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Examining incentives for adjacent non-industrial private forest landowners to cooperate

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ABSTRACT

Individual landowners may capture non-timber benefits from both their own forested parcels and adjacent parcels owned by different landowners. These benefits may affect incentives for landowners to cooperate in their forest management decisions. Landowner survey data is used to examine incentives to cooperate concerning joint forest management and coordination of harvesting. We find spatial factors to be particularly important to these incentives. The percentage of neighboring land employed in agriculture or crop uses and the number of bordering landowners are important positive predictors of willingness to cooperate concerning joint forest management, while the latter has a negative effect on willingness to coordinate timing of harvest. We also find that the non-timber values an individual receives from adjacent land are important positive predictors of cooperation incentives in general. Our results confirm, first, that cross parcel externalities modeled in theoretical work do in fact exist, and, second, that there is merit to formulating future policies with the incentives of landowners to participate in cooperative agreements with neighbors in mind. Such information could be important to addressing landscape level threats to forest health and sustainability.

1. Introduction

Many of the current threats facing forest health and sustainability, such as fire and invasive species or destruction of wildlife corridors, stem from processes and management activities that occur across landscapes populated with many landowners. These processes are not contained within artificial boundaries that delineate property ownership. Nowhere is this more evident than with non-industrial private (NIPF) landowners, who hold the majority of forestlands throughout the Eastern and Midwestern United States. These landowners represent the front line when addressing any landscape level threat to forest health and sustainability, and it is their land management activities that will determine the extent and efficiency of efforts to control such threats. In many cases, reducing threats such as fire or pests, or providing quality wildlife habitat, will ultimately require landowners to cooperate when determining forest management decisions.

Cooperation might be expected to develop among landowners. Despite private property rights, many predominantly theoretical studies have suggested that individual landowners receive amenity benefits from adjacent properties (or stands) (Bowes and Krutilla, 1985; Swallow and Wear 1993; Amacher et al. 2004). Most rigorous empirical forest studies, however, have focused on landowner decisions without consideration of adjacent landowners when interactions of adjacent forest managers are needed to effectively address landscape level threats (e.g., see Amacher et al., 2003 and Kuuluvainen et al., 1996 for reviews of prior NIPF landowner studies).

The purpose of this study is to examine incentives for landowner cooperation by investigating how adjacent land parcels (owned by different landowners) influence decision making. We focus on one specific preference of a landowner — to participate in forest management agreements with adjoining landowners. The incentives for landowners to participate in an agreement such as this depends to some extent on the non-timber (non-market) amenities the landowner receives from their own standing forests, as well as non-timber amenities derived from standing forest on adjacent lands. How these non-timber benefits are linked across a landscape are important to an individual's valuation of utility received from standing forests and has been referred to as spatial interdependence.

Spatial interdependence incorporates the economic characterization of substitutes and complements in the individual's objective function (Koskela and Ollikainen, 2001). For example, consider landowners A and B holding adjacent parcels. If one of the parcels provides an excellent source of food for a particular wildlife species valued by landowner A, and the other parcel provides an excellent source of cover for this species, then the parcels are complements in landowner A's non-timber valuation (e.g., see Swallow and Wear, 1993). If landowner B decides to harvest her forest, perhaps to convert the land to an alternative use (i.e., agriculture), this would have a negative impact on landowner A's

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valuation of her own stand as the parcels would no longer be complements in the provision of wildlife habitat. This simple example illustrates how individual owners may receive benefits from adjacent parcels and how individual action could result in welfare changes, and possibly inefficiencies, across the landscape. The potential of landowners to cooperate and what role, if any, spatial interdependencies play in this decision can therefore provide an important piece of information when addressing any landscape level threat to forest cover.

We depart from previous empirical studies of non-industrial landowner behavior by considering how adjacent parcels affect decisions. This is accomplished using data from a mail survey of over 2600 forest landowners to test hypotheses regarding willingness to enter into cooperative behavior with adjacent landowners. This data is used to identify characteristics that influence a landowner's stated preference regarding cooperation with others. Identifying these characteristics is important for targeting policies that would serve to remove welfare inefficiencies that might exist from a single landowner engaging in their own private decisions without regard to the effects of these decisions on neighbors and the immediate landscape.

