PREFERENCES ON THE LANDSCAPE: HOW MUCH DO INDIVIDUAL VALUES MATTER?

by

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Abstract: Models of land-cover change have typically examined the phenomena on a regional scale. These models are often empirical driven and at best infer the motives driving individual actors. Those models examining the decisions of individual actors assume purely economic motives, with land cover understood purely as a factor in production. This paper seeks to explain the micro-level processes at work in determining land cover change. It accepts that economic incentives and conditions are important, but that there may be important differences in the preferences of a population that explain the variation observed across a landscape. The analysis concerns landowner's values and use of forest cover and how they interact interaction with the characteristics of individual private parcels to affect land cover. Using a multinomial logit, it examines the impact of parcel size, agricultural use, the length of ownership, existing rules affecting land use, the presence of a residence, as well as landowner's valuation of forest resources on the change in forest cover on a parcel from 1972 to 1997. Of these variables, parcel size, agricultural use and length of ownership were all found to be significant at a 0.05 level. Landowner valuation of forest cover was weakly significant at a 0.13 level. Of the factors examined here, parcel size had the greatest effect on forest cover change. Surprisingly, smaller sized parcels (< 40 acres) had the highest probability of having experienced a net forest gain during the study period. As expected, parcels with a larger percent of area under agriculture had a higher probability of having experienced a net forest loss than did parcels with a smaller percent of area under agriculture. The most interesting result is the effect of individual landowner's preferences. While they affect the likelihood that a parcel had experienced a change in forest cover in the past, they did not determine the direction of that change. It was equally likely for parcels with landowners expressing strong forest conservation values to have experienced net forest loss or gain. The results lead to interesting implications for a theory of the causes and impact of land cover change in industrial societies.

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Theories of Land Cover Change

Increasing concern with deforestation, urbanization and other processes of rapid land cover change has driven researchers to begin to outline the theoretical model of the key causal factors. This interest in land cover change models has been stimulated by a combination of factors; including a growing focus on global effects of regional changes, the negative local effects of the loss of certain types of land cover and the availability of technologies allowing the recording of these changes (Lambin 1994, Liverman 1998). The factor leading to land cover change across a landscape are numerous and vary from region to region (Bilsborrow 1992, Geoghegan et al 1998, Kaimowitz and Anglesen 1998, Lambin 1994, McCracken, Brondizio, et al 1999). The research that has emerged from this growing subfield is a rich collection of empirical studies of the various types of land cover change. While case studies represent an important step toward developing a more generalizable theory of land cover change, many of these have measured the impact of various variables adequately outlining the underlying process (see Kaimowitz and Angelsen 1998 for a discussion). The behavior and motives of the individuals driving the processes, whether deforestation due to shifting cultivation or urban expansion into a because of local political elites and developers, are often left unexamined. The process is understood as driven deterministically, without specifying either the actors or individual decision criteria. Often, regional aggregate-level variables are used to measure individual-level behavior, ignoring the problems of ecological inference (Achen 1995).

This study used individual landowners in Monroe County, Indiana to build an actor-based understanding of land cover change. Monroe County is fragmented into thousands of privately-owned parcels and presents an ideal location for examining the links between individual behavior and aggregate change. Across the landscape one encounters the typical mix of residential and agricultural properties in a small rural city. Among agricultural parcels there are a variety of land cover types, from active agricultural production to long-fallowed fields. Residential plots are interspersed among the agricultural and represent a variety of land covers from manicured lawn to heavy forest. Viewed from above the landscape appears as a patchwork mosaic.

In some places the reasons for a specific land cover type are obvious. Agricultural fields cover the flat tillable land while forest covers the steeper slopes and creek ravines. However, on other areas the reasons are less evident. Two tillable plots sitting side by side often have very different land cover types. One may be actively under agricultural production, while a second is covered by a mature secondary forest. The reasons for such differences are complex and multifaceted. Individual landowners are ultimately responsible for the type of land cover they choose to leave or create on any particular piece of land. Physical characteristics such as soil quality or slope are better understood as presenting a high costs to alternative uses rather than as deterministic predictors of land cover. Even the most broadly defined economically rational actor chooses agricultural production for the most productive soils and allows forest cover to remain on the steeper slopes and poorer soils.

Micro-motives and Macro-outcomes

As Schelling (1978) proposed, and Axelrod (1997) continues to so skillfully illustrate, mass behavior is the aggregate outcome of multiple individual decisions. Any understanding of the driving forces of land cover change likewise requires a model of individual decisions. This requires clearly stating the principle actors, their decision-making criteria and constraints on behavior. However, merely designing models based on economically rational actors does little to illuminate the decision-making processes underlying the mosaic of land covers. Understanding the outcome of individual decisions requires understanding the heterogeneity of actors.

This paper begins with the proposition that preferences matter. Individuals hold various degrees of value for different types of land cover. Thus the preferences of individual property owners should be expressed in the decisions regarding how they manage their land. The survey instrument asked a random sample of landowner questions regarding how they value the forest on their parcel. Whether this had a relationship to the type of land cover change experienced by the parcel was then tested using classified remote sensing images of forest cover change. Rather than either a comparison across regions to explain variation in land cover types, this paper attempts to explain variation within a single region across individually owned private parcels. Since all land owners in our relatively small area have been subject to the same economic changes over time, this allows for control of many of the economic incentives, including agricultural subsidies and prices. Additionally, it maintains some consistency in the constraints on individual behavior in the form of institutions. Since this study only examines privately owned parcel, it avoids the problem of other types of actors (such as local or state governments) and institutional constraints (such as strict entry or use restrictions on public lands) that may explain regional variation.

