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Econometric analyses of nonindustrial forest landowners: Is there anything left to study?

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Abstract

In this paper we review recent econometric studies focusing on how nonindustrial private forest landowners make decisions. We use our synthesis of previous work and a discussion of emerging problems involving these landowners as motivation for future research. The majority of research undertaken prior to the late 1980's involved determining variables affecting reforestation or harvesting decisions. In the past decade, researchers have studied a broader set of issues, including the interrelationship between nontimber activities and other important decisions, such as bequests, examination of how landowner type and preferences affects decision making, and incorporation of landowner level responses into spatial landscape models. Using these trends as motivation, we end by proposing several new research directions. These include characterizing landowner reservation prices for various activities as a way of assessing market participation, evaluating the importance of adjacent landowners to a given landowner's behavior, investigating the substitution between various types of land use decisions, continuing to integrate landowner-level data into spatial landscape models, and broadening our understanding of institutional arrangements and landowner willingness to enter evaluating informational asymmetries, into such arrangements.

Key words: nonindustrial forest landowners, timber supply, land use.

JEL classification: Q230, N500

Introduction

In this Journal, Newman (2002) recently demonstrated how the Faustmann Model has been a historically important research area among forest economists. Aside from Faustmann, perhaps no other area of forest economics has been so widely studied as the behavior of nonindustrial private forest landowners. There have been two directions in this literature. One proposes new theoretical models to explain landowner behavior under certainty, uncertainty, complete and incomplete markets, as well as the policy interventions that can be used in many cases to

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change behavior.[1] Our purpose in this paper is to review the other set of literature, namely econometric studies undertaken to explain how nonindustrial forest landowners make decisions, and to identify the types of variables and preferences important to theis decisions. We will not attempt to review the entire history of this work, but rather we will focus on research spanning the last 15 or so years. The majority of the work completed prior to this period involved determining variables important to landowner reforestation or harvesting decisions, with the emphasis on explaining the probability that landowners harvest or reforest. In the past decade, researchers have studied a broader set of issues, including the interrelationship between nontimber activities and harvesting, reforestation and timber bequests, and examination of how landowner preferences or the type of landowner affects decision making.

Given the multitude of work and results that exist, one might suppose that there is nothing left to learn from the study of nonindustrial landowners. This is far from true. In fact, the development of theoretical models has provided many questions that have yet to be investigated empirically. In the second part of the paper, we will propose several new research directions building upon yet-unstudied, or little-studied, areas that have been modeled in the theoretical literature. These include characterizing reservation prices for various activities as a way of assessing landowner willingness to participate in market, rather than nonmarket activities, evaluating the importance of adjacent landowners to a given landowner's behavior, investigating the substitution between various types of land use decisions, evaluating informational asymmetries involving these landowners in markets, continuing to integrate landowner-level data into spatial landscape models, and broadening our understanding of institutional arrangements and landowner willingness to enter into such arrangements.

A word about our literature review is needed before proceeding. Early on, researchers attempted to identify the most important determinants of landowner harvesting and reforestation investment behavior. As government programs and interventions grew in scope during the 1980's and 1990's, the work focusing on these programs did as well. Researchers also increasingly examined the decision to participate in reforestation cost share programs or the decision to leave timber/land as bequests. Most recently, there has been a shift in attention from assuming nonindustrial forest landowners maximize profits, to viewing their problem as one of maximizing utility (Binkley 1981, Boyd 1984, Max and Lehman 1988, Hyberg and Holthausen 1989). It is the utility-based post 1985 period that we will mainly concentrate on here. Readers are referred to Boyd and Hyde (1989) and Hyde and Newman (1991) for a discussion of the earlier literature, and

[1] Amacher 1997 provides a recent review of policy research related to these landowners, while Brazee and Newman 1999 provide a review of work related to landowner decision making under uncertainty. Hyde and Newman 1991 provide a somewhat recent review of other issues related to NIPFs.

to Pattanayak et al. (2002) for an excellent review of previous timber supply modelling as it relates to NIPF landowners. We will also focus only on those aspects that are important to the design of landowner behavior models. Thus, we will not discuss the large literature, mainly US-based, which looks at program participation of landowners.[2] We will also not focus on the large set of sociological literature regarding landowner attitudes and preferences. The reader is referred to Egan (1997), Bliss et al. (1997), Bourke and Luloff (1993), and Johnson et al. (1997) for examples of this work.

