Impacts of Landscape Fragmentation in the Central Hardwood Region of the United States[a]

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A comprehensive study of ownership fragmentation and subsequent ecosystem and landscape fragmentation in the Central Hardwood Region of the United States has identified the consequent social and ecological impacts. A consortium of three universities examined the human dimensions and ecological impacts of fragmentation, at the watershed scale, in Indiana, Missouri and Tennessee. Additional aspects of the study addressed in this paper include efforts to build collaborative planning groups and effects on resource values.

INTRODUCTION

Nonindustrial private forest (NIPF) lands comprise nearly half of all forests in the United States, nearly 10 million citizens own 393 million acres, and average ownership size is declining significantly (Birch 1996). A consequence is fragmented landscapes with more individuals owning smaller tracts. A continuation of this trend renders NIPF and other wild-lands (i.e. land not used for conventional agricultural or development purposes) increasingly vulnerable to urban development resulting in environmental degradation (Sampson and DeCoster 1997). Sustaining the value of these lands will require decisions and actions by knowledgeable policy makers, natural resource managers, and individual property owners.

The mission of the consortium and toward which all efforts were focused was to lead owners of nonindustrial private forest (NIPF) lands and other wildlands to initiate management practices that satisfy their personal goals, are acceptable to society and are consistent with sustainable resource management. In achieving this mission, the following purposes were addressed: 1) develop and establish collaborative processes with private landowners and land management agency personnel to sustain ecosystems across the region and 2) provide private landowners science-based information. Partnerships between landowners and professionals were the core premise of the project.

Central Hardwood Region

The consortium focused on the Central Hardwood Region (Figure 1). The vast majority of this area is privately owned and is dominated by temperate deciduous forest with a biologically diverse association of plants and animals. The region spans 18 states, encompasses 340 million acres, and is the principal source of high-value hardwood species in the U.S. (Parker 1993). This area contains numerous small- to medium-sized agricultural operations that include wooded tracts, often in a fragmented pattern. Much of the region has been converted from forest to other land uses over the past 150 years, predominantly to farmland and urban centers (Iverson 1988). Most of the remaining wildlands are privately owned and account for much of the nation's timber production. Increased production pressures on private woodlands have resulted from the shift in demands for wood and fiber from federal lands. The combination of more landowners with less knowledge and increasing pressure to harvest is

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[a] This project was supported by the Initiative for Future Agriculture and Food Systems Grant number 00-52103-9643 from the USDA Cooperative State Research, Education, and Extension Service

Figure 1. Central Hardwood Region.

threatening the sustainability of NIPF lands. Consequently, facilitated networking among the landowners is essential to achieving landscape-level, sustainable natural resource management. Engaging owners in a collaborative process and making use of objective, science-based information to answer technical questions is needed to increase environmental protection, improvement and sustainability across the watersheds.

Target Areas

Several target issue areas were identified to address natural resource sustainability issues in the region - collaborative planning/policy, agroforestry, forest taxes, natural resource values, landscape fragmentation, best management practices, human dimensions, and decision support tools. An additional target area was later added – geographic information systems - because of its importance to decision making from a landscape perspective. (Note: Not all target areas are discussed in this paper due to space limitations.) Even though specific target areas were utilized as the basis for particular research projects, the projects generally were conducted within the context of multi-disciplinary research because of their inherent interdependency. All target areas, with the exception of forest taxes, best management practices and geographic information systems were addressed in each of the respective states. Because of their strength in respective areas, Purdue University took the lead in forest taxation and the University of Missouri took the lead in geographic information systems. In addition, a course on management of privately owned forest ecosystems was included to add an extra dimension of curriculum integration.

Watershed Study Areas

Projects were undertaken at the watershed-level in each of the three states. Due to the geographically diverse nature of the Central Hardwood Region, watersheds were selected by the consortium to span the range of fragmentation level likely to be encountered. The principal criterion for watershed selection was level of fragmentation, both in terms of property ownership and natural resources. A secondary criterion was minimization of the level of public ownership.

The St. Francis and Black River Watersheds in southeast Missouri were chosen because they represent a low degree of fragmentation and minimal urban development; several small sawmills and one chipping facility are located in the Missouri study area. The Upper Black River Watershed (USGS Unit 11010007) includes 1,925 miles2, with a lake area of 4,227 acres. In Indiana, two watersheds were selected to represent a gradient of agriculture – the Wildcat Creek Watershed (USGS Unit 05120107) and the Little Vermillion/Middle Wabash Watershed (USGS Unit 05120108) in the Upper Wabash River Basin. The Wildcat Creek Watershed includes 803 miles2 with 693 acres of lake area and the Little Vermillion/Middle Wabash Watershed includes 2,276 miles2 with 4,279 acres of lake area. In Tennessee, two watersheds were selected – the Emory-Obed Watershed in east-central Tennessee and the Upper Hatchie Watershed in southwest Tennessee. The Emory-Obed Watershed (USGS Unit 06010208) includes 878 miles2 with 3,151 lake acres and the Upper Hatchie Watershed includes 1,138 miles2 and 2,627 acres of lake area.

