

Forests become fragmented when forested lands are developed for agriculture, logging, or residential settlement purposes. Previously expansive forested landscapes become insular blocks, or fragments, separated by industrial sites, roads, railroads, town sites, and tree harvesting operations (Bell, 1995). Such forest cover changes have been shown to negatively affect timber production (Birch, 1983), wildlife habitat (Hill, 1985), and ecosystem biodiversity (Iida and Nakashizuka, 1995).

At the same time, subdivision of large land parcels under a single ownership into smaller parcels under diverse ownerships in various stages of development or use greatly reduces the effectiveness of coordinated management strategies dealing with wildlife habitat, profitable agriculture, and timber production. In Northern Michigan, "public forest managers have recently observed that the influx of new woodlot owners often inhibits their ability to manage State and Federal Forest timber resources" (Wyckoff, 1995:29) in a manner that satisfies the public policies set forth to utilize and protect said resources. Hence, State and Federal officials are concerned about forested areas in Michigan that are affected by parcel subdivision.

The Michigan Society of Planning Officials (MSPO) has explicitly stated a need for research on "the impact of local, regional, and statewide land fragmentation on natural resources" (Warbach and Norberg, 1995:A-3). This paper summarizes research that has responded to the MSPO's stated need. In order to determine how the influx of new land owners and subsequent parcel changes have manifested as physical landscape changes, in terms of forest cover, we posed three related questions: (1) What were the changes in ownership parcelization within a forested region in Michigan? (2) What were the changes, if any, in forest cover and forest fragmentation within this same region? And (3) Were the relative changes in forest fragmentation related to relative changes in land parcelization?

STUDY AREA

Grand Traverse, Kalkaska, and Crawford Counties were selected as suitable areas for study for several reasons. First, the three counties are representative of an extreme case in Northern Lower Michigan as each has experienced substantial population increases over the last twenty years, although not concurrently. The same three counties are also expected to incur continued population growth through the next twenty years (Wyckoff and Reed, 1995). Table 1 highlights the population growth trends for the three counties, the NLP, and the State. The %CHANGE figures in Table 1 demonstrate that population growth has occurred more rapidly in the NLP than in the state. In turn, the three selected counties have grown more rapidly than all of Northern Lower Michigan.

Table 1 Population.

County	1970	1990	Change	%CHANGE
Region	50929	90030	39101	76.8
Crawford	6482	12260	5778	89.1
Grand Traverse	39175	64273	25098	64.1
Kalkaska	5272	13497	8225	156.0
NL Michigan	383965	538534	154569	40.3
State	8881826	9295287	413461	4.7

Source: US Dept. of Commerce, 1970 and 1990 Census of Housing and Population.

Second, Grand Traverse, Kalkaska, and Crawford Counties contain common topographic, geologic, hydrologic, and forest features found throughout the NLP. Such features can influence forest distributions independently and codependently. Finally, the region contains forested lands that are owned by each of the dominant ownership institutions (federal agency, state and county agency, industry, and non-industrial private (Leatherberry, 1993)) found in Michigan.

PARCEL OWNERSHIP DATA

The general approach we adopted to quantify land ownership parcelization included; converting published parcel plat maps into a digital GIS polygon format, classifying each parcel by ownership type, and using a GIS to aide in calculating average parcel sizes for each of the three counties, minor civil divisions, and nested survey sections. Spatial distributions of average parcel size and annual rates of parcelization were examined with basic statistical summaries.

Instead of the arithmetic mean, the geometric mean was used to calculate the average of parcel areas because the distribution of large parcel areas was positively skewed. The natural log transformation of area values used in the calculation of the geometric mean attempts to normalize the distribution of areal data for further use in common statistical techniques.

The Average Parcel Size (APS) index used, which is similar to the index proposed by Brown and Vasievich (1996), is expressed in the following equation:

$$APS = \left(e^{\left(\left(\rho_{large} \cdot \frac{\Sigma \ln A}{n_{large}}\right) + (\rho_{small} \cdot \ln 2000)\right)} \right) / 10000$$

Where:

ρ_{large} = The proportion of private land area classified as large parcels.

ρ_{small} = The proportion of private land area classified as small tracts.

$\frac{\Sigma \ln A}{n_{large}}$ = The mean of natural log transformed large parcel areas (m^2).