This paper does not explicitly address either the bio-physical or macro/regional economic variables which may impact rates and directions of forest loss or regrowth. Furthermore, it seeks to not examine solely the economic decision-making, such as competition between alternative land uses, family income and labor constraints, but also the role of individual preferences. We use the term preferences to refer to the value that an individual places on a specific type of land cover. This implies heterogeneity across landowners and diversity in the systems of land cover valuation. Rather than assuming thin economic rationality, that all landowner will necessarily respond to the same price signals, it proposes private parcels owners will react to the same signal differently depending on how an environmental benefit such as forest cover fits into their overall system of beliefs. Given the same plot of land, with identical forest cover, different individuals will manage the resource based on their own valuation of the environmental good.

Valuing the Forest from the Trees

That changes in economic circumstance and opportunity emerges as one of the key variables of regional-level studies is not surprising (Kaimowitz and Angelsen 1998). In the aggregate, we all share fundamental needs for basic economic security. However, a number of authors have proposed that once basic needs are met, that other values and interests become more salient. This follows Inglehart's (1977, 1990) thesis that in post-industrial societies material needs are generally supplied, and individuals become more concerned with quality of life issues. This is supported by much of the literature on the impact of social economic status (SES) on voting behavior and ideological positions. Inglehart's contribution is an idea of social learning and generational shifts in societal values. Our application of this idea of post-material value as being an important component of understanding land use in post-industrial society borrows heavily from Inglehart's ideas.

The value of forest cover to an individual includes the full range of environmental values; from purely economic gains to intergenerational bequests and a intrinsic good. However our model is not one of individual belief systems, but rather their impact on the environmental change. Thus beliefs and values must have an impact on the behavior of individuals in how they manage land cover.

The relationship of a landowners preferences for a given land cover can be hypothesized as one of two temporal models. Since the ultimate goal is to understand land cover change, the point in time at which individual behavior is observed is crucial. In one scenario, an individual purchases a parcel of land and changes the land cover to suit his or her needs. In this case the land cover is formed to fit the tastes of the owner. Forest is cleared to allow for agriculture or allowed to regrow for aesthetics. Of course, landowners are not able to freely choose according to their tastes. Actions are constrained by household budgets, free time, labor, previous land use and the physical characteristics of the parcel. Since forest cover at one time has been ubiquitous across the entire state of Indiana there are few constraints to its regrowth (Evans, Green and Carlson 2000). If a landowner perceives no benefits from forest cover, we would expect a slow clearing of forest into other land uses from the time they had purchased the parcel. If they express a value in forest, either for monetary, recreational or even ideological reasons, we should expect a slow increase in forest cover over time.

A second relationship is that landowners do not recreate land cover types that conform to their tastes, but purchase parcels based on their preferences. Rather than a landowner inheriting or purchasing a piece of land, and changing it to conform to their tastes they use existing land markets. This allows selection of land that best fits their set of preferences. Thus those who place a high value on forest purchase a parcel with more forest than do those who place little to no value of forest land. Obviously, it is likely that both relationships are present to some extent. Landowners purchase property based on a variety of criteria, from distance to workplace to price, and change the existing land cover based on their needs and resources.

Study Area

The study was conducted in Monroe County, Indiana. It is characterized by gently rolling hills in the southern half of the county with long valleys and agricultural land in the north. The population is concentrated in the semi-urban area of Bloomington and the town of Ellettsville. According to the 1990 census, sixty-eight percent of the population is urban and thirty-two rural. Of the rural residents, only three and a half percent are classified as active in agricultural production. The City of Bloomington is dominated by the Indiana University campus and associated activities. There is a sizable industrial base and service sector economy as well as university related employment. Property tenure reflects the proximity to the university, with fifty-four percent of homes owner occupied and the remaining forty-five percent renter occupied (see Figure 7).

Figure 1: Satellite Image and GIS of Private Parcels in Monroe County.

Sampling Methods

Data for the analysis was obtained from the Indiana Private Landowner Survey. Interviews were conducted with a random sample of 220 private landowners in Monroe County, Indiana. These were selected using from a list of all private property parcels in the county provided to the researchers by the Monroe County Assessor's Office. These were then divided into size classes according to the size of parcel and a stratified random sample was selected from each. Property owners were contacted either by telephone and/or mail and asked if they were available for an interview of up to 2 hours. A wide variety of questions were asked in semi-structured interview format by a team of two interviewers. In addition, respondents were asked to fill out a short questionnaire. Information from each interview was coded by the interviewers into a standard format and cross-validated by each member of the interview team and database managers. A detailed description of the methodology is available in Koontz, Kauneckis and Carlson 1998.

Measurements

Examining the affect of individual micro-level preferences on aggregate land cover change demands utilizing a combination of data sources that are rarely combined in analytical research. This study incorporated interview data obtained from the 1998 Indiana Private Landowner Survey, Landsat satellite images for the Monroe County area for both 1972 and 1997, and a geographic information system (GIS) coverage of individual property boundaries obtained from the Monroe County Assessor's Office. While combining social data with remote sensing data has been conducted for a variety of regions (Liverman, Moran, Rindfuss and Stern 1998), this is one of the few studies linking remote sensing data and individual decision-making to large-scale land cover change. The other examines deforestation processes and farm-level behavior in Brazil (McCracken, Brondizio, Moran et al 1998a; 1998b).

Data for land cover change was obtained by examining changes over time of two land cover classifications created from 1972 and 1997 satellite images. Details on the processing of the remote sensing images are available in Appendix 2. Land cover was classified as either forest or non-forest in both images. Those types of land cover classified as non-forested included urban, residential and agricultural use. Using the two product together allowed an examination of land cover change within each private property boundary.