Missouri Example

With the aid of GIS, the study area (Figure 2) was divided into square cells measuring 23.3 km^2 (3 miles x 3 miles) - a total of 372 cells resulted. Random sampling with rejection was then applied in order to select a sample of 15 cells. Cells were

rejected if: (1) any portion of the cell fell outside of the study area; (2) the cell was less than 70% forested; (3) less than 50% of the cell was in private ownership; or (4) the cell was more than 25% urban. To determine which properties fell within the sample area, ownership boundaries shown on plat maps were digitized in GIS. Ownership of each parcel of land falling partly or entirely within the sample area was then determined through an examination of the property record cards available at the county assessors' offices.

Within each watershed complex, the 9-mile square block (cell) served as the elementary sampling unit with a minimum of 15 blocks (or cells) selected in a stratified random sampling scheme. Stratification was based on the physical variation within the selected watersheds.

Using plat maps and parcel boundaries digitized in GIS, private landowners in each of the 15 cells with at least 40 acres were identified. Their demographic information was obtained through the respective County Assessors Office's and input into an Access database as the base sampling frame.

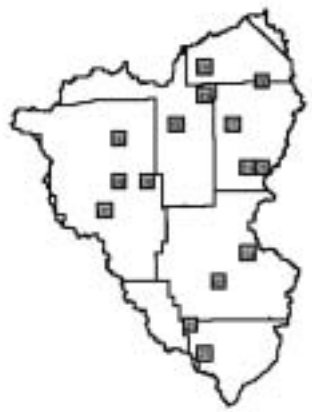

Figure 2. Location of study cells in the Missouri study area.

TARGET AREA RESULTS

Because of the comprehensive nature of the project, results will be reported here for studies conducted in specific states, rather than for the project as a whole. The constraint on length of manuscript prevents a discussion of all target area studies in this document; a copy of the final project report is available from the senior author at KurtzW@missouri.edu.

Resource Values

Many landowners lack information regarding the uses and values associated with natural resources (Munn and Rucker 1994, Hodges and Cubbage 1990, Best and Wayburn 1995), which creates major obstacles to encouraging natural resource management on private lands. This target area was developed to identify a framework for valuing commodity and non-commodity uses of private wildlands and contribute to a decision support model to inform landowners and the public about natural resource values. Specific objectives were: 1) to summarize the current state of knowledge regarding valuation of commodity and non-commodity goods associated with wildlands in the study areas of the three states; 2) to develop a standardized methodology for valuing natural capital associated with wildlands of the identified sampling blocks; and 3) to assist in development of a decision support model to inform landowners, resource managers, and community leaders of the tradeoffs in values associated with alternative management strategies.

The hedonic pricing model (Rosen 1974) was used to quantify various determinants of values associated with the various uses and goods of wildlands (Chicoine 1981, Xu et al. 1993, Elad et al. 1994). In essence, hedonic modeling is a system by which existing variability of a good is attributed to buyers' willingness to pay for certain characteristics of that good.

Missouri - Land sales data were gathered from the respective County Assessors' offices in Wayne and Iron Counties on normal land sales (where the price for the land and improvements appeared to be in line with the historical market) in unincorporated areas for the years 2000 through 2004 on all tracts ≥10 acres. For each land sale recorded during the candidate years, the following data were gathered: legal description, tract size, types of improvements (if any), value of improvements (if any), land class, property type and whether the land was sold to a relative. A multiple linear regression model was

applied with $\log_{10}$ per acre net land value as the dependent variable, and $\log_{10}$ tract size and $\log_{10}$ improvement value as the independent variables; a binary variable for the county of origin also was included. The hedonic regression was developed using all land sales.

Iron County, on the north edge of the study area, is in closest proximity to St. Louis, approximately 50 miles and one hour driving time south of the metropolitan area. Iron County has experienced a slightly declining population from 1980 (11,068) and 1990 (10,726) to 2000 (10,697). This can be attributed to the loss of jobs in the local mining industry. Wayne County, in a more rural setting, is further south, in the center of the study area, and is some 120 miles south of St. Louis, approximately 2 hours driving time. For Wayne County, the nearest urban area is Poplar Bluff (population 16,651), approximately 30 miles south. Wayne County, in contrast to Iron County, has experienced a 17% increase in population during this same period – 1980 (11,338), 1990 (11,540) and 2000 (13,259).