2. Methods

In the absence of possible cooperation a representative landowner i is assumed here to have the following utility function,

$$V(c, M, K_i, K_j; \Omega) = E[U(c, M; \Omega) + N(K_i, K_j)], \tag{1}$$

where $V(.)$ is the maximum expected utility received when landowner i makes all forest management decisions optimally. In Eq. (1), c is the market price of timber, M is the landowner's exogenous income, Ω is a vector of landowner characteristics important to utility, K_i is the forest stock owned by the landowner i, K_j is the forest stock owned by another adjoining landowner j, $i \neq j$, $U(.)$ is some function measuring the income benefits of harvesting, and $N(.)$ measures non-timber benefits generated by the individual's own forested stock and adjacent stocks. The term E is an expectations operator reflecting uncertainty that the individual may have regarding adjacent landowner decisions and how they affect her utility; these follow from the (resulting) forest stock on the adjacent parcel K_j. The utility of a representative landowner is assumed separable in terms of revenues from harvesting and non-timber benefits related to amenities provided by standing timber resources; this is consistent with most studies of amenities in the forest economics literature beginning with Hartman (1976). However, we also assume that the landowner's utility is derived from both her own forested parcel and from its relationship to adjacent forest parcels owned by other landowners bordering the property. This assumption parallels the theory of Hartman (1976), who also suggested that amenity production was not solely dependent on one forested plot when there are many plots comprising an individual's decision-making unit.

Suppose landowner i is confronted with an offer in some time period to enter into a cooperative agreement, in which she must commit K_{ia} of forest stock in an arrangement with neighbors, who also commit K_{ja}.[1] The landowner, by entering into such an arrangement, effectively gives up individual management rights for K_{ia}, but in doing so resolves some uncertainty associated with the condition of adjacent forest stock(s), at least for the stocks committed to the joint agreement.

From Eq. (1), expected utility under this agreement can be written

$$\overline{V}(c, M, K_i, K_{ia}, K_j, K_{ja}; \Omega) = U(c, M; \Omega) + N(K_{ia}, K_{ja}) + V(c, M, K_i - K_{ia}, K_j - K_{ja}; \Omega). \tag{2}$$

The first two terms on the right hand side in Eq. (2) are certain utility obtained from forest stocks committed to the agreement, which derives from both the landowner and her neighbor, while the third term comes from Eq. (1) for the remaining forest stock; this term represents expected utility obtained from forest stocks not subject to the agreement. Without loss, each component of Eq. (2) could be assumed to reflect streams of discounted net benefits from the point of the agreement onward. Further the reduction in utility implicit in the last right hand side term can be interpreted as an opportunity cost of cooperation.

Landowner i will enter into a cooperative agreement if the benefits from cooperation in utility terms are greater than utility that the landowner expects to receive if she continues to maintain private control of all forest stocks on her land (along with uncertainty in her neighbor's management for some of the stocks) or using the above notation,

$$\overline{V}(c, M, K_i, K_{ia}, K_j, K_{ja}; \Omega) > V(c, M, K_i, K_j; \Omega)$$

which implies,

$$[U(c, M; \Omega) - EU(c, M; \Omega)] + [N(K_{ia}, K_{ja}) + EN(K_i - K_{ia}, K_j - K_{ja}) - EN(K_i, K_j)] > 0. \tag{3}$$

The first bracketed term on the left hand side is the difference in expected timber income possibilities from cooperation relative to those obtained in private decision making. The second bracketed term represents the change in expected non-timber benefits from cooperation relative to private forest management. If this term is large enough, then the landowner will cooperate, primarily because of the expected change in non-timber amenities.