Interview data was obtained from the Indiana Private Landowner Survey database. Detailed information on land use and land management was self-reported by respondents and recorded by the interview team. One of the problems in using self-reported data to assess landowners values regarding forest resources is that of over-stating their preferences. In order to deal with this problem, an index using multiple questions was developed to code landowners forest valuation. This included a variety of questions, ranging from a self-reported assessment of the type of value they place on the forested area on their parcel to the actual dominate activity on the parcel. Landowners were then coded as representing one of four types corresponding to the types of forest benefits they reported.

Figure 2: Index of Recognized Benefits from Forest Conservation

View of Forest Benefits:	Examples of Expressed Value:	% (#):
Indifferent	Respondent recognized no uses or benefits from forest cover on their parcel. If forest cover was present, it was due to inactivity and neglect rather than active management and use. Typically a parcel was purchased as an investment or for agricultural use rather than as a residence. If the parcel was a primary residence, it was selected on attribute separate from forest cover.	27 % (60)
Economic Values	They included relatively minor ecological benefits such as windbreaks and as a buffers from neighbors as well as larger pecuniary benefits from timber harvesting. This category also includes those who may perceive some benefits from the forest, but still plan to eventually develop in the future. It includes those who conserve forest resources primarily for timber.	47% (103)
Recreational Values	The primary benefit of forest cover emphasized by the respondent was that of recreation. This included recreational uses as diverse as hunting to horseback riding.	14% (30)
Conservation Values	The respondent stressed non-consumptive benefits of forest cover. This also included those who state that they actively preserve land for ideological reasons such as being concerned about "global environmental problems". In this same group are included landowners who expressed concern for intergeneration equity and who held anti-development sentiments. Aesthetic was typically mentioned as the primary benefit of forested areas. This category also includes those considering adding environmental restrictions on their title such as conservation easements, or who are actively managing for wildlife and/or removing foreign tree species. It included anyone who expressed interest in letting land revert to natural state. When timber cutting does occur on the parcel, aesthetics was always mentioned as being more important than economic benefits.	12% (27)

These four categories of landowners were coded into two basic types of landowners; those placing no value or economic value only on forest cover and those expressing either recreational or conservation values. This bifurcation was made to parallel Inglehart's conception of post-material values. In Inglehart’s conceptualization of belief structures quality of life issue become more important that merely material benefits.

For Inglehart, the source of post-material values are the experiences of an individual as shared by their age-cohort. He proposes that the economic experiences of an individual during their initial years as a young adult forms concrete value structures that are held through an individual's life (Inglehart 1977, 1990). Thus a generation raised in an economic environment possesses a value system based on attaining material goods. Whereas one raised in an environment of economic abundance, follows a different set of values. Evidence from individual-level studies repeatedly point to the importance of social economic status (SES) as well.

In order to understand the basis of belief systems and forest valuation, a series of logit models were conducted on landowner's expressions of forest value. Binary values were assigned to whether a landowner was categorized as expressing forest conservation values or not. Corresponding with Inglehart’s theory, three variables were measured; the age of landowner, education level and income.

Figure 3: Logit Model Results for Conservation/Recreation Valuation vs. Indifference/Economic Benefits Only

Economic Benefits from Forest Cover:	**β**	**Std. Error**	**Wald**	**Sig. Level**
Age	-0.004	0.013	0.080	0.777
Education	0.237	0.104	5.175	0.023 *
Income	0.000	0.000	0.762	0.383
Constant	-1.476	0.078	3.104	0.078

N = 220. * = significant at the 0.05 level.

Our analysis suggests that SES is a stronger predictor of post-materialist values regarding forest cover than is age-cohort. Education is the only significant value at the 0.05 level, followed by income at 0.383. The size of the beta coefficients also suggests education has a larger influence.

A Model of Forest Cover Change and Forest Value

A multinomial logit (MNLM) was selected as an appropriate statistical model given the nature of the dependent variable in this analysis. Land cover change was represented by a nominal category for two reasons; one methodological and the second theoretical. The methodological reason is due to the accuracy of the unsupervised classification of forest / non-forest land cover classes. While such classifications are adequate for examining broad scale changes (Green, Schweik and Hanson 1998), it is more problematic when examining change within a relatively small property boundary. Error exists in any unsupervised classification of land cover, but is especially problematic when examining small areas. Edge effect in classificiations may misrepresent any land cover type that is in more than one class. The use of a categorical variable gets at the broad changes in land cover on the parcel, while not over-representing potential classification error such as would be present in a continuous variable.

Secondly, the use of the logistic regression has the important theoretical quality of expressing outcomes in terms of odds ratios. It explains the relationship of between variables as the probability of an event occurring (King 1998; Long 1997). Our interest is in the aggregate effect of individual decisions on land cover change, not on the characteristics of within parcel boundary forest changes. A probability model better represents whether a parcel associated with a specific type of owner has higher probability of being associated with a specific type of land cover change.

The mathematical expression of the MNLM is expressed as:

$$\mathbf{Pr}\ (y_i = m|\mathbf{x}_i) = \exp\ (\mathbf{x}_i\ \beta_m)\ /\ (\Sigma^{J}_{j=1} \exp\ (\mathbf{x}_i\ \beta_m))$$

Where $\Pr(y_i = m|\mathbf{x}_i)$ is the probability of observing outcome m given $\mathbf{x}_i$. In this application, the outcome m is represented by the independent variable, which is one of the three classes of land cover change. The dependent variables, $\mathbf{x}_i$ are listed above in Table 1.

