

## Integrated Research on Midwestern Landscape Change: A Program Description and Progress Report

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**Abstract:** The USDA Forest Service North Central Research Station has embarked on a new integrated research and development program to identify and understand the development-related aspects of Midwestern landscape change. This paper describes the framework and scope of the Landscape Change Integrated Program and highlights projects begun during the first two years. Partnerships are seen as essential to the success of the program, to help implement studies and to provide answers to pressing questions concerning the Midwestern region and beyond.

### Introduction

Across the seven-state North Central region of the U.S., critical forest landscapes are becoming increasingly fragmented and transformed by development. Sometimes abrupt and sometimes subtle, these changes in the landscape are having unintended consequences on the valued natural character of the region. As a result, people who look to the forests of the region for their livelihood and their leisure are finding the very characteristics and experiences they desire are changing very rapidly or disappearing altogether.

Concerns raised by landscape fragmentation, urban/suburban sprawl, and shoreland residential development usually revolve around reduced quantity or quality of resources, decreased access to these resources, and higher costs for managers and users. These general types of concerns translate into significant management and policy issues for a wide range of stakeholder groups, including:

- **Commodity interests:** reduced timber and mining resources and higher extraction costs; higher levels of conflict with adjacent landowners
- **Environmental interests:** reduced biodiversity; loss of habitat, air, and water quality
- **Community interests:** overcrowding, social and economic differences between new and established residents resulting in potential conflicts
- **Recreational interests:** loss of access to private lands, conflicts between new and established recreational activities, loss of opportunities for solitude
- **Governmental interests:** increased infrastructure costs and community planning challenges

The problems and concerns faced by the North Central region are indicative of changes occurring in other areas across the nation, where communities large and small are grappling for ways to manage growth and protect the critical natural resource base upon which they depend. In the November 1999 General Election alone, voters passed 85% of more than 150 anti-sprawl and open space ballot initiatives and allocated more than \$7 billion in funds for new land acquisition. Local, state, and federal programs aimed at "smart growth" and "livable communities" are gaining visibility and have become a significant priority that has bipartisan support. Fragmentation of long-established forest ownership patterns has become a concern shared by a wide range of stakeholders.

Scientists have begun to study the patterns of landscape change, the forces that drive them, and the effects of landscape change on sustainable forest productivity and other ecosystem functions and values. There is also a growing literature on the relative success of alternative response strategies for guiding change and mitigating its negative consequences. This work forms a solid foundation for addressing problems critical to the North Central region, with its complexity of forest types, landforms, and land use issues. This complexity makes this region in urgent need of improved tools and information that can help decision makers address important questions regarding natural area protection, resource use, and economic growth and development. How fast are forest lands being lost or converted to other uses and where? What are the negative and positive effects of landscape change? How can forest managers and communities help direct growth and development or mitigate their negative consequences? Answers to these and other critical questions are needed so that managers and policy makers can channel their energies and funds where they will be put to best use.

### **Program Description**

The types of concerns described here are being addressed through the Landscape Change Integrated Research and Development Program (LCIP) of the North Central Research Station. Launched in the fall of 1998, this program brings Station scientists from different Research Work Units and scientific disciplines together in interdisciplinary teams to address substantive regional research and development problems. The LCIP is one of three integrated programs recently instituted by the Station, the others focusing on riparian areas and forest productivity.

### **Program goals and issues**

The specific goals of the LCIP are to obtain the scientific knowledge necessary to:

- Characterize landscape changes in the region
- Understand the physical, biological, social, and economic factors and interactions influencing the rate and extent of changes
- Determine the effects of landscape change on people and ecosystems
- Assess the effectiveness of public policies that regulate landscape change

The forests of the North Central Region are diverse and varied, ranging from large, contiguous tracts in the Northwoods; to scattered fence rows, woodlots, slopes, and bottomlands of the central and southern portions of the region; to parks, forest preserves, and private open lands in and around metropolitan areas. Together, these forests provide timber, outdoor recreation, aesthetics, water, wildlife, and other important goods and services at local and regional scales and beyond. With rapid changes in the nature of these forests due to development, intentional changes made for a given purpose often are having unintentional repercussions across the mix of goods and services for which these forests are valued. These aspects of landscape change are becoming increasingly apparent across the North Central region, but are manifesting themselves in different ways for different areas. For example:

- There is increasing concern that large forest parcels in northern Wisconsin, Minnesota, and Michigan that were once principally devoted to timber production are being subdivided into smaller parcels and marketed primarily as recreational property. Little systematic information is available about the rate and extent of this conversion or of its consequences for a host of forest resources and values: How will conversion affect the efficiency of the timber industry to log private lands? To what extent will small-acreage non-industrial private forest owners include timber production among other resource management objectives? How will these changes affect forest management for biodiversity? Recreational access (e.g., hunting)? Solitude and other experiential values of forests?