2000 = The assumed size (m^2) of all parcels in small tracts.

10000 = A constant used to convert meter^2 to hectares.

Large values of APS are associated with larger average parcel sizes and, conversely, small values are associated with smaller averages.

FOREST COVER DATA

Forested landscape patterns were measured using classified remotely sensed imagery. Each image, a georeferenced Landsat Multispectral Scanner (MSS) scene distributed as part of the North American Landscape Characterization (NALC) dataset, was classified using a consistent process of unsupervised classification techniques. The three resultant maps, each representing a historical land cover landscape (for the years 1973, 1985, and 1991), were tested for accuracy with several common assessment techniques, including the use of historical aerial photographs as ground truth references. Quantitative measures of historic forest cover and forest fragmentation were calculated for the three counties, each minor civil division, and all survey sections. Spatial patterns of forest fragmentation and annual rates of change were also examined with basic statistical techniques.

A new core fragmentation (CF) index, expressed in condensed terms here, is expressed in the following equation:

$$CF = \frac{CORE_{max} - CORE_{obs}}{CORE_{max}}$$

The CF index can be interpreted as the proportion of potential core area ($CORE_{max}$) that is not core area ($CORE_{max}$ - $CORE_{obs}$) because of shape-induced edge effects. Potential core area is defined as the amount of core area that a circle the same size as the amount of forest cover would have. The index is constrained between zero and one, has a one-to-one relationship with core area fragmentation, and is useable on its own. Calculated CF values approaching a value of one indicate a highly fragmented landscape with all forest areas being influenced by edge effects. Calculated CF values approaching zero indicate an unfragmented forest area with little to no edge effects. Such areas would include the interior areas of very large forest stands.

RESULTS

Between the years 1970 and 1990, calculated average parcel sizes for all counties and minor civil divisions decreased over time with higher rates of parcelization occurring during the 1970's than during the 1980's. Due to space limitations, Figure 1 illustrates only the trend of decreasing parcel sizes for the three counties. Since population growth rates were greater during the 1970's than during the 1980's (US Dept. of Commerce, 1972, 1982, 1992a), this observed trend seems reasonable and justifiable.

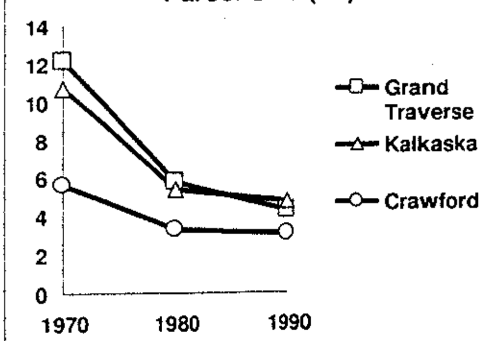


Figure 1
Estimated Average Parcel Size (ha)

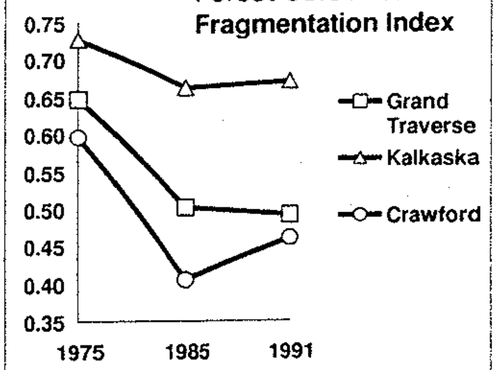


Figure 2
Forest Core Area Fragmentation Index

The results shown in Figure 2 came as somewhat of a surprise. Calculated CF indices indicate that privately owned forests were de-fragmenting during the late 1970's and fragmenting during the late 1980's. In effect, forested areas either increased in extent or forest patches coalesced during a period of rapid population growth and parcel subdivision. Also, forest areas became fragmented during a period of relatively lower population growth and parcel subdivision. A simple interpretation would suggest that land subdivision was associated with forest defragmentation, at least within this particular study area. Since land ownership subdivision has often been cited as a cause of forest degradation, these observed trends appeared counter-intuitive and required additional investigation.