Multinomial logit models are appropriate in cases where the dependent variable consists of categories that cannot be ordered. It simultaneously estimates a binary logistic model for all possible comparisons between outcome categories. In the model used here, each outcome is understood to represent the effects of specific landowners' choices regarding their preferred land cover. The probability of any outcome is specified as a nonlinear function of the independent variables. The MNLM is linear in the log of the odds and can be interpreted as discrete change in the probabilities and factor change in odds of an outcome occurring (King 1998). Given the number of probabilities compared to the binary logit model, graphical methods for interpretation are also useful for interpretation (Long 1997: 151-156).

Figure 4: Variables and Descriptive Statistics

Variable	**Type:**	**Mean (Median):**	**Standard Deviation:**	**Min - Max:**	**Notes:**
Land Cover Change Class	Categorical	--- (2)	---	1 - 3	Three categories of land cover change were assigned: 1) Increase in Forest Cover, 2) Decrease in Forest Cover, 3) No appreciable Change
Years Owned:	Continuous	17.3 (13)	13.8	0 - 57	Represents the number of years the parcel was owned by the current owner
Parcel Size (acres):	Continuous	32.10 (20.46)	28.65	3.6 - 148.56	Acreage of the parcel
Percentage Agriculture:	Continuous	0.27 (0)	0.35	0.0 - 1.0	Percent of parcel in Agricultural Production in 1997
Rules Affecting Land Use	Binary	---	---	0 - 1	Represents the presence or absence of formal rules and regulations affecting land use
House on Parcel	Binary	---	---	0 - 1	Marks whether a house existed on the parcel in1997
Type of Forest Valuation Expressed by a Landowner	Binary	---	---	0 - 1	Represents whether the current land owner expressed strong forest valuation

The selection of variables represented the difficulty of measuring the effects of information gathered today, on land cover change that occurred in the past. The selection of independent variables was not made to identify the factors important to forest cover today, but rather those which we hypothesized would have had a lasting effect on past forest cover change.

Land Cover Change: The dependent variable for the model was one of three classes of land cover change: parcels experiencing a net gain in forest cover, a net loss, and those with no appreciable change.

Years Owned: Obviously, the length of time an owner has had a parcel determines how much impact an individual can have. There is a simple linear relationship (β=0.367, std. error = 0.127, t = 2.89, sig. 0.004) between the length of time parcels in our survey were owned and the size of that parcel where larger parcel tended to have been owned longer. This fits with our expectation that parcels subdivided into smaller housing residential units are more likely to be exchanged in the residential housing market than larger parcels, which are typically further from urban centers and may not be developed. The relationship with forest cover is more complex. It was hypothesized that the length of time a parcel was owned was directly related to the change in forest cover that that parcel had experienced. Each time a parcel passes hands, a new owner may attempt improvements for his/her specific needs and tastes. The shorter the time under an individual owner the more rapid the rate of land cover change. This relationship does not necessarily specify the direction of the change, either increased or decreased forest cover, only that some change should occur.

Parcel Size: Larger parcels were thought to have a higher probability of contained larger expanses of forest, and to have generally experienced less change than smaller parcels. The idea being that it is simply easier to convert a smaller area land into a different land use than a large expanse. Smaller parcels should experience greater change, and with the transition from agricultural to urban and residential use, they should also experience a higher probability of forest loss. As mentioned earlier, that changes in parcel size over time complicate this simplistic hypothesis. The assumption here is that small parcels were likely once part of larger ones and that the trend has been subdivisions.

Percentage Agriculture: Simply put, the higher the amount of a parcel being used for agriculture the less likely it should be that there is forest cover in any period. This variable attempts to control for physical characteristics and potential alternative land uses. The idea being that most marginal agricultural land in Monroe County was out of production by the early 1970's, and that only those areas in which agriculture was a viable option would still have been under agriculture in the 1972 MSS image. Thus the expected pattern was that areas under agriculture when the interviews took place in 1998 would only be those still viable. Thus the amount of agricultural land would restrict the amount of forest gain that could have been experienced in the past.

Restrictions Affecting Land Use: In a wide variety of cases of natural resource management, Ostrom (1990, 1994) has illustrated that rules and other institutional constraints on behavior are instrumental in understanding resource governance. The presence of existing rules affecting land use was expected to increase the probability of forest gain, or at a minimum decrease the probability of loss. These included all programs regarding forest management which a land owner may have inherited when the parcel was purchased, zoning, and any other ordinance that the current owner stated affect land use decisions. Few laws affect land use directly. According to land owners, the primary impact on land use was that of zoning and building restrictions (Jones 1997, Kootnz 1998).

House on Parcel: This variable represents whether or not a house was present on the parcel in 1997. Two hypotheses were implicit in the inclusion of this variable. First, that if a house was built, then a parcel should have experienced some forest loss in the past. Second that residential parcels are likely to be different from those being used for any type of agricultural or large scale timber production.

Landowner Preferences toward Forest Cover: This variable represents the primary hypothesis being tested by this paper. It states that the values a landowner holds today regarding how they chose to use the land will be discernible on their parcel.

Results

Figure 5: Results of Likelihood Ratio and Wald Tests

Variable:	LR	p	Wald	df	p
Parcel Size (acres):	31.03	0.0000***	19.15	2	0.0001***
Years Owned:	5.82	0.0546**	5.25	2	0.0723
Percentage Agriculture:	22.66	0.0000***	16.48	2	0.0003***
Rules Affecting Land Use	0.33	0.8497	0.33	2	0.8489
House on Parcel	2.28	0.3206	2.25	2	0.3253
Expresses Environmental Values	4.10	0.1287*	4.10	2	0.1290*

NOTE: N=210. *** Significant at the 0.001 level. ** Significant at the 0.05 level.
* Significant only at the 0.13 level.