In our empirical analysis, we study two types of cooperative agreements that can be identified in Eq. (3). The first is whether a landowner would cooperate with neighboring landowners when making decisions regarding maintenance of forest stocks across parcels. Second, we consider whether a landowner would jointly harvest with other neighboring landowners if a price increase (parameter c) could be obtained through coordination of harvest timing. The first relates to the second bracketed term in Eq. (3), while the second type of agreement relates to the difference in the first bracketed term in Eq. (3). Each of these discrete decisions is described by Eq. (2), because they differ only in their effects on non-timber benefits and harvesting income. We use a simple empirical approach based on a random sample of forest landowners to understand the behavior of a representative landowner confronted with the decision to coordinate management activities with adjacent landowners.

With either agreement, the probability of observing a landowner who is willing to cooperate is given by,

$$Pr(a_i = 1) = Pr\{\overline{V}(c, M, K_i, K_{ia}, K_j, K_{ja}; \Omega) > V(c, M, K_i, K_j; \Omega)\}, \tag{4}$$

where $a_i = 1$ implies that the landowner enters the agreement. The term on the far right hand side of Eq. (4) is the reservation utility obtained by not cooperating and making only private forest management decisions. An econometric form of Eq. (4) is obtained by converting expected utilities to random utilities by appending discrete choice-based error terms, and then assuming that these error terms have an extreme value distribution for the discrete choice made by each landowner i (e.g., see Maddala, 1983, pp. 22–27). The resulting econometric task is to estimate,

$$Pr(a_i = 1) = \frac{e^{\beta' X}}{1 + e^{\beta' X}}, \tag{5}$$

where β is a vector of parameters to estimate and X is a vector of variables thought to explain the discrete choice. These variables

[1] Eqs. (1) and (2) developed here are similar to an econometric model developed in Sullivan et al. (2005), who examined a single landowner in a rotation model without regard to adjacent parcels.

coincide with those important in the decision to cooperate from Eq. (3) and include some measure of the exogenous net assets of the landowner, a vector of forest and land characteristics on landowner *i*'s land and adjacent land important to timber income or non-timber values, a vector of landowner characteristics important to decision making, and any variable reflecting transactions or opportunity costs associated with cooperation, some of which may be unobserved components of the error.[2] In the analysis that follows, spatial interdependencies will play a role in the individual's decision to participate in cooperative management. Strategic behavior by landowners can also be tested using an indicator variable for whether the individual landowner takes into account how their land management decisions affect neighboring lands in the decision to jointly plan future forest management activities with neighbors. This variable provides some indication of whether a landowner responds to externalities that might be present in adjacent stand management. Next, we turn to estimation of Eq. (5) for a sample of non-industrial private forest landowners.

3. Study area and data

We administered a survey questionnaire to individual non-industrial private forest landowners in order to estimate Eq. (5) for both types of cooperative agreements. Specifically, we asked a) whether a landowner would consider jointly planning future forest management activities with neighboring landowner(s) and b) whether the landowner would consider harvesting at the same time as neighbor(s) if there were a 20% increase in the price received for timber assuming that both parcels have timber old enough to harvest. In the survey, landowners' use of the surrounding landscape for recreation activities was assessed in order to quantify whether this particular non-timber benefit was an important characteristic factoring in the individual owner's incentive preference. The survey instrument was a mail-out/mail-back questionnaire targeting NIPF landowners in four central Virginia counties, specifically Albemarle, Goochland, Hanover, and Louisa. The design of the survey questionnaire, available from the authors, and implementation followed Dillman (2001) and Dillman (1978).

Counties were selected that offered a specific taxation status for forest use, allowing easy identification of our target population. Counties sampled were located near the urban centers of Richmond and Charlottesville, Virginia, which are undergoing increasing fragmentation pressures, and thus facing one of the primary threats to forest sustainability — loss of the contiguous forest land base to development. Corporate landowners were excluded from the random selection of forest landowners.