Landowner Objectives

Nonindustrial private forest (NIPF) landowners comprise close to 70 % of land ownership in many U. S. states and significant land holdings throughout Europe and especially Scandinavia. Not surprisingly, the behavior of nonindustrial landowners has been one of the most frequently visited topics in forest economics and policy research. Several books and hundreds of papers have been written. There are several good surveys of the early pre-1990 literature (see, for example, Boyd and Hyde 1989, and Hyde and Newman 1991). Since these early sets of reviews, much more econometric sophistication has been added in the study of landowner preferences and decisions, and more is known about how nontimber services are important to predicting the behavior of these landowners.

The objectives of these landowners and the decisions they make are critical to future timber supplies. Selected studies are summarized for the purpose of comparison in Table 1. The assumptions regarding nonindustrial landowner objectives have evolved over time in empirical work. The behavior of private landowners has been argued to be different than forest industry behavior due to the multi-objective nature of NIPF ownership. Nonindustrial landowners may not always respond to prices in the same way that forest industry does, and this makes predicting timber supply from NIPF land quite difficult, as noted first by Dennis (1989). However, Newman and Wear (1993) estimated a restricted profit function for NIPF and industrial landowners in the Coastal Plain region of the Southeastern U. S., finding that the two ownership groups respond similarly to input and output price changes. However, they also show that NIPF owners differed from their industrial counterparts with regards to the value attached to growing stocks for the amenity values they provide. Kuuluvainen et al. (1996) also find no significant differences between classes of forest landowners with regard to harvesting in Finland. Finally, Hultkrantz (1991) compared results from econometrics studies in the U. S. and Scandinavia during the 1980's, also showing that NIPF landowners responded to prices, costs, and interest rates in a way that is consistent with profit maximization.

[2] Most of these programs are found in the U. S, and some parts of Latin America. For examples of this literature, see Esseks et al. (1992), Bell et al. (1994), Nagubadi et al. (1996), Crabree et al. (1998), Romm et al. (1997), and Brockett and Gephard (1999).

Table 1. Estimation Results for NIPF Landowner Choice Models from the Literature.

	Binkley (1981)	DeSteiguer (1982, 1984)	Cohen (1983)	Boyd (1984)	Royer (1985)	Brooks (1985)	Greene and Blatner (1986)	Romm et al. (1987)
Explanatory Variables	Harvesting (%)	Forestry Investment W/out Cost-share Assistance	Reforestation (Acres)	Harvesting (%)	Reforestation (%)	Reforestation (%)	Timber Management (%)	Forestry Investment (%)
Region	New Hampshire	Southern U. S.	Southern U. S.		Southern U. S.	Southern U. S.	Arkansas	Northern CA
Degrees of Freedom		4	14		9	3	8	14
Sample Size		Not Available			251		511	471
Intercept		(+)***			(–)			(+)
Stumpage Price (Pulpwood or Sawtimber)	(+) and significant		(+)***	(+) and significant				
Sawtimber Price ($)		(+)			(–)	(+)		
Pulpwood Price ($)					(+)**			
Reforestation Cost ($)			(–)		(–)**	(–) and significant		
Cost Sharing		(–)	(+)***	0	(+)***	(+) and significant		
Interest Rate (%)		(–)**	(–)					