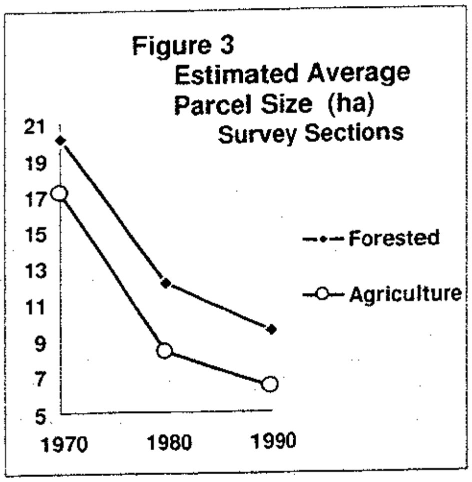
A SECOND LOOK

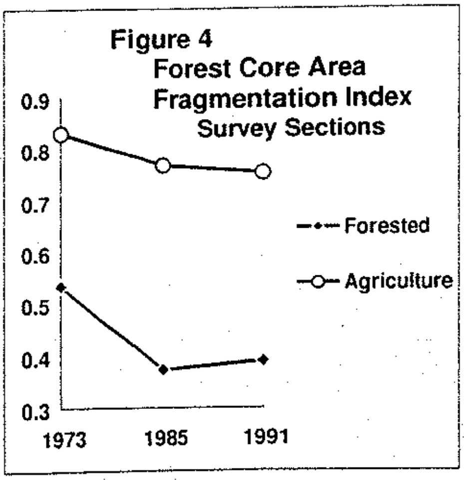
Since the 1970's, Michigan has been experiencing a continuing period of agricultural decline. Many Michigan counties have reported either small farm aggregation into fewer and larger farms or losses in both the number of farms and total acreage farmed (US Department of Commerce, 1992b). Although to a lesser areal extent, decreases in agricultural production have also been reported (US Department of Commerce, 1992b) for the study area. Erickson (1995) demonstrated that urbanization and population growth alone, between the years 1968 and 1988, did not serve to predict forest cover change "as might be expected" (p. 230). Her original hypothesis suggested urbanization and agricultural decline simultaneously effected a net decrease in forested area. Instead, agricultural decline was shown to have a significant inverse relationship with forest cover change. Erickson specified forest succession, which had occurred on marginal farmland as a result of farm consolidation, and the retirement of farmland from production, which occurred during the early stages of residential development, as reasons for the trend she observed. Erickson's results guided the next stage of our analysis.

The digital parcel ownership and forest cover data sets were resampled using Jeffersonian Survey sections as basic units of observation. Survey sections were then classified further according to the calculated percentage of privately owned lands designated as agricultural land. Next, the set of 1678 survey sections was subset into 'non-forested agricultural', 'forested non-agricultural', and 'other' areas. Finally, average APS and CF values were calculated for each set of 'forested non-agricultural' and 'non-forested agricultural' sections, for each time period.

MORE RESULTS

Parcelization test results indicate that agricultural sections exhibited higher rates of parcel subdivision during the 1970's (-0.81 ha/year) than did those sections associated with forests (-0.78 ha/year). However, this trend reversed during the 1980's as forested sections tended to subdivide faster (-0.24 ha/year) than did those survey sections associated with agriculture (-0.19 ha/year). For each decade, calculated rates of change for each subset were determined to be significantly different using matched pairs *t* tests and a 99% confidence interval. Figure 3 illustrates declining parcel size trends for both subsets over the twenty year period while higher rates existed for both during the 1970's than the 1980's.





Forest cover change test results, shown by Figure 4, indicate that those sections associated with agriculture have exhibited signs of forest defragmentation over the entire time period and for both inclusive decades. However, forested areas within the region exhibited significant signs of forest regrowth and coalescence during the 1970's and a dramatic increase in fragmentation during the 1980's. Calculated rates of change for each subset were determined to be significantly different from zero using matched pairs t tests and a 99% confidence interval.

The additional parcelization and fragmentation test results, when interpreted together, can serve to explain the counter-intuitive trends reported above for the county level analysis. Since parcel subdivision was concentrated more heavily in non-forested agricultural areas during the 1970's, those areas that were forested, subsequently, had an opportunity to regenerate and develop into larger and less fragmented forest stands. However, when parcel subdivision became focused on forested lands instead of non-forested agricultural areas, as did happen during the 1980's, forest areas became disturbed by increased pressures, and hence, exhibited signs of increased fragmentation.