Neither the presence of rules nor that of a house on the parcel was a significant determinant of the type of change in forest cover a parcel experienced. The single most significant impact of any variable over the time period analyzed here is that of parcel size. The effect of a standard deviation change in the size of the parcel increases the odds that a parcel will experience some type of land cover change by an equal magnitude (Figure 10). No parcel size showed a greater probability of having not experienced some significant change. However, smaller parcel sizes were more likely to have experienced a net gain in forest cover, while larger parcels were more likely to have experienced a net loss (Figure 13). Two points are essential in interpreting these results. First, parcel size is a measure taken from the 1997 property coverage, and thus does not account for changes resulting from the splitting and merger of private parcels over the last two and a half decades. The overall trend in the County has been the transition from larger parcels to smaller ones. A property that appears as a small parcel in 1997 was likely part of a larger parcel in 1972. This has a number of interesting theoretical implications. As larger parcels are subdivided into smaller tracks we would expect to see two paths of land cover change depending on the type of the original land use. If a large parcel was forested in 1972 and then subdivided into smaller parcels as residential use there should be an overall loss of forest cover. However if a large parcel was under agricultural use in 1972 and was subdivided into residential plots it might experience net forest growth over time as individual landowner allow small patches of forest to return as buffers from neighbors, roads or for aesthetic reasons. Disaggregating this hypothesis from the results reported here has yet to be tested.

The percent of agriculture of a given parcel, not surprisingly, also has a large effect, as can be seen by comparing the relative size of the beta coefficients (Figure 9). The percent agriculture has the second greatest effect on forest loss of any variable. The percent agriculture currently existing on a parcel is negatively related to the probability that a parcel has experienced some net forest loss. As is illustrated in Figure 14, the larger the percentage of land in agricultural production, the higher the probability that a given parcel has experienced a loss in forest cover. While the temporal element of this data is problematic, it appears that rather than agricultural land having stayed constant over the time period studied here, there has been some forest loss and expansion or concentration into the current agricultural area. This is most clearly seen in the case where a parcel is currently covered by 100% agriculture. This has almost a ninety percent probability of having experienced a net decrease in forest cover. Smaller parcels have tended to show a net gain in forest cover, while larger parcels a slight increased probability of no change having occurred (Figure 13).

Landowners' preferences for forest cover were only weakly significant ($z = 4.1$, $df = 2$, $p>|z| = 0.13$). However the variable suggests some interesting results. Strong preferences for forest cover are most likely to increase the probability that no change has occurred on a parcel. There is approximately the same magnitude of effect on the probability of a loss of forest cover as there is on the probability of a gain of forest cover for those with strong preferences for forest cover. What this tends to suggest is that rather than landowners' preferences guiding outcome, that land owners chose to buy parcels based on their preferences. So that an individual tends to choose the type of land cover best suited for their particular values and preferences at that time.

Additional Evidence

In proposing that an individual's values and preferences can effect land cover changes at the aggregate level we assume a model where the individual owns and manages a given parcel long enough to allow change to occur. Given the high mobility of American household a second possibility is also likely that the only way values matter is in the type of land cover selected during the purchase of a parcel. As a whole, the population of Monroe County is exceptionally mobile due to the student population surrounding the Indiana University Campus. According to the 1990 U.S. Census Office, fully thirty percent of the population had lived within their current home for a year or less and sixty percent less than five years (Figure 7). Given that this study is concerned with property owners and managers rather than renters, it was expected that our sample would have dramatically lower mobility rates. However, even among land owners in the county there was a surprising degree of mobility. Twenty-five percent of those interviewed has only owned their property for five years or less and fifty percent for thirteen years or less. Central tendency statistics illustrate the skewed distribution toward frequent mobility (mean = 17.3 years, median = 13 years, mode = 1 year).

Evidence presented below, tends to support the land market model. Two linear regression models were performed to predict the amount of forest cover currently on a parcel. Of the variables discussed here, only two were found to be significant, the number of years a parcel has been owned and the type of value a landowner places on forest cover.

Figure 6: Regression on 1972 Forest Cover

Variable:	Unstandardized Coefficient (std. error):	Standardized Coefficient:	t	Sig.
Constant	0.699	-	-	-
Size	0.001 (0.001)	0.134	2.062	0.040 **
Percent in Agriculture	-0.336 (0.055)	-0.410	-6.135	0.000 ***
Rules affecting land use	0.002 (0.040)	0.027	0.422	0.674
House Present on Parcel	0.041 (0.039)	0.068	1.061	0.290
Non-economic Forest Values	0.035 (0.041)	0.055	0.858	0.392

Model parameters: R^2 = 0.18, Adjusted R^2 = 0.157. * = significant at the 0.01 level. ** = significant at 0.05 level. *** = significant at 0.001.

Figure 7: Regression on 1997 Forest Cover

Variable:	Unstandardized Coefficient (std. error):	Standardized Coefficient:	t	Sig.
Constant	0.683	-	-	-
Size	0.002 (0.001)	0.137	2.528	0.012 *
Percent in Agriculture	-0.630 (0.055)	-0.633	-11.404	0.000 ***
Rules affecting land use	0.004 (0.040)	-0.049	-0.926	0.355
House Present on Parcel	-0.003 (0.039)	-0.047	-0.870	0.385
Non-economic Forest Values	0.113 (0.041)	0.145	2.737	0.007 *

Model parameters: R^2 = 0.43, Adjusted R^2 = 0.42. * = significant at the 0.01 level. ** = significant at 0.05 level. *** = significant at 0.001.