- Recent state and federal initiatives provide incentives for farmers to plant forest buffers and convert highly erodable and/or frequently flooded agricultural lands to forests or other natural communities. These initiatives also have the potential to produce significant added social, ecological, and economic benefits to rural communities and their residents, but little information is available to help local landowners and public agencies make appropriate decisions. What restoration or reforestation strategies can help optimize habitat for threatened plant and animal species and maintain gene pools for commercially valued tree species? What economic benefits might be realized by managing converted lands for timber? What are the potential effects on recreation and aesthetics?
- Rapid expansion of metropolitan areas in the North Central region threatens the loss of natural areas and the quality of life that people associate with these resources. Protection and restoration of urban forest ecosystems have become important objectives of park and forest managers, but better information is needed to guide decision-making. What acquisition and management strategies will most effectively sustain regional biodiversity? How can ecological restoration be best applied in urban settings to minimize conflicts among competing social values? How can the design and construction of new homes and subdivisions minimize disruption of wildlife habitat and susceptibility of forest areas to pest and disease outbreaks like gypsy moth and oak wilt? At the same time, urban planners and private developers need better guidelines for how urban forests can help make cities more livable places, and how growth can be best guided to protect critical natural resource values. How can urban natural areas be managed to provide safe and enjoyable experiences to a broad spectrum of residents? How can we reclaim urban brownfields to revitalize both the ecological and economic potential of our Rustbelt communities?

While the issues and concerns presented in these examples are varied, a common point underlying them is their multifaceted nature. Like the other cross-cutting programs developed by the Station, these examples attest that issues of landscape change can benefit substantially from an integrated, interdisciplinary approach.

### **A model for understanding landscape change**

The three examples given above capture the regional and locational (i.e., urban/rural/wildland) variability of landscape changes taking place in the North Central region. They also indicate the types of issues and questions inherent in understanding the nature of landscape change. These concerns often present themselves as specific issues of local importance, but attain a higher level of significance when understood within a more general conceptual model that can be applied at a regional or national level. Such a model is shown in Figure 1.

This model presents a sequence of organizing concepts for understanding landscape change, specifies the types of indicators and data or variables needed for their assessment, and suggests the kinds of outputs or products that might be expected from an analysis within each component. The four model components tie directly to the four goals of the LCIP mentioned earlier, and also relate to the categories of research questions that follow this section.

The first component in the model deals with the analysis of landscape character. The aim here is to describe the physical, biological, and social patterns in the landscape at the regional or sub-regional scale—ecological land types, forest cover, land use, population densities, and so forth. Information for this component is useful in understanding the phenomenology of landscape change, and the principals and ideas of landscape ecology are particularly important in this respect. Data sources include Ecological Classification Systems (ECS), Forest Inventory and Analysis (FIA), TIGER Census files, and the like. Time series data are critical for identifying the magnitude and rate of landscape change.

The next component in the model focuses on the drivers or forces of landscape change. Two types of drivers are distinguished here. *Primary drivers* are major social and economic forces of change; these push-pull factors include public policies such as taxing and incentive programs, improvements in technology such as mound septic

systems, infrastructure improvements in transportation and communication, demographic shifts in population, and markets at local-to-global levels. While it is useful to describe and understand these principal forces of change in and of themselves, they take on added utility when they can be related to changes in development patterns affecting forest landscapes. These *secondary drivers* (or primary effects) are observable manifestations of landscape fragmentation, urban/suburban sprawl, and related phenomena and include data that quantify changes in land ownership, land use, parcel size, and housing and road network density.