CONCLUSIONS

While all the intricacies of landscape change cannot be accounted for in a single study of parcelization and forest fragmentation, enough can be accounted for so that one may achieve a better understanding of the way forests and humans relate to each other. It seems clear that the link between ownership parcelization and forest fragmenttion cannot be correcly understood without accounting for the role of land use. We note here that historic and current variations in regional topology, geology, and hydrology can and do influence forest distributions independently and codependently and need to be incorporated into future research. Also, variations in regional population growth trends, land ownership institutions, ecological determinants, and a few planning ordinances can influence parcel subdivision independently and codependently, as we suspect they do within the study area. However, by organizing landscape research into multiple spatial and temporal scales, proposed linkages between humans and their environments can be better tested and better characterized. Also, as shown is this brief example, landscape changes can be complex. Testing of data at several scales was necessary in order to avoid false or misleading generalizations.

LITERATURE CITED

BELL, P.D. 1995. Forest fragmentation: Adverse effects on old growth forest biodiversity. Pages 45-47 in G. Blovin (Ed). *Forestry on the Hill, Old growth forests.* Canadian Forestry Association.

BIRCH, T.W. 1983. *The forest-land owners of New York.* USDA Forest Service. Resource Bulletin NE-66.

BROWN D.G. and J.M. VASIEVICH. 1996. A study of land ownership fragmentation in the upper Midwest. *Proceedings. GIS/LIS '96 Annual Conference and Exposition.* Denver. 1179-1186.

ERICKSON, D. 1995. Rural land use and land cover change: Implications for local planning in the River Raisin watershed. *Land Use Policy*. 12(3):223-236.

HILL D. 1985. Forest fragmentation and its implications in Central New York. *Forest Ecology and Management*. 12:113-128.

IIDA and NAKASHIZUKA. 1995. Forest fragmentation and its effect on species diversity in sub-urban coppice forests in Japan. *Forest Ecology and Management*. 73:197-210.

LEATHERBERRY, E.C. 1994. *Forest statistics for Michigan's Northern Lower Peninsula Unit, 1993.* Resource Bulletin NC-157. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Experiment Station.

U.S. DEPARTMENT OF COMMERCE. 1972. *1970 Census of Housing and Population.* Washington D.C.: U.S. Government Printing Office.

U.S. DEPARTMENT OF COMMERCE. 1982. *1980 Census of Housing and Population.* Washington D.C.: U.S. Government Printing Office.

U.S. DEPARTMENT OF COMMERCE. 1992a. *1990 Census of Housing and Population.* Washington D.C.: U.S. Government Printing Office.

U.S. DEPARTMENT OF COMMERCE. 1992b. *1990 Census of Agriculture-Michigan.* Washington D.C.: U.S. Government Printing Office.

WARBACH and NORBERG. 1995. *Michigan Society of Planning Officials Trend Future Project: Public Lands and Forestry Trends Working Paper.* Michigan Society of Planning Officials. Rochester, MI. A-3.

WYCKOFF, M.A. 1995. *Michigan Society of Planning Officials Trend Future Project: Final Report.* Michigan Society of Planning Officials. Rochester, MI. 29.

WYCKOFF, M.A. and R. REED. 1995. *Michigan Society of Planning Officials Trend Future Project: Demographic Trends Working Paper.* Michigan Society of Planning Officials. Rochester, MI.

ABOUT THE AUTHORS

Scott A. Drzyzga is a Ph.D. candidate in the Department of Geography at Michigan State University, East Lansing, Michigan. His research specializes in Geographic Information Systems and the legal environment of GIS, land ownership, and natural resource applications. He can be reached via e-mail at *drzyzgas@pilot.msu.edu* and by the World Wide Web at *http://www.msu.edu/user/drzyzgas/index.htm* for more information.

Dr. Daniel G. Brown is Associate Professor of Geography at Michigan State University, East Lansing, Michigan. His research focuses in three broadly defined areas: digital terrain analysis, ecological mapping, and land cover change. For more information about this research and other projects, he may be contacted by e-mail at *brownda@pilot.msu.edu* and via the World Wide Web at the following address: *http://www.msu.edu/user/brownda/index.html.*