A total of 405 land sales were recorded for the period – 243 in Iron County and 162 in Wayne County. The mean per acre net sales price (less improvements) was $1,566 for Iron County and $866 for Wayne County; mean tract size over the period studied was 128.4 acres in Iron County and 92.6 acres in Wayne County. Over the five-year period, mean net sales price per acre increased from $599 in 2000 to $1734 in 2004 in Iron County and from $476 to $1,218 in Wayne County. Improvements were reported on 43 tracts sold in Wayne County and 62 tracts in Iron County. The mean per acre value of improvements on improved tracts in Wayne County was $8,633, and $8,324 in Iron County. Mean tract size decreased over the period in both counties over the period studied – 78 to 45 acres for Iron County and 90 to 64 acres in Wayne County. However, annual variations due to some relatively large sales would seem to discount any statistical trends.

The above findings support the notion that ownership fragmentation has taken place within the watersheds and that it is continuing to take place in an ever-widening band from the St. Louis metropolitan area. Further, anecdotal information gained from tax records indicates that land speculation, hence fragmentation, began earlier in Iron County than in Wayne County.

Fragmentation/Ecology

Landscape fragmentation is extensive but unevenly distributed in the Central Hardwood Region. High levels of fragmentation can be detrimental to biological diversity and ecosystem processes (Saunders 1991, Noss and Csuti 1997), but little research has addressed the extent to which fragmentation constrains future land-use possibilities and affects attitudes regarding land stewardship. Land-use change, especially with respect to agriculture and forestry, has affected the Central Hardwood Region more severely than any other factor (Sala et al. 2000), and the rapid rate of fragmentation caused by urban sprawl has serious ecological, economic, and social repercussions (Friesen 1998, Swihart and Moore 2004).

The purpose of this target area was to determine, at multiple spatial scales, the degree to which environmental and anthropogenic fragmentation of land influences natural resources and landowner attitudes regarding land-use opportunities. Specific objectives included the development, refinement, and validation of spatially explicit models to forecast the effects of fragmentation on: levels of biological diversity for various vertebrate taxa (Swihart et al. 2006), commodity and non-commodity values associated with natural resources, and societal attitudes regarding land use.

Field sampling included measures of structure and composition of understory and overstory vegetation, ground truthing of existing data layers, and assessment of occurrence or relative abundance for selected species of birds (including neotropical migrants) and mammals (including rodents and bats) using standard techniques. Assessment of several taxa enhances the robustness of models developed to forecast biological diversity in a spatially explicit scale and permits identification of potentially useful indicator species for various types of habitats. Spatially explicit models of habitat suitability, probability of occurrence, and species richness

were constructed as a function of fragmentation measured at multiple scales.

Landscape fragmentation, at differing degrees across the three states included in the study, was found to affect animal and plant populations. In particular, the presence/absence of habitat "mainlands" and riparian corridors significantly affected species occupancy in highly fragmented areas. Bat species presence is affected because of differing structural characteristics of the forested areas, including amount of forest cover, amount of edge and remnant forests along riparian corridors (reviewed by Duchamp et al. 2006a). Small mammal population density and abundance were higher in the forests of Indiana and Tennessee than in the Ozark Highlands, which is the least fragmented. Bird species, similar to bats, were most influenced by forest type. Plant species and communities are restricted to the local-scale, and were largely unaffected by landscape-scale factors.

Indiana - Three related studies were conducted – one studying environmental conditions relating to bat communities, another examining the effects of forest fragmentation on small mammal and songbird diversity, and a third that identified site and landscape factors affecting the distribution of woodland herbaceous species. Selected aspects of these studies are summarized here.

The study area, consisting of the upper Wabash River basin, was deemed an appropriate scale to assess the impact on bat populations because bats historically have experienced local population declines or extinctions while maintaining their overall range (Pierson 1998). The upper Wabash River basin also was considered ideal for studying the effects of habitat loss and fragmentation because it contains landscapes exhibiting a wide range of agricultural intensity, with a corresponding range of conditions for forest loss and fragmentation (Swihart and Slade 2004). It covers over 20,000 km^2 and spans 31 counties. This basin drains >20% of the state, and is predominantly agriculture (88%) and privately owned (96%). Only about 8% of the basin remains in forest. Agriculture consists predominantly of corn and soybean.

Environmental conditions relating to bat communities – The purpose of this part of the study was to identify environmental conditions necessary for a diverse bat community and to develop predictive models for bat species occurrence in a major river basin that demonstrates a gradient of agricultural intensity. Two sets of data were collected: 1) bat species occurrence; 2) environmental measurements collected at three spatial scales: vegetation features at the sample site, habitat patch area, shape and relative configuration, and landscape composition and configuration. These data were then compared using appropriate regression techniques to explore correlations that describe the range of appropriate conditions for the existence of multiple bat species.