Overall, 2662 landowners were sent an initial survey and follow-up postcard, and 1470 returned a completed questionnaire, for a 45% response rate. This response rate is significantly higher than other non-industrial landowner surveys recently conducted in the region (Conway et al., 2003; Sullivan et al., 2005; and Vokoun et al., 2006). To test for latent non-response bias, we compared the mean parcel size from respondents and non-respondents from the county tax records using a two-sample *t*-test. The null hypothesis of equal mean parcel sizes in the two samples could not be rejected at a *p*-level of 0.05.

Summary statistics for variables used in the analysis are presented in Table 1. Nearly 41% of respondents indicated that they take into account how their land management decisions affect neighbors, defined as those lands directly bordering the individual's parcel. This suggests, first, that cross parcel externalities modeled in theoretical work to date do exist, and, second, that there is merit to examining the willingness of landowners to participate in cooperative agreements with neighbors. We also found that 36% of respondents were willing to consider jointly planning future forest management activities with neighbors. Approximately 44% of respondents indicated willingness to harvest timber at the same time as neighbors if there would be a 20% increase in the price received as a result of harvesting together, under the assumption that both their own parcel and neighboring land parcels had trees ready to harvest. It should be noted that individual indication of willingness to participate in a given cooperative arrangement with neighboring landowners, described above, is not limited to selection of one particular option by survey participants.

Table 1
Descriptive statistics from survey of non-industrial private forest landowners in four central Virginia counties.

Variable	Mean	Standard deviation
Absentee (0,1)[a]	0.142	
Household income ($)	78,723.52	43,834.11
Number of children	2.067	1.445
Number of private individuals owning bordering parcels	4.034	2.754
Forested acres	53.42	66.28
Percent of land parcel bordered by forestland	63.325	32.918
Percent of land parcel bordered by cropland or pasture	18.971	25.655
Relatively flat terrain (0,1)	25.6	
Roads (miles)	0.614	0.988
Permanent structures present (0,1)	0.605	
Completed college (0,1)	0.523	
Employed full time (0,1)	0.472	
Inherited parcel (0,1)	0.256	
Years owned property	19.446	14.545
Sold timber in the past (0,1)	0.377	
Past participation in land management activities with neighbors (0,1)	0.169	
Hunted on own parcel in last year (0,1)	0.398	
Non-consumptive recreation on own parcel in last year (0,1)	0.803	
Hunt or fish on neighboring parcel(s) (0,1)	0.199	
Non-consumptive recreation on neighboring parcel(s) (0,1)	0.278	
Allow others to hunt or use own land for recreation (0,1)	0.701	
Importance of owning land for environmental reasons (protection of water quality, wildlife habitat) (0,1)[b]	0.667	
Importance of owning land as an investment (0,1)[b]	0.559	
Risk associated with growing trees for income purposes (0,1)[b]	0.159	
Risk associated with losing timber to natural occurrences (0,1)[b]	0.247	
Account for how own management affects neighbors (0,1)	0.413	
Plan to give land to heirs (0,1)	0.686	
Jointly plan future forest management (0,1)	0.362	
Coordinate in hypothetical harvest with 20% increase in price (0,1)	0.438	

[a] 0 = no; 1 = yes.
[b] Categorical variables 1 = least importance/risk to 5 = most importance/risk recoded to dummies with 1-3 = 0(no) and 4,5 = 1(yes), bold = dependent variables.

4. Results

The stated preference responses to our two questions were modeled as discrete choices, with “don't know” responses for these assessments treated as indicators of disagreement, following NOAA panel recommendations for these types of responses (Randall, 1997). The estimation of Eq. (5) for the preference to enter into a joint plan for future forest management with neighbors is presented in Table 2. There were nine explanatory variables statistically significant at a *p*-value less than 0.1, including whether the landowner completed college (+), participation in non-consumptive recreation,

[2] Factors governing the stated preference of landowners towards participation in a cooperative agreement are proposed to be similar to those governing the decision to harvest (e.g., see Vokoun et al. 2006) with the addition of neighboring land characteristics.

Table 2
Logit estimation of a representative central Virginia NIPF landowner's willingness to enter into a joint agreement with neighbors for future forest management activities.