Obviously, examining the dynamic temporal process of land cover change using two time periods is problematic for both conceptual and methodological reasons. Given the high rates of land ownership change, characteristics of land owners have no relationship to those of land owners in the past. Furthermore, some of the variable used have not remained constant across the two time periods. While the physical characteristics of a parcel have probably remained unchanged, the size, configuration and other attributes have not. Large agricultural parcels of the past have been subdivided into many small residential units. Ownership of a groups of contiguous parcels by a family or individual, has since been divided among heirs and either retained or sold. Houses have sprung up according to the distance of a parcel to major transportation route, work sites and city and county utility services. However, even this those caveats, there are interesting relationships worthy of discussion.

First, the single most important determinate of the forest cover currently on parcel appears to be previous land use. The second most significant variable was that of parcel size. This conforms to our general understanding of parcel subdivision over time. The final bit of evidence supporting the idea that preferences impact land cover primarily in the selection of parcels in a land market comes from comparing the effect of land owner preferences on land cover. Individual preferences are only significant in terms of the most recent land cover and have no significant effect on land cover present in the 1972 image.

Discussion

These results are a preliminary attempt to understand the aggregate effects of individual-level behavior on land cover change. Given that linking social science to remote sensing is a relatively new methodology the results should be viewed with caution.   The model presented here has yet to be tested for the robustness of its' results either empirically or mathematically. Additionally, the sampling size for many of the dependent variables can be increased by using spatial measures apart from the interview data and examining the characteristics of all parcel in the county using existing land cover data.

Variables such as parcel size, and percent in agricultural production can be estimated using the total population of property boundaries available in the existing GIS coverage. Finally, additional work on the actual pattern of parcel split still needs to be verified through historic records. Patterns of change over time not determined by household characteristics can be tested against the broader database from which this sample was drawn to obtain a better picture of change on the landscape as a whole as compared to the specific sampled examined here.

However even these tentative results leads to interesting implication about the interaction of individuals, private property and forest change. Remote sensing as a methodological tool is rarely used to understand individual-level behavior. Typically it examines broader regional phenomena. Remote sensing technology provides a means to empirically test our understanding of the theoretical linkages between individual behavior and environmental change. However developing models and theory about regional land cover change requires firm micro-level foundations. Understanding the micro-level foundations of macro-level phenomena demands making these linkages explicit.

Building an understanding of land cover change from the individual actor up has important implications for land use policy. Models of land cover change inform policy decisions at multiple scales. Local governments use informal and conceptual models in watershed management, hydrology, the creation of urban green space and zoning decisions affection rural to urban transformations. Understanding the dynamics of landscape change affects policy decisions at the global level as well, from biodiversity, to deforestation and policy prescriptions regarding carbon sequestration. Current models of land cover change often fail to allow for adequate heterogeneity across the full range of actors impacting a landscape. Policy decisions need to be based on an understanding of the linkages between individual action and the institutional and physical factors that mediate those decisions.

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Appendix I.

Figure 8: 1990 Census Data Summary for Monroe County

	Percent of Population:
Urban and Rural Residence:	
Urban	68.2
Rural	31.8
Farm Population	03.5
Year Householder Moved into Current Unit:	
Within 1 Year	30.9
2 – 5 Years	29.8
6-10 Years	12.0
11-20 Years	14.4
21-30 Years	07.2
31 or more	05.8
Residence in 1985	
Lived in same house	37.9
Lived in different house in the U.S.	59.3
Lived in same state	70.9
Same county	53.2
Different county	46.8
Different state	29.1
Occupancy and Tenure	
Owner occupied	54.8
Renter occupied	45.2

Source: U.S. Census Bureau; 2000.

Figure 9: Logit Coefficients for Multinomial Logit Model of Effect of Strong Forest Valuation on Land Cover Change

		Logit Coefficient for:			
Comparison		**YEARS OWNED**	**SIZE OF PARCEL**	**PERCENT IN AGRICULTURAL PRODUCTION**	**OWNER EXPRESSES STRONG FOREST VALUATION**
L | G	β	0.010	-0.007	-3.465	-0.032
	z	0.704	-0.955	-3.711	-0.067
L | N	β	0.044	0.043	-2.0143	-0.820
	z	2.239	3.399	-1.916	-1.603
G | L	β	-0.011	0.007	3.465	0.032
	z	-0.704	0.955	3.711	0.067
G | N	β	0.033	0.051	1.451	-0.788
	z	1.972	4.315	2.332	-1.839

L = Net Loss in Forest Cover; G = Net Gain in Forest Cover; N = No change.