This study was conducted between May and August of 2001 – 2004. Echolocation recording and bat mistnet captures began during early May, when bats typically arrive and congregate into maternity colonies, and ended in the beginning of August after maternity colonies began to disperse in preparation for fall migration. Sampling for bats was conducted within 29 3 mile x 3 mile landscapes randomly selected throughout the basin using a stratified design. The sample landscapes encompassed a wide variation of forest habitat amount and degree of fragmentation. Landscape metrics were measured from existing landcover data, digitized from U.S.G.S. Digital Ortho-rectified Quarter Quadrangle images. Classification categories included agriculture, forest, grassland, treed corridors, grassland corridors, roads, urban, and wetlands. Within sample landscapes, the locations of survey sites were assigned using a randomization algorithm stratified by habitat type and habitat patch size.

To establish species distribution throughout the watershed, a species occurrence survey was conducted within sample cells using both bat echolocation recorders and mist nets. Bat echolocation calls were recorded using remotely set ANABAT II bat detectors and CFZCAIMs (Titley Electronics, Ballina, New South Wales, Australia) housed in plastic containers (Duchamp et al. 2006b). Detectors recorded for one night at a site, before being relocated. Recorded calls were identified to species using artificial neural networks based on an established call reference library (Britzke et al. 1999). Two detectors were used at forest sites to measure the probability of

detection (Nichols et al. 2000, Duchamp et al. 2006b).

Bats captured in mist nets were identified as to sex and species and then released. Both survey methods were needed, because captures in mist nets allow 100% identification accuracy but restrict the sampling location to areas suitable for setting nets. Identification using the calls recorded with bat detectors results in slightly lower accuracy in identification (Britzke et al. 1999), but affords much greater flexibility in the location of sampling sites and a vast increase in the number of potential sites that can be sampled. Identified echolocation recordings served as the primary means of locating species. Captures with mist nets supplemented these data and permitted assessment of the reliability of the echolocation call survey.

Collecting environmental measures at three spatial scales allowed two separate analyses: one examining community structure for different landscape configurations, and a series of species-specific spatially-nested habitat suitability models for predicting the probability of occurrence (Mackey and Lindenmayer 2001). To investigate the relationship between landscape composition and bat communities, regression models for species richness and measures of nested community structure were formed using landscape metrics for 27 sampled landscapes throughout the upper Wabash River basin, north-central Indiana, USA. Nested patterns of species occurrence imply a predictable order to species extinction in fragmented landscapes (Atmar and Patterson 1993). These were calculated using the algorithm from the nested temperature calculator (Atmar and Patterson 1993). Candidate models were selected using a best subsets algorithm (SAS v. 9.1) and ranked according to AICc values.

Species richness across different landscapes exhibited a positive relationship to the forest area and two measures of forest edge. Species assemblages exhibited a greater nested structure in landscapes with reduced forest area and increased urban area and urban sprawl. These results support the existence of an increasing relationship between local extinction risk for bats and forest fragmentation that is exacerbated by urban development.

To develop predictive models for individual species, the occurrence patterns of six bat species were compared with variables measured at three spatial scales: site, patch, and landscape. Candidate models were selected using a best subsets variable selection algorithm (SAS v. 9.1). The occupancy model in program MARK was used to simultaneously model the probability of occurrence and also the probability of detecting a species if present (MacKenzie et al. 2002). The most appropriate model for each species was selected based on QAICc rank. Model accuracy was assessed using receiver operating curves (ROC; SPSS v. 12.0). The accuracy of models for all species was substantially improved by including both site and landscape level variables. Basal area per tree and the density of over-story forest canopy and total forest area in a landscape were positively correlated with the presence of most species modeled. Also, urban area in a landscape and measures of urban sprawl were negatively correlated with the presence of most species modeled. The notable exception was the big brown bat, *Eptesicus fuscus*, which was positively affected by urban sprawl. Results suggest that landscape-level attributes in addition to site-specific conditions govern the presence of most bat species in a fragmented landscape.

Effects of forest fragmentation on small mammals - Remaining forest throughout much of Indiana exists in small fragments, with consequences for wildlife that have included regional extirpations of fauna, patch-level alteration of plant and animal communities that may affect local ecological processes, and large-scale disturbances that may be threatening regional persistence of several extant species. This study quantified the effects of habitat and landscape-level metrics on diversity of rodent communities in forest habitats of northern Indiana. Predictive models of species occurrence also were developed as tools for managing land use in maintaining integrity of these animal communities.

Forest rodents were sampled at a total of 525 study sites, spread across 35 landscapes in the basin. Sampling was conducted from May – July in 2001, 2002, 2003. At each sampling point, a grid (usually 5m x 5m, with 15m spacing) of Sherman, Fitch, and Tomahawk live traps was established to

sample for rodents. Each point was trapped for 5 consecutive days. Simultaneous modeling of detection and occupany occurred with and without a spatial autocovariate (Moore and Swihart 2005).