Variable	Coefficient	Standard error	Marginal effects[a]
Constant	−2.962***	0.734	
Absentee	0.346		
Household income	4.88E−6**	2.26E−6	1.19E−6
Plan to give land to heirs	−0.289		
Inherited parcel	−0.426*		
Roads (miles)	−3.32E−2	0.103	
Importance of owning land for environmental reasons (0,1)	0.100		
Years owned property	−2.00E−3		
Risk associated with growing trees for income purposes (0,1)	−0.386		
Risk associated with losing timber to natural occurrences (0,1)	−5.90E−2		
Forested acres	1.23E−3	1.87E−3	
Number of children	−7.31E−2	6.93E−2	
Employed full time	0.324		
Sold timber in the past	0.199		
Relatively flat terrain	−0.251		
Permanent structures present	−7.83E−2		
Importance of owning land as an investment (0,1)	−0.300		
Completed college	0.919***		
Hunted on own parcel in last year	9.66E−2		
Non-consumptive recreation on own parcel in last year	0.497		
Percent of land parcel bordered by forestland	0.701	0.447	
Percent of land parcel bordered by cropland or pasture	0.938*	0.558	0.229
Number of private individuals owning bordering parcels	8.65E−2**	4.10E−02	2.11E−2
Allow others to hunt or use own land for recreation	0.200		
Hunt or fish on neighboring parcel(s)	−5.21E−2		
Non-consumptive recreation on neighboring parcel(s)	0.632***		
Past participation in land management activities with neighbors	0.677***		
Account for how own management affects neighbors	0.436**		

*** Significant with *p*-value 0.01.
** Significant with *p*-value 0.05.
* Significant with *p*-value 0.10.
[a] Marginal effects of non-dummy variables computed at the overall mean of the data set.

i.e., hiking and horseback riding, on neighboring parcels (+), previous cooperation with neighboring landowners in land management activities, e.g., trail building, improving stream quality, developing wildlife habitat, timber harvesting, or farming (+), whether the landowner takes into account how their land management decisions affect neighboring lands (+), the number of private individuals (parcels) bordering the parcel in question (+), the percent of agricultural lands bordering the parcel (+), household income (+), and whether the landowner had acquired the parcel by inheritance (−).

Prior studies examining interest in participation in joint management activities with neighbors have had mixed results regarding the significance of education in determining landowner likelihood to cooperate (e.g., Stevens et al., 1999 and Jacobson, 2002). Our study falls along the lines of Jacobson (2002) in finding the education variable positive and significantly related to interest in joint management. Interestingly, if the landowner inherited the parcel, then this decreases the likelihood that an individual would indicate willingness to participate in joint forest management decisions. A possible explanation is that these landowners place high values on retaining property rights and managing their land independently that stem from this particular method of acquisition.

A landowner's willingness to jointly plan future forest management activities is increased when they use neighboring properties for non-consumptive recreation activities. This factor has not been considered in previous empirical work of landowner cooperation, yet the results clearly show evidence that spatial interdependencies influence an individual's interest in cooperating—i.e., it is also clear evidence of the jointly-defined utility we assumed earlier. Also, landowners who indicated they had cooperated with neighbors in the past in land management activities were more likely to exhibit willingness to enter into this joint agreement. Both the above activities by landowners indicate a level of familiarity with and interest in neighboring landowners and land characteristics, and would thus serve to reduce uncertainty inherent in entering such an agreement, through improved information, in individual preferences.

The marginal effects for the continuous explanatory variables (Table 2) provide an assessment of the change in the probability of a landowner participating in a joint agreement from Eq. (4) for future forest management given a 1% change in the explanatory variable beyond the sample mean, with all other variables held constant (Greene, 2000, pp. 816–818). These results indicate that the likelihood of entering into such an agreement increases by approximately 12% with a $10,000 addition in landowner income, which is comparable to a study of North Carolina landowners conducted by Jacobson et al. (2000). Landowners with greater exogenous wealth, income apart from that generated from timber harvesting, have alternate profiles regarding marginal utility of income from timber when compared to the average income landowner (Hyberg and Holthausen, 1989). While all landowners by assumption have declining marginal utility of income from timber, these landowners would be less likely to depend on revenue from timber and more likely to participate in a joint agreement that has the potential to interrupt planned timber revenue streams.