Figure 10: Factor Change Plot

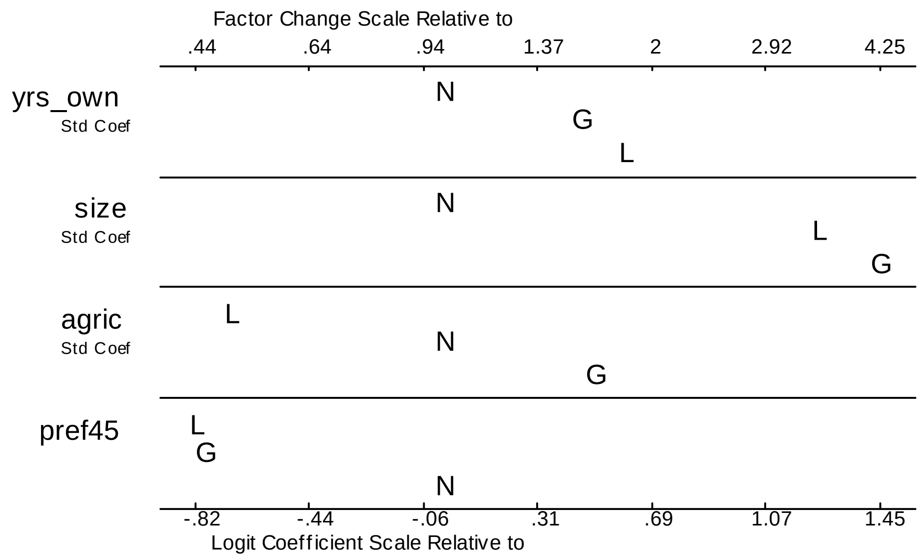


Figure 11: Odds Plot

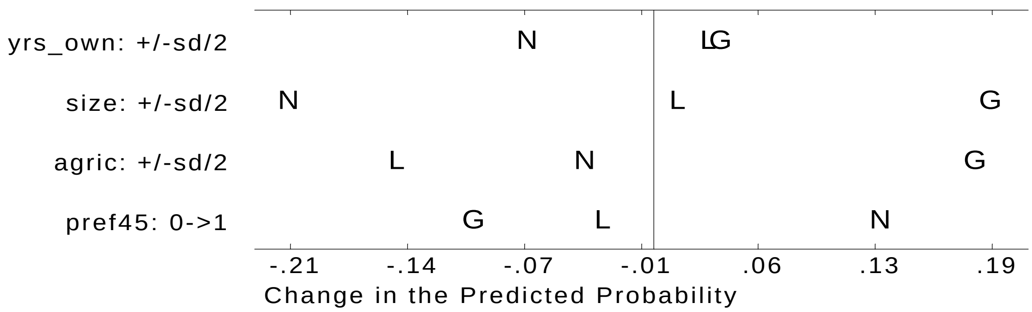


Figure 12: Cumulative Probability for Forest Cover Change over Years Owned

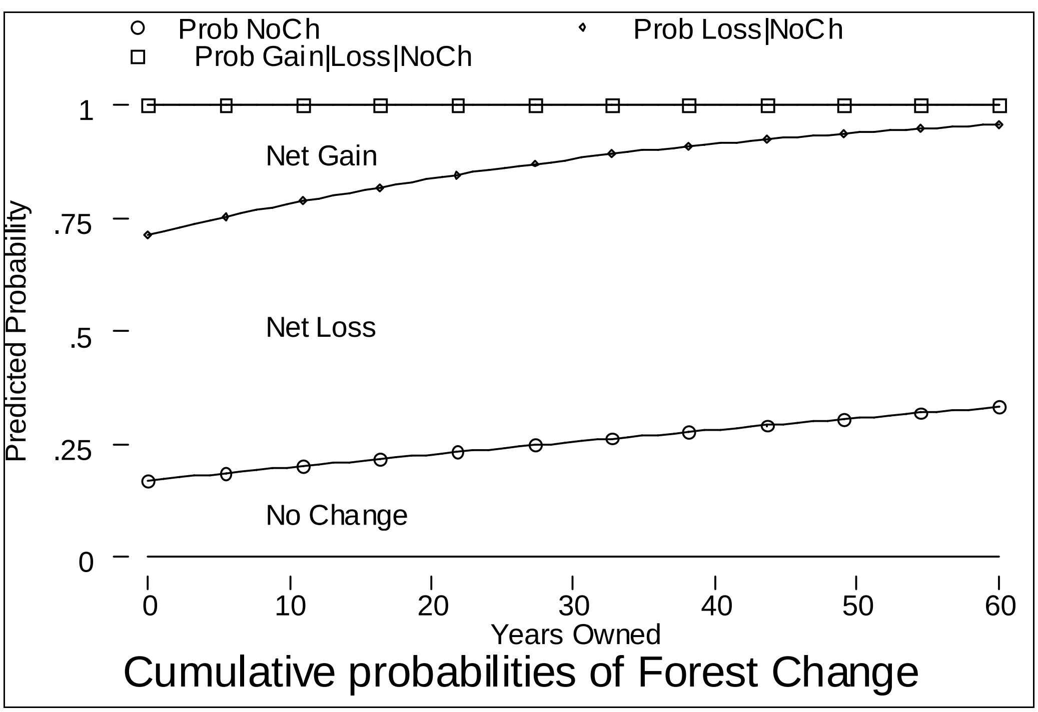


Figure 13: Cumulative Probabilities for Forest Change over Size of Parcel

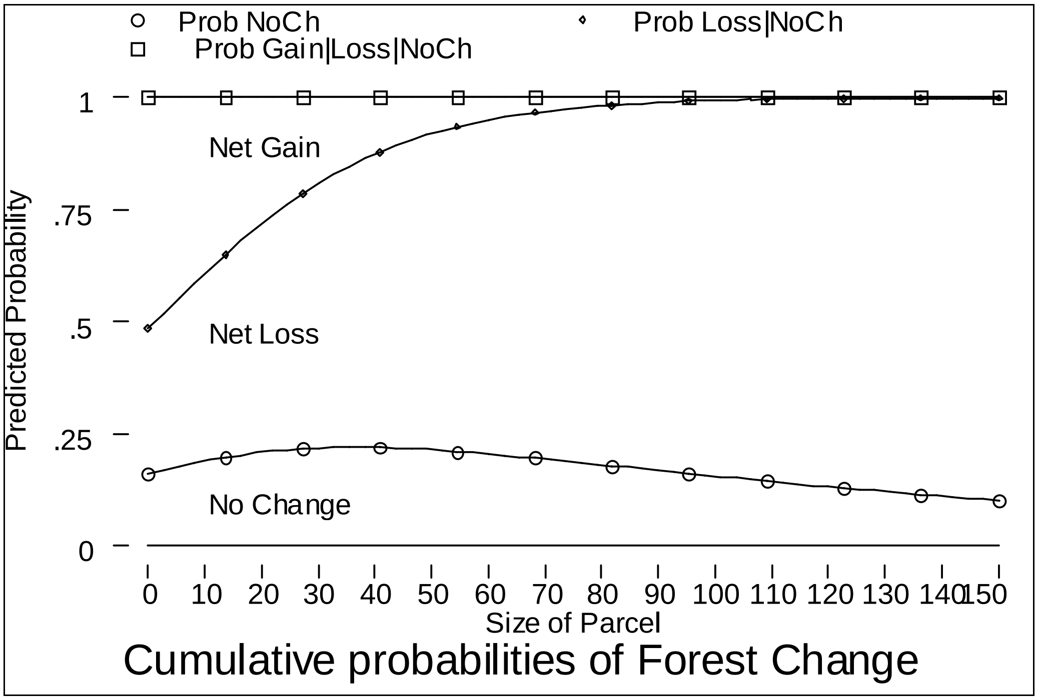
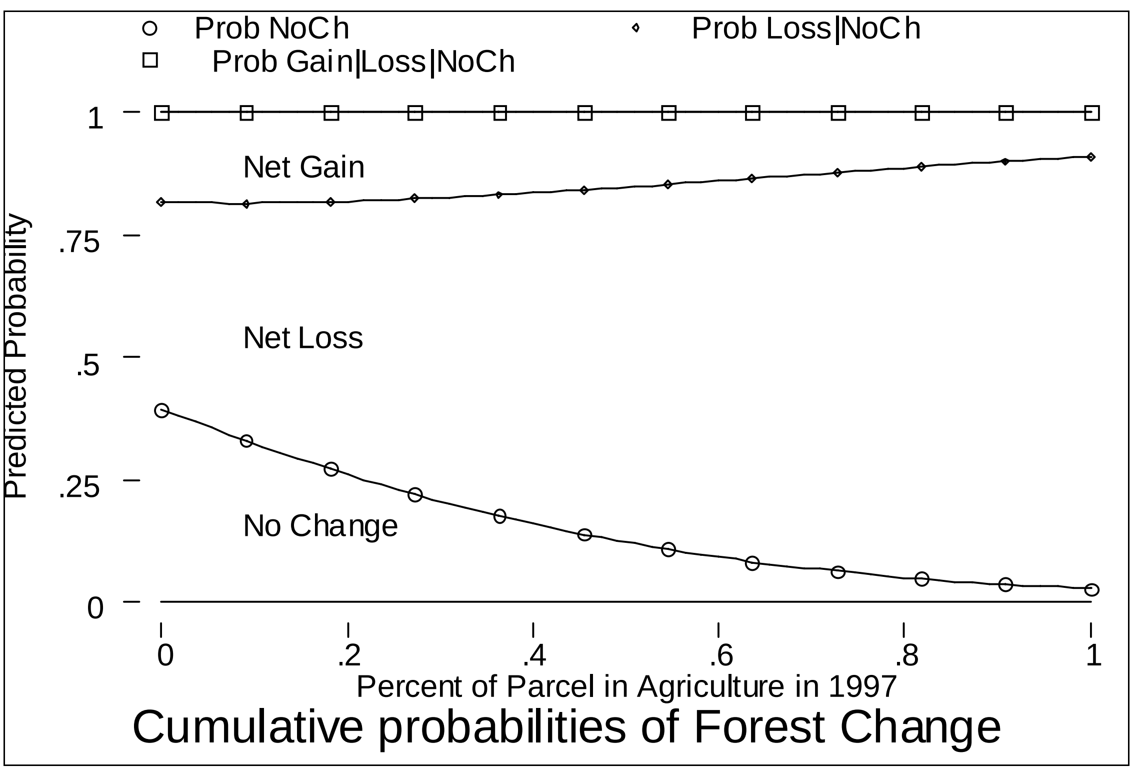


Figure 14: Cumulative Probabilities for Forest Change over Percent of Parcel in Agriculture



Appendix II:

Remote Sensing Image Processing Methods:
Measures of land cover change were derived using a 1972 MSS image and a 1997 TM. Given the relatively crude classification it was determined that an unsupervised classification would be adequate. Each image was classified with an initial 25 classes, with a convergence threshold of 0.95 and maximum iterations set at 10. The convergence threshold is the maximum percentage of pixels whose cluster assignments can go unchanged between iterations. By specifying a convergence threshold of .95, it specify that as soon as 95% or more of the pixels stay in the same cluster between one iteration and the next, the utility stops processing. Maximum Iterations refers to the number of maximum times that the ISODATA utility should recluster the data. This parameter prevents this utility from running too long, or from potentially getting "stuck" in a cycle without reaching the convergence threshold.

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Calcuating Net Forest Change:
Measurements on four classes of land cover change were obtained from the two classified images.

1 – Non-forest to Forest
2 – Non-forest to Non-forest
3 – Forest to Non-forest
4 – Forest to Forest

Less than a one pixel change was counted as no change for any single category or calculation of net forest change. From these four categories the net forest gain or loss was calculated for the total parcel area. This resulted in three final categories of land cover change: net forest gain, net forest loss and no significant change in forest canopy cover.