Important predictors of rodent species occurrence varied with species, and included a combination of habitat, patch, and landscape level factors. Eastern chipmunks (*Tamias striatus*) had greater occurrence rates in smaller woodlots with greater understory density. Fox squirrels (*Sciurus niger*) had higher occurrence rates in more isolated fragments. Gray squirrels (*Sciurus carolinensis*) were adversely affected by habitat fragmentation; they occurred only in larger, less isolated forest patches; they were more likely to occur where basal area of nut-bearing trees was greater; and most importantly, they did not occur anywhere beyond 15 km of the Upper Wabash River, the major riparian corridor in the region. Red squirrels (*Tamiasciurus hudsonicus*) occurred more frequently in more isolated patches with reduced basal area of nut-bearing trees. This result is consistent with competition models between red squirrels and gray squirrels. White-footed mice (*Peromyscus leucopus*) were nearly ubiquitous, but showed reduced occurrence rates as a function of a variety of habitat-edge measures when in less forested landscapes (Moore and Swihart 2005).

Forest fragmentation and woodland herbs - This research examined the composition of herbaceous species across woodlands and the factors which determine their distribution across the Upper Wabash basin landscape. Percent cover, estimated along transects within each of 54 woodlands, was combined with data on landscape factors described in prior sections to examine correlations (Lamprecht 2005).

An occurrence index for each species was calculated by weighting relative frequency with the midpoint of estimated percent cover. These indices were then evaluated across the gradients of disturbance, woodland area, and distance to edge of woodland. In general, those species that displayed a significant difference in weighted occurrence between disturbance histories tended to be more important in logged woodlands. None of the species had significantly greater occurrence indexes in recently undisturbed woodlands. Woodland area also was correlated with the weighted occurrence of some of the herbaceous species in this study. Except for dock species and rough bedstraw, all species had higher occurrence indices in woodlands larger than 0-2 hectares.

The presence of species index value (SIV) species groups was examined in relation to woodlands that had been grazed, logged, or had not had any significant recent disturbance. Species usually found in wooded floodplains (SIV 4) and those found in undisturbed upland wooded habitats (SIV 6) had significantly greater presence in woodlands that had been logged than in woodlands with past grazing or no disturbance. Native species richness in logged sites also was greater than in grazed or undisturbed sites. The number of introduced species tended to be smaller in undisturbed woodlands than in disturbed woodlands, although this result was not statistically significant.

The number of woodland floodplain species (SIV 4) increased as the size of the woodland increased from 0-2 ha to 6-14 ha to greater than 14 ha in size. Species adapted to disturbed woodlands (SIV 5) increased in number when the woodland increased in size from 0-2 ha and 6-14 ha to greater than 14 ha. Those species whose realized niche was an undisturbed woodland (SIV 6) increased in number from a woodland area of 0-2 ha to greater than 14 ha.

The distance of a sampled woodland to the nearest urban area was of interest in this research, because urban areas are potential sources of non-native species in woodlands. Surprisingly, the number of species within each SIV group did not change with distance to urban area. The distance to urban area may be important as a wave of invasion begins with a particular introduced species, but time since introduction may mask this effect. Human disturbances radiating from towns began in the 1800s in the upper Wabash River basin.

When fragmented forests are considered, changes in species occurrence due to the proximity to the edge of the fragmented woodland is of great concern. When the average number of species within an SIV level was calculated for an edge category, the species that prefer an undisturbed woodland (SIV 6) significantly increased with an increase in distance from edge. SIV 5 was

relatively even across all distances from edge. These species prefer disturbed woods, and therefore are expected to grow in areas closer to the edge of the woodland. Native species richness increased with distance from the edge, whereas introduced species richness decreased from edge to interior.

Modeling of individual species occurrence in the woodlands of central Indiana was not effective for most herbaceous species (Lamprecht 2005). However, four species yielded acceptable models using the parameters in this study. Enchanter's nightshade was best explained by the perimeter to area ratio of the woodland - as the woodland's perimeter to area ratio decreased, enchanter's nightshade was more likely to be present. The species was less likely to be in a woodland that had been grazed as opposed to one that had been logged or had no recent disturbance. The model predicting the occurrence of false Solomon's seal was best explained by the presence of logging in a woodland. Recently logged woodlands were more likely to contain false Solomon's seal. As the average basal area increased, the likelihood of the occurrence of this species decreased. Similar to the model for false Solomon's seal, logging increased the likelihood of occurrence of wild licorice in a woodland. An increase in the distance to the nearest urban area was positively correlated with occurrence of wild licorice. Woodland area best explained the presence of wood nettle - an increase in the area of a woodland increased the likelihood of wood nettle occurrence. In addition, the absence of recent disturbance reduced the occurrence of wood nettle.