The third component in the model deals with the effects of landscape change on people and ecosystems. This is the part of landscape change that tends to draw the most attention from policymakers, for it is where the positive and negative impacts are most directly felt. Studies here include descriptive analyses of the impacts of current or proposed landscape changes (e.g., EISs, SIAs) and predictive modeling efforts. Studies and research questions aimed at this level are extremely varied, and range from assessments and predictions of the viability of critical species' populations and estimates of timber supply to the stability of rural economies and the quality of life of urban and rural residents.

The fourth component in the model examines response strategies to enhance or mitigate the effects of landscape change. Work at this level aims to inform managers and decision makers of the likely consequences of alternatives, and includes technology transfer efforts, policy studies, and attitude and behavior surveys. In Figure 1, an arrow from this last model component back to the first component indicates the dynamic nature of landscape change. This implies that response strategies, if successful, can alter the state of affairs toward a more desired landscape character, which in turn can alter conditions throughout the rest of the model.

Although this model portrays the understanding of landscape change as a total process—from pattern recognition to causes and effects to response strategies—it should be emphasized that studies of landscape change need not address all of these components, nor do they need to begin at the first model component before proceeding to other concerns. The model is offered as a tool to organize concepts and studies and to help map where research efforts are being focused as part of the bigger picture.

The last piece of the model includes dimensions that account for variability across the region. While the process described in the model is a generic one, the dimensions indicate that specific questions and issues may vary depending on the places or locations under study. Forest type and degree of urbanization are two important dimensions of variability in the North Central region that will guide research issues and questions regarding landscape change.

### **A Two-Year Progress Report**

The range of research questions that come under the purview of this model is potentially very broad. Thus a major challenge of the program will be to distill from this menu key issues that will best benefit our constituencies and will also help build a focused research program at the Station. Finding this center has been a key activity during the initial year of our program, and a series of workshops with Station scientists and external clients have helped to identify priority projects. In the spring of 2000 we also sent out a mailing soliciting suggestions from some 300 individuals and groups regionally and nationally to extend this needs assessment to a broader sample. In concert with the survey we are conducting literature reviews and Web searches to find out what others are doing or finding important.

Based on these efforts, we have identified three main problem areas of research dealing with patterns and drivers of landscape change, the effects of change on people and ecosystems, and assessing policies and strategies for dealing with change. (These problem areas map directly to our model and program goals, with the first problem combining goal/model components one and two dealing with patterns and drivers.) Within these areas we have

begun a number of projects that bring Station scientists and outside research cooperators together in cross-disciplinary teams (Table 1). The following sections highlight some research efforts we have begun in these three areas to date.

### **Where are the hotspots of change in the North Central region?**

A high priority project that emerged from our workshops was to identify important patterns and drivers of change operating across the North Central region. This broad scale assessment will be useful in detecting where the “hotspots” of change are occurring and where we might want to conduct more detailed, subregional studies in the future. The objectives of the project are to:

- Produce maps showing the spatial distribution of rates of change for a multi-disciplinary set of socioeconomic and natural resource characteristics. The focus will be on changes related to the distribution of people over the landscape and related changes in land cover and selected natural resources in that landscape. Variables to map have been selected based on the usefulness of the information to support further research and to inform policy.
- Study interactions of rates of change among socioeconomic and natural resource characteristics. Potential interactions to study include land development (housing density) and timber supply; seasonal home development and changes in human-held values in those areas; pest outbreaks and timber extraction patterns, changes in land use and bird diversity, road density and tree mortality rates, urban development and ozone pollution.
- Develop methods to quantify the amount and patterns of change and infer the processes (drivers) that produce the patterns. Spatial statistics and neural net analysis methods show promise for this work.

Directed by landscape ecologist Eric Gustafson, the project includes participants from many of North Central’s research work units. A major outside contributor to the effort is the Applied Population Laboratory at the University of Wisconsin-Madison under the direction of Paul Voss. The lab is providing essential data on demographic change in the region, including housing density changes and migration patterns across the region during the last 50 years. This information will also benefit assessments being conducted by the Station’s other integrated programs as well as the Forest Service’s Global Change Research Program, which is funding a portion of this project.

### **Effects of sprawl on metropolitan amenity resources**

We have begun a series of interrelated studies aimed at understanding the impacts of sprawl on people-nature relationships at the urban fringe. Residential development on the fringes of urban areas and in urban-proximate communities can transform landscapes and bring changes in the natural environment, the quality of life, economic development, and government programs. Prospects for these changes raise important policy questions.