Incremental changes in the number of private individuals bordering the parcel in question increased landowner willingness to consider jointly planning forest management with neighbors by approximately 2% per additional neighbor. Thus an additional adjacent private landowner beyond the sample average increases an individual landowner's willingness to participate in this cooperative management agreement. Similarly an increase in the percent of agricultural lands bordering the parcel increases probability of participation by 23% per property, perhaps because in this case forest cover is scarcer locally. Increases in the number of surrounding landowners and percentage of agricultural lands may also raise concerns regarding future bordering land use activities that could be alleviated through entering this agreement.

Landowner preferences expressed as a willingness to harvest at the same time as neighbor(s) when there is a 20% stumpage price premium for harvesting together, are examined in Table 3. This decision was examined by posing a hypothetical situation, where landowners were asked to assume that both their own and neighboring parcels had trees that were old enough to harvest, and then they were asked to indicate their willingness to coordinate the timing of harvesting given the aforementioned stumpage price premium. By formulating the question in this manner, factors influencing this stated preference (Eq. (5)) take on point-in-time values. That is, we are not required to account for differences in each parcel's value (as calculated using quantitative measures of stock) but can assume that each respondent has a similarly stocked stand when they make this statement regarding their willingness to participate. Referring to the table, there were ten explanatory variables that significantly influenced a representative landowner's incentive with a *p*-value less than 0.1, including whether the landowner had harvested trees for sale from the parcel in the past (+), whether the landowner completed college (+), whether the landowner placed importance on owning the parcel for investment purposes (+), the presence of structures on the property (−), household income (+), the forestland

Table 3
Logit estimation of a representative central Virginia NIPF landowner's willingness to harvest at the same time as neighbor(s) with a 20% increase in the price received for timber.

Variable	Coefficient	Standard error	Marginal effects[a]
Constant	−2.080***		
Absentee	0.421		
Household income	6.44E−6***	2.31E−6	1.38E−6
Plan to give land to heirs	−0.110		
Inherited parcel	0.103		
Roads (miles)	−0.109	0.102	
Importance of owning land for environmental reasons	−0.145		
Years owned property	1.29E−2	8.69E−3	
Risk associated with growing trees for income purposes (0,1)	−0.443		
Risk associated with losing timber to natural occurrences (0,1)	0.129		
Forested acres	4.85E−3**	1.97E−3	1.04E−3
Number of children	8.12E−2	6.94E−2	
Employed full time	0.339		
Sold timber in the past	0.630***		
Relatively flat terrain	−0.162		
Permanent structures present	−0.570***		
Importance of owning land as an investment (0,1)	0.447**		
Completed college	0.525**		
Hunted on own parcel in last year	−0.435*		
Non-consumptive recreation on own parcel in last year	−0.117		
Percent of land parcel bordered by forestland	−0.323	0.439	
Percent of land parcel bordered by cropland or pasture	0.657	0.539	
Number of private individuals owning bordering parcels	−5.66E−3*	4.17E−2	−1.22E−3
Allow others to hunt or use own land for recreation (0,1)	0.171		
Hunt or fish on neighboring parcel(s)	0.703**		
Non-consumptive recreation on neighboring parcel(s)	0.152		
Past participation in land management activities with neighbors	−8.21		
Account for how own management affects neighbors	−0.272		

*** Significant with *p*-value 0.01.
** Significant with *p*-value 0.05.
* Significant with *p*-value 0.10.
[a] Marginal effects of non-dummy variables computed at the overall mean of the data set.

acreage of the parcel (+), participation in consumptive, i.e., hunting and fishing, recreation on the parcel (−), participation in consumptive recreation on neighboring parcels (+), and the number of private individuals (parcels) bordering the parcel in question (−).