Human Dimensions

This target area used social and behavioral theory and research methods to help guide the interactions with landowners and develop a social database to aid in the development of private landowner resource management opportunity models. These models enabled categorization of landowners, subsequently permitting development of specific strategies for communicating with landowners in terms of process (e.g. collaborative planning) and content (e.g. information and education on resource management).

Private landowner characteristics were found to be somewhat different between the three watersheds, although there was a great deal of overlap between the different types identified and specific interpretations regarding their descriptions. Greater proportions of owners were identified as types that are the more active managers. These owners were most likely to have a management plan and future management intentions. Interestingly, some of these owners viewed forest management as a means of achieving their specific goals for the forest, often amenity values as related to their way of life, rather than timber production.

Tennessee - The research was used to gain a greater understanding of how private landowners experience their land, the meanings they ascribe to their land and to inform the practice of natural resource professionals as they work in partnership with private forest landowners to sustain their forestlands in the Central Hardwood Region. The central question of this research was, "What is the role of meaning and perception in private forestland management for both landowners and resource professionals?" The objectives were: 1) describe how "non-participant" and "actively managing" private forest landowners experience their land and what it means to them, and 2) determine the meaning of "forest management" to private forest landowners and natural resource professionals. A third objective was to identify clusters or typologies along dimensions of landowner receptiveness to talking to other landowners, motivations for owning land, attachment to land, and feelings about the community in which landowners live.

Methods - This research used on quantitative and qualitative methods to investigate the meaning of forestland and forestland management for private forest landowners and natural resource professionals. The level of engagement of private forest landowners with forest management activities was determined via a pre-screening telephone survey. Private forest landowners owning 10 or more acres of forestland based on property tax records (as described in the survey section below) responded to a series of 14 questions regarding their level of forest management and their level of participation in

landowner educational opportunities, assistance programs and groups. An "active" private forest landowner was operationalized as those landowners who had, 1) participated in a landowner educational event, 2) participated in a landowner organization, 3) a written management plan, 4) sought advice or assistance in managing or using forestland OR responded affirmatively to three of the following five activities 1) planted trees, 2) used chemicals, pesticides or fertilizers, 3) had a timber sale, 4) planned to sell timber, 5) planted food plots or vegetation to encourage wildlife.

Qualitative interviews, or more specifically phenomenological interviews, were used to identify salient variables, or descriptive themes, of meaning from first person accounts describing how private forest landowners experience their land. Two sets of interviews were conducted: (1) private forest landowners actively engaged in three or more of several forest management activities and (2) non-participant private forest landowners. Interview and analysis procedures followed those developed by the Center for Applied Phenomenological Research at the University of Tennessee and described in Pollio et al. (1997) and Thomas and Pollio (2002).

Results - Six major themes described the ways in which non-participant private forest landowners experience their land: 1) Connection, 2) Continuity, 3) Power and Awe, 4) Peacefulness and Frustration, 5) Value, 6) Freedom and Control/Constraint. Connection was the central and dominant theme for most participants. No differences in the prevalence or prominence of the other themes were noted. The phenomenological approach revealed that the activities private landowners undertake on their land may in some cases be more similar to natural resource professionals' traditional definition of management related activities than we, or they, may have thought.

Five major themes describe the ways in which active private forest landowners experience their land: 1) Natural/Un-natural, 2) Being With/Part of It, 3) Pleasure, 4) Freedom to Be and to Choose, 5) Continuity. The Natural/Un-natural theme was the central and dominant theme. Active private forest landowners experienced the land and the activities undertaken on it as either natural or un-natural. Natural and good activities were most closely associated with local landowners who did not seek to profit from their land. These landowners live by the "law of the land" in that they eat what they kill, plant what they cut, put back what they disturb, etc. Un-natural and bad activities were most closely associated with outsiders and commercial operations that waste and exploit resources.

Landowner experiences on the land can also be broken down into those that focus on the self, or the person having the experience, and those that focus on the land. Self-focused experiential factors were more prevalent among non-participant private forest landowners. Land-focused experiential factors were more prevalent among active private forest landowners. Self-focused experiences include maintaining connections to times and people no longer present and can provide a landowner with the opportunity to continue to experience a sense of belonging and a sureness in knowing who they are and from whence they come. Such experiences are powerful and fundamental to one's identity, thus they focus on the landowner rather than the land.