Research underway in the metropolitan and rural areas of northeastern Illinois, southern Wisconsin, and southeastern Michigan is examining how new development is impacting the perceived quality of life of new and established residents. Research objectives being addressed through social surveys, in-depth interviews, and discrete choice experiments include:

- Describe the characteristics, recreational use patterns, socioeconomic impacts, and work-commuting patterns of those who live full or part-time in urban-proximate, high-amenity areas.
- Examine the dynamics of residential choice and the role of the natural environment in the decision to build or buy housing at the urban fringe.

- Explore the implications of diverse nature opportunities for residential satisfaction and benefits in fringe areas.
- Understand how developers view their work and its relationship to issues of sustainability and the natural world.

A team of social scientists headed by North Central's John Dwyer and Susan Stewart includes several Station scientists and research cooperators from four universities with expertise in demography, marketing, anthropology, environmental psychology, and sociology. As these projects progress, we will develop a range of information including decision support models and computer simulations to enable urban planners and policy makers to predict how new regulations, incentives, and zoning policies may affect patterns of development, and the impact of these patterns on natural resources on the urban fringe.

### **Assessing the effectiveness of social, ecological, and management response strategies**

Our third problem area will examine different strategies being used to manage landscape change. North Central economists David Bengston and Robert Haight are working with researchers at the University of Minnesota on projects that will provide information in this area at two different scales. At the broad scale, a comprehensive review of the literature is underway to:

- Identify and classify the full range of policy options that have been implemented or proposed for managing forest landscape change at a range of spatial scales.
- Assess the lessons learned from evaluations of the effectiveness and the economic, social, and environmental impacts of these policies.
- Develop an agenda for future research on public policies for managing landscape change.

At a more detailed scale we are beginning to evaluate one primary mechanism for ameliorating the negative effects of landscape change on natural resources—that of natural area land acquisition. In metropolitan areas land acquisition costs can be very high, and land managers face complex and often-competing goals for allocating limited funds. Important goals include protecting critical species and plant communities, linking existing public holdings to extend areas and corridors for wildlife and recreation, acquiring the most acreage possible, and spreading new purchases equitably among constituents. To help policy makers weigh the impact of these alternative goals and visualize how they will influence the future landscape, this research project will:

- Identify the goals of natural area protection at county and regional scales.
- Develop models of natural area selection that are consistent with the alternative goals.
- Use these models to investigate the tradeoffs between alternative natural area selection strategies.

### **Conclusion**

While the studies just described are still a year or more away from completion, in our project and program development thus far we have quickly learned that “integration” in our Integrated Program means more than patching together a collection of disciplinary knowledge. The ultimate success of an integrated program will depend on the meaningful collaboration among multiple disciplines to solve a problem of scientific and/or practical relevance. We are finding that there are different ways to successfully achieve such integration, some better suited to a given problem than others. Common elements, however, often include working together under common issues and hypotheses, and in common locations.

Partnerships are a critical part of this integration, and just as we have begun to see the benefits of pooling resources from our disciplinary work units to implement integrated projects, so too, are we seeing the necessity of pooling talent, ideas, and funding from the many groups outside our Station who have an interest and concern in landscape change. As the Landscape Change Integrated Program progresses we hope to contribute toward the establishment of a network of groups from the public and private sector, including planners, managers, and researchers, to help identify research questions and implement studies. By working together, we can more effectively address the pressing issues affecting landscape change in Midwestern region and beyond. Please contact us with your ideas, suggestions, and willingness to participate!