Household Income ($)	(–) and significant	(+)****	(+)*		(+)***			(+)***High (+) Low (–)**** Mid
Tract Size	(+) and significant		(+) and significant	(–)		(+)****	(+)	
Standing Stock								
Farming (0/1)	(+) and significant		(+) and significant	(–)*		0		
Inheritance								
Technical Assistance (0/1)				(+) and significant	(+)***			
Absentee Ownership								(–)***
Age (Years)							(+)*	(–)* 64 and over
Education								
Organization Membership	(+) and significant		(+) and significant		(+)*			
Multiobjective Ownership								
Professional Occupation								

Notes: Only select explanatory variables are included.
(+) indicates coefficient is positive, (–) indicates coefficient is negative, (0) indicates coefficient is not significant.
* significant at 0.20 level, ** significant at 0.10 level, *** significant at 0.05 level, **** significant at 0.01 level.

Table 1. Continued.

	Straka and Doolittle (1987, 1988)	Hyberg and Holthausen (1989)	Hyberg and Holthausen (1989)	Dennis (1989)	Dennis (1990)	Esseks et al. (1992)	Bell et al. (1994)	Hardie and Parks (1996)
Explanatory Variables	Reforestation (%)	Harvesting (%)	Reforestation (%)	Harvest (%)	Harvest (%)	Participation in Cost Share Program (%)	Participation in Tennessee's Forest Steward-ship Program (%)	Reforesta-tion (Acres)
Region	Alabama	Georgia	Georgia	New Hampshire	New Hampshire		Tennessee	Southern U.S.
Degrees of Freedom	8	9	9	6	8	6	19	11
Sample Size	56	Not Available	Not Available	68	596		378	78
Intercept		(+)****	(–)****	(+)	(–)			(–)***
Stumpage Price (Pulpwood or Sawtimber)		(–)****	(+)****					
Sawtimber Price ($)				(+)				(+)***
Pulpwood Price ($)								(+)
Reforestation Cost ($)			(–)****				(–) and significant	(+)***
Cost Sharing		(+)****	(+)****				(+)	(+)***
Interest Rate (%)								

Household Income ($)	(+)****	(–)***	(+)*	(–)***	(–)***	(–)***	(+) and significant	(+)***
Tract Size	(+)****	(+)*	(+)		(+)	(+)	(–)	(+)****
Standing Stock				(+)***	(+)***			
Farming (0/1)		(+)****	(–)				(+)	(–)
Inheritance								(+)****
Technical Assistance (0/1)		(+)****	(+)*			(+)***		(+)****
Absentee Ownership								
Age (Years)	n/a							(+)
Education	(+)****			(–)**	(–)***		(+)	
Organization Membership	(+)**							
Multiobjective Ownership	n/a							
Professional Occupation				(+)	(+)**			

Notes: Only select explanatory variables are included.
(+) indicates coefficient is positive, (–) indicates coefficient is negative, (0) indicates coefficient is not significant.
* significant at 0.20 level, ** significant at 0.10 level, *** significant at 0.05 level, **** significant at 0.01 level.

Table 1. Continued.

	Kuuluvainen et al. (1996)	Nagubadi et al. (1996)	Nagubadi et al. (1996)	Conway (1998)	Conway (1998)	Conway (1998)	Kline et al. (2000)
Explanatory Variables	Harvest (%)	Participation in Classified Forestry Programs (%)	Participation in Cost-share Programs (%)	Harvest (%)	Reforestation (%)	Timber Bequests (%)	Willingness to Accept Payment to Forgo Harvest ($)
Region	Finland	Indiana	Indiana	Virginia	Virginia	Virginia	Oregon/ Washington
Degrees of Freedom	11	16	16	13	8	14	15
Sample Size	730	329	329	190	98	220	461
Intercept	(–)	(–)	(–)	(–)	(–)**	(+)	(–)***
Stumpage Price (Pulpwood or Sawtimber)	(+)**				(+)	(+)**	
Sawtimber Price ($)							
Pulpwood Price ($)							
Reforestation Cost ($)							
Cost Sharing							
Interest Rate (%)							