Due to the personal engagement of active private forest landowners with the land in terms of tending to it and caring for it, these landowners develop a strong sense of morality in terms of how land should be treated. The land-use decisions of active private forest landowners are therefore influenced more by what they see as the right and wrong way to treat land, and less by how their decisions make them personally feel, thus their experiences are land focused. Through their work with the land, these landowners feel they are part of it in a way that cannot be separated; therefore the land is less of an object and more an extension of self. This feeling seems to be created through the prolonged intimate interaction with the land, through the actual working of and with the land, which may explain why it is absent for landowners who do not engage in these activities and are more likely to live "on" the land than "with" the land.

Collaborative Planning and Policy

Mechanisms and incentives historically have not existed to encourage landowners to consider public

goods and values as they make land-use decisions. The goal of the collaborative planning and policy target area was to provide those decision-making mechanisms and financial or other incentives that are attractive to private landowners and which will result in land-use decisions that benefit public interests. Such public interests are comprehensive in nature and involve both long-term and landscape-level factors and consequences.

Indiana - Although there is a growing body of literature examining collaboration as a new natural resources management and governance paradigm (e.g. Baker and Kusel 2003, Brunner et al. 2002, Colfer 2005, Cortner and Moote 1999, Koontz et al. 2004), there are few studies that specifically examine the inclusion of private landowners (Bergmann and Bliss 2004, Rickenbach and Reed 2002) and fewer still that examine collaborative stewardship in landscapes dominated by private ownership (Belin et al. 2005, Broussard and Schaaf 2004, Muth 2004, Rickenbach et al. 1998). Using a qualitative approach, framed as two comparative case studies, the focus was on (1) interviewing private landowners about their attitudes towards collaboration and related concepts of place and community, and (2) describing and analyzing the process and outcomes of two year-long efforts to initiate and facilitate collaborative management among private landowners.

This research project explored the potential for collaborative natural resource management among private landowners, and was driven by the major research question: how can collaborative natural resources management on private lands be initiated, sustained, and evaluated? More specifically, the project 1) investigated how landowners relate to place, community, and processes that may influence collaborative natural resources management, 2) examined landowners' attitudes towards working collectively, and 3) explored the process and outcomes of efforts in collaborative stewardship on private lands. This research was undertaken using a comparative case study design, as one case study was conducted in two counties in north-central Indiana.

Preparatory phase - The preparatory phase consisted of ten key informant interviews with natural resources agency personnel that were conducted in the winter of 2002 for the purposes of: 1) gaining familiarity with and access to the field prior to commencement of subsequent phases, 2) shaping study site selection, and 3) aiding interview guide development. These key informants also provided landowner contacts who generally were individuals enrolled in government programs and/or active in conservation issues throughout the county. Referrals, who were designated as stakeholders in the sample, were sought to: 1) augment the sample in the phase 1 interviewing, 2) create a list of individuals who may be interested in participation in phase 2 community forums, and 3) garner contacts for individuals who had conservation practices on the land.

In phase 1 (2002 – 2003), semi-structured interviews (n = 81 taped and transcribed interviews) were conducted with private landowners in the study counties, which revealed landowners' sentiments on land ownership, relationships with place and community, and attitudes towards collaboration. In one county, 43 interviews were conducted (for an overall participation rate of 51.7%); in the other county, 38 interviews were conducted (for an overall participation rate of 44.2%).

During phase 2, a year-long series of Natural Resources Community Forums (2004 – 2005) were conducted, which provided the opportunity for landowners to work collaboratively to address natural resources issues. Participant observation, reflective journaling, and focus groups comprised the data collection techniques used in these Forums. Beginning in April 2004, monthly Natural Resources Community Forums were held in a public venue in each of the study sites. In total, there were 10 forums (9 open meetings and 1 focus group) held in one county and 11 forums (10 open meetings and 1 focus group) held in the other county, including the focus group in each case. In each case, 7 members of the core group (individuals who had participated in 2 or more previous forums) took part in the focus group. The focus groups were digitally-taped and transcribed.

Framework and analysis - Theories of collaboration, social capital, sense of community/community attachment, and sense of

place formed the analytical framework. Grounded theory (Strauss and Corbin 1998) procedures structured the analyses, which were performed for each case and then assessed comparatively. Atlas-ti, Version 4.1, was used to aid in analysis of all qualitative data.

Sense of place - Broadly stated, sense of place explains how people come to know and experience a place. During phase 1 of the two qualitative case studies, conducted with semi-structured interviews and participant observation, sense of place was explored for landowners in the two selected north-central Indiana counties. Interviewees described place in terms of the physical, the social, and as home. The two most prominent expressions of meaning were connections and the provision of lifestyle through place. Five major components of sense of place were established in both case studies, including ownership, knowledge, experience, identity, and attachment. In terms of implications for collaboration, ownership may serve as a "membership" attribute to begin the creation of a community of landowners (membership in the community granted through ownership) in specific local places. The question is - if identification with a place, in addition to identification as a landowner, can transcend entrenched perceptions of differences among landowners in a place (e.g. traditional rural residents v. newer rural residents)? For many individuals, the meaning of a place was created because of connections to others and because of the ability of a place to provide for a desired lifestyle. These commonalities with landowners could be used to foster collaborative relations.