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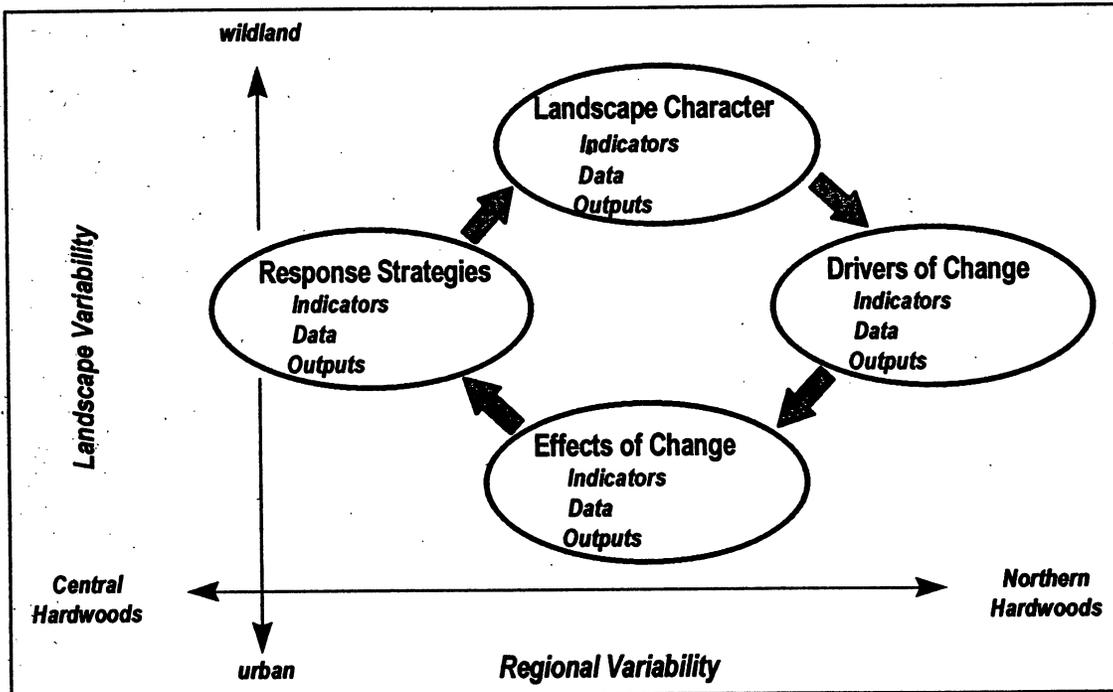


Figure 1. Model for understanding landscape change.

Table 1.

**Landscape Change Integrated Program Research Projects 1999-2000**  
(Cooperating institutions in parentheses)

**Problem Area 1: Patterns and Drivers of Change**

- Demographic Characteristics and Population and Housing Unit Projections in the North Central Region (U of WI)
- Identification of Past and Future Residential Development and Demographic Change Hotspots across the North Central Region (U of WI)
- County-Level Net Migration in the U.S., 1990 to 2000 with Analysis of Age-Specific Migration Selectivity to Recreational and High Amenity Counties (U of WI, Loyola U)
- Aligning Social and Ecological Drivers of Urban Landscape Change: The Calumet Urban Riparian Area (U of MI)
- Landscape Change in the Upper Wabash Watershed (Purdue U)
- Recreation-Amenity Migration in Urban Proximate Areas (Loyola U)
- Landscape Change at Midewin National Tallgrass Prairie (U of IL)

**Problem Area 2: Effects of Change on People and Ecosystems**

- Predicting Impacts of Development on Oaks in Minnesota Peri-Urban Forests (U of MN, MN DNR)
- Nest Predation and Nest Predators of Songbirds along an Urban-Rural Gradient (U of MO)
- Use of Amenity Indicators to Understand Private Landownership Fragmentation in the Lake States' Northwoods
- Landscape Level Analysis Linking Urban Sprawl and Aquatic Ecosystems (U of MI)
- Social Costs & Benefits of Forest Buffers at the Urban Fringe (U of IL)
- Understanding the Dynamics of Residential Choice: The Role of the Natural Environment in Urban Fringe and Older Suburban Areas (U of MI)
- Nature at the Urban Edge: Ecological and Psychological Values (U of MI)
- Perceptions of Development, Sustainability, and Nature: Understanding Real Estate Developers and Regional Growth Coalitions (MI State U)
- The Role of Urban Forests and Greeninfrastructure on Suburban Sprawl and on Housing Choice Decisions (DePaul U)
- Urban Sprawl and a Sense of Self in Place (Northern MI U)
- Tropospheric Ozone Dynamics in the Western Great Lakes Region (Dept. Energy, North Carolina Supercomputing Ctr.)

**Problem Area 3: Assessing Policies and Strategies for Dealing with Change**

- Policies for Managing Forest Landscape Change: An Assessment and an Agenda for Future Research (U of MN)
- Sustaining Natural Resources on Private Land in the Central Hardwood Region (Purdue U, U of TN, and U of MO)
- Exploring Goal Tradeoffs in Metropolitan Natural Area Protection (U of MN)

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**Sustaining Private Forests in the 21<sup>st</sup> Century**

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