Landowners who indicated that ownership of their land is important for investment purposes were more willing to coordinate timing of harvests with neighbors.[3] Either constant or increasing marginal utility from timber benefits provided with the additional price incentive could explain why these landowners are more willing to participate in an agreement that would serve to effectively alter the timing of their overall investment strategy. Also, it could be that these landowners realize that such a price incentive would increase their overall return on investment at that time. Similarly, landowners with previous timber harvesting experience were more likely to state willingness to participate in a cooperative agreement. Prior experiences with timber harvesting increase knowledge of such practices and along with completion of college may serve to increase the landowner's information base, improving willingness to participate in an agreement that has potential benefits in terms of economies of scale. While those individuals who intend to bequeath land to heirs were less likely to indicate a willingness to participate in the arrangement that would coordinate timing of harvests which would in effect constrain harvesting options available to their heirs.

Willingness to coordinate timing of harvesting was more likely for higher income landowners. Again, landowners may have more income timing flexibility and thus may be more willing to offset their planned harvest schedules because they have a current best alternative for income generation (e.g., Hartman, 1976). Participation in consumptive recreation is an indicator of value for other tangible resources provided by forest stands. Interestingly, we find an increased likelihood of entering the cooperative agreement among individuals who participated in such activities on neighboring lands and a decreased likelihood among individuals who participated in such activities on their own land. For those individuals who participate in consumptive activities on their own land, they have both amenity values associated with the forest stand condition and transaction costs, in terms of finding an alternative place to engage in these activities, to consider. These results are contradictory to Conway et al., (2003), who found that number of hunting days positively influenced an individual's probability of harvesting, but similar to those of Jenkins et al., (2002) where consumptive forest users held forest protection values that were sensitive to a change in forest conditions. Increased likelihood in participating in a joint harvesting agreement by individuals who participate in consumptive recreation activities on neighboring lands could be the result of either the presence of substitute areas in which to undertake these activities at a transaction cost no more than the incentive payment received or that the own and adjacent parcels are complementary in production of these products and thus by coordinating harvest timing there are efficiencies to scale created along with the addition of a price incentive.

The results indicate that the likelihood of entering into such an agreement increased by approximately 14% with a $10,000 addition in landowner income (Table 3). Here both the price premium and additional exogenous income allow for flexibility in an individual landowner's timber management plans. Both additional own forestland acreage and surrounding fragmentation in terms of numbers of bordering landowners that are private individuals have negligible effects on an individual's willingness to coordinate timing of harvests with adjacent owners. The first result may be due to economies of scale in that the individual does not experience the benefits of coordination that would result from combining many small parcels, and transactions costs of coordination may be enough to offset any marginal gain that did result. A similar argument could be used to explain the 0.1% decline in individual willingness to coordinate timing of harvest per property related to increased fragmentation, in terms of a 1% increase over the average in the number of private individuals who own neighboring parcels. This effect may also be a result of increased desire for privacy from adjacent properties that is afforded by standing timber.

We also tested the null hypothesis that coefficients of variables representing use of own land and adjacent lands for recreation activities were jointly equal to zero using the likelihood ratio test to compare the unrestricted models previously described with models that were restricted through exclusion of the recreation use indicators. These indicators of recreational use provide a means of attributing value for non-timber benefits for standing timber resources and the position of the parcel in the landscape, i.e., spatial interdependencies factoring in an individual's valuation decision, and were thus essential to the premise of this analysis. The null hypothesis that these coefficients were jointly equal to zero was rejected at a *p*-level less than 0.05. This indicates that valuation of own and adjacent parcels by landowners for non-timber

[3] Here the categorical variable indicating level of importance, where the endpoints of the range are 1 indicating least important and 5 indicating most important, were converted to dummy variable with 1–3 indicating no importance (0 value for dummy variable) and 4 and 5 indicating importance of the objective.

benefits do appear to play an important role in landowner decision making.