Sense of community - Initiating and sustaining collaborative natural resources management efforts are partially contingent upon the community context in which these efforts occur. Understanding how people describe community, acquire membership and sense of belonging in community, cultivate attachment to community, and participate in community can contribute to improved collaborative or community-based natural resources management. Phase 1 data from participant observation and semi-structured interviews in the comparative qualitative case studies revealed that landowners in north-central Indiana described their communities in numerous ways, generally attributed positive evaluations to rural features of community, and relied on the church as a community involvement mechanism. Membership and sense of belonging in community were not dependent on community involvement, but individuals in both cases who were not originally from the area often noted an increased feeling of being a an outsider. Rural reciprocity emerged as a theme in both cases, indicative of expectations that rural landowners will help each other in times of need. Similarities, rather than differences, characterized the findings from these comparative case studies. The findings from these case studies indicate that relationships between individuals in a community are largely predicated on identities in a community, and in particular their identity as it relates to tenure and farming in an area. These identities are largely driven by membership in a certain group of individuals. In many of these interviews, heritage and history in a place equate to legitimacy as a "real" community member - an insider rather than an outsider. Thus, there are implications for the perceived legitimacy of diverse stakeholders that place-based collaboration demands.

Collaboration among private landowners - Comparative case studies of "natural resources community forums," shed light on collaboration in landscapes dominated by private ownership and demonstrate that participants realized several beneficial social outcomes from a year of participation in the community forums. The prevalence and prominence of positive attitudes towards working collectively were uncovered during phase 1 interviews with landowners, yet these did not translate into behavioral outcomes, as less than 20% of invitees in each case participated in forums designed to embody collaboration. In each case, the forums assumed different trajectories, due largely to attributes, interests, and commitment of participants. Both sets of forums attracted a core set of participants, who reported positive experiences in these process and outcomes of expanded networks. Social capital and sense of place were also key elements of the process and outcomes of the series of forums in each study site. Participants were generally positive about outcomes in the Forums, though many participants in the one of the forums lamented the group's inability to take more tangible actions.

In both cases, participants discussed experiences in the forums that they enjoyed (e.g. making connections, learning) and found frustrating (e.g. lack of participation from broader community, difficulty finding a galvanizing issue). Key findings, generated from participant observation and focus groups, include the importance of encouraging broad community-wide participation, fostering emergent local leadership, spending time to become "group literate," and recognizing the time-intensive nature of collaborative efforts. Recommendations for initiation and facilitation of private landowner collaboration include the importance of promoting group literacy, encouraging emergent leadership, and balancing structure and openness of the process.

SUMMARY AND FINDINGS

Ownership fragmentation and subsequent landscape fragmentation on private lands within the Central Hardwood Region is increasing due to exurbanization as city dwellers seek a different way of life away for the urban environment. Resource values studies found that large parcels were becoming increasingly divided through land sales, with factors such as proximity to a city or town, ease of access and natural amenities having positive effects on land values.

Landscape fragmentation, at differing degrees across the three watersheds included in the study, affected animal and plant populations. In particular, the presence/absence of habitat "mainlands" and riparian corridors were found to have significant affects on maintaining species persistence in highly fragmented areas. Bat species presence was affected because of differing structural characteristics of the forested areas, including amount of forest cover, amount of edge and remnant forests along riparian corridors. Small mammal population density was greater in the forests of Indiana and Tennessee than in the Ozark Highlands, which is the least fragmented. Bird species, similar to bats, were most influenced by forest type. Plant species and communities were restricted to the local-scale, and were largely unaffected by landscape-scale factors.

Private resource owner characteristics were somewhat different between the three watersheds, although there was a great deal of overlap between the different types identified and specific interpretations regarding their descriptions. Greater proportions of owners were identified as types that are the more active managers. These owners are the most likely to have a management plan and future management intentions. Interestingly, some of these owners viewed forest management as a means of achieving their specific goals for the forest, often amenity values as related to their way of life, rather than timber production. Collaboration among landowners may serve as a means to move towards landscape-level decision making, thus alleviating some of the negative aspects of landscape fragmentation. Collaborative forums served to show some participating landowners the benefits derived from making management decisions in the context of landscape-level impacts, however, these groups generally represented only a small proportion of landowners and were not deemed sustainable. It appears that in order to affect significant change in management decision making in a landscape context, a coalescing issue must be defined in which a significant percentage of landowners within the target area are interested and consider themselves as stakeholders.

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