5. Conclusions

Empirical research focusing on how adjacent landowners affect any given non-industrial landowner's decisions is sparse. Much of this work has focused on the concepts of ecosystem management under the assumption of a single landowner managing multiple stands across a landscape (Brunson et al., 1996; Jacobson, 2002; Klosowski et al., 2001). There has also been a separate set of theoretical literature considering the spatial interdependence of forested parcels in the production of non-timber benefits for an individual landowner or social planner (Swallow and Wear, 1993; Koskela and Ollikainen, 2001; Amacher et al., 2004). This work has established that there are externalities present in individual management of forested parcels, because landowners may not account for spatial interdependence of their parcel with adjoining neighboring parcels in the production of landscape level benefits that are non-market in scope.

Our study adds to this literature by offering an empirical analysis of landowner behavior with respect to adjoining landowners. Our finding that a relatively high percent of responding landowners account for adjacent lands when making land management decisions serves to confirm existing theories regarding the spatial sensitivity of landowner forest management decisions. Further, our examination of landowners' stated preferences towards participation in a joint agreement governing forest management activities with neighboring landowners lends even more support to prior theoretical analyses. Another interesting result concerns landowner participation in recreation activities on adjacent land, an indicator of the individual's value for services provided by standing timber on adjacent parcels not related to income effects on their own land. This quantifiable measure of spatial interdependence in the production of non-timber benefits served as a significant positive characteristic in determining an individual landowner's incentive preference.

We find that spatial relationships of land parcels are important to a given landowner's willingness to cooperate. In fact, we show that spatial interdependencies in the production of a particular good, i.e., recreation, are clearly considered by landowners contemplating participation in cooperative management activities. Also, the number of bordering landowners that were private individuals (as opposed to public or industrial) and the percent of bordering land employed in agricultural crop or pasture uses both tend to increase a given landowner's willingness to participate in jointly managing forest stocks. But the number of bordering private landowners decreased willingness to participate in the coordination of harvesting decisions.

The two cooperative management agreements we examine here are not necessarily mutually exclusive decisions. However, they do provide insight into the most important characteristics factoring in an individual's willingness to participate in cooperative agreements with neighbors in the context of our data. Completion of a university education is significant in determining willingness to participate in the two cooperative agreements analyzed here and has a positive effect. Exogenous income sources, quantified here as household non-forest income, have a positive effect on the likelihood of an individual expressing willingness to participate in the two cooperative agreements. We also found that prior experiences relating to the proposed cooperative agreement, either by harvest or management are important positive factors to landowner participation in the respective agreement. This may support the well known idea that the best way to learn is through experience and is supportive of prior studies (Brunson et al. 1996), where landowners indicated that they would first have to observe cooperation in action prior to agreeing to take part in such an activity. Most importantly, spatial links for non-timber values measured through non-consumptive and consumptive recreational use of adjacent parcels mean an increased willingness of the landowner in question to coordinate management activities and coordination of harvest activities, respectively. Clearly, these results show that non-timber valuation of a landowner in our sample is dependent on adjacent stands, as the theory literature supposes.

In the future, our approach and results could be used in simulation exercises to model future forest landscapes with information on probabilities that landowners with specific characteristics would enter into cooperative agreements on a large scale, perhaps with an interest in determining how forest cover in a region changes through various types of cooperative agreements. This type of analysis will become increasingly important as forest fragmentation and urbanization continue to place pressure on remaining forested landscapes. The estimated equations could also be used to further evaluate the role that spatial interdependencies have in affecting individual behavior when addressing threats to forest health and sustainability. Threats such as invasive species and fire may eventually merit governments seeking to encourage cooperation, and our results provide a first empirical examination of the factors important for targeting of such programs. Finally, the estimation of spatial interdependencies and landowners' willingness to coordinate management of forest resources with neighbors could be used together to assess how changes in landscape and landowner characteristics influence future supplies of timber and the services provided by standing timber resources across the landscape through integration with landscape level models and ecological process models.

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