Household Income ($)	(–)		(–)				(–)***
Tract Size		(+)****	(+)****	(+)****	(+)	(+)**	(–)****
Standing Stock	(+)***						
Farming (0/1)		(+)	(+)				
Inheritance							
Technical Assistance (0/1)							
Absentee Ownership				(+)****		(+)***	
Age (Years)		(+)**	(+)****				(+)**
Education		(+)	(+)*				(+)***
Organization Membership		(+)***	(+)***				
Multiobjective Ownership	(+)***						(–)**
Professional Occupation	(+)	(+)					

Notes: Only select explanatory variables are included.
(+) indicates coefficient is positive, (–) indicates coefficient is negative, (0) indicates coefficient is not significant.
* significant at 0.20 level, ** significant at 0.10 level, *** significant at 0.05 level, **** significant at 0.01 level.

Nontimber management goals are now assumed to be a major part of the objective function maximized by NIPF landowners (Hartman 1976, Binkley 1981, Boyd 1984, Newman and Wear 1993), and many empirical studies have found this to be true (Conway et al. 2002, Pattanayak et al. 2002, Marler and Graves 1974, Hodges and Cubbage 1990, Alig et al. 1990). One explanation, noted by Alig et al., is the effect increasing wealth has had on nontimber benefits when viewed as leisure goods. In many cases landowners still appear to have an interest in jointly producing both timber income and forest amenities (Egan 1997, Newman and Wear 1993, Conway et al. 2002, Pattanayak et al. 2002).

This shift in landowner objectives toward nontimber uses of land has sometimes meant that public intervention was viewed as necessary to induce landowners to manage their land for timber, despite that economists would not argue for public intervention of this type in every case (Boyd and Hyde 1989, Bell et al. 1994). An ongoing concern has therefore been the specific role governments should take in the management of NIPF lands, particularly with regard to tax and incentive design (e. g., see Amacher 1997). In the United States, the government has relied much more heavily on financial incentives for landowners compared to other countries. Many of these programs target reforestation and began in the 1930's (Goodwin et al. 2002). Incentives have taken the form of funds for research, extension, and technical assistance, as well as tax benefits and input subsidies such as cost sharing of tree planting activities.

Landowner Decisions

As assumptions about landowner objectives have evolved, so to has our understanding of the decisions they make. A significant interest in early work was to study the harvest, reforestation, and program participation decisions of landowners using qualitative response models. Here, the probability of a landowner undertaking some activity is related to prices, costs, interest rates, physical land characteristics, and landowner demographics and preferences. Binkley (1981) was among the first to rigorously examine the harvest behavior of NIPF landowners for a sample in the Northeastern U. S., finding stumpage price to be a significant predictor of harvest behavior. His results suggested that the substitution effect of a price increase might be stronger than the income effect (see also Dennis 1989 for an interpretation of this). Boyd (1984) investigated the effect of reforestation cost sharing on the harvest decision, but showed that the cost share payments were not a significant predictor of harvesting. Significant variables in the harvest decision included stumpage price, technical assistance, size of landholding, farm occupation, and education. Hyberg and Holthausen (1989) presented both harvest and reforestation models based on survey data collected in Georgia. Several variables were found to be significant in predicting harvesting, including income and land values, which were inversely related to the probability of harvesting. Stumpage prices were negatively correlated with harvesting, while landholding size, knowledge of cost share, technical assistance, and farming as an occupation were positive predictors. Dennis (1989, 1990) found the harvest decision was influenced by income, education, and the relative values landowners place on amenities and consumption. Amenity preferences were represented by standing forest stock (Pattanayak et al. 2002 also represented these preferences by forest area in their study of timber supply and nontimber services from NIPF lands). The negative coefficient Dennis obtained for the income variable also suggested, like others, that affluent landowners were less interested in timber production. In a similar study of Finnish landowners, Kuuluvainen et al. (1996) concluded that high stumpage prices, standing stock, and forest growth were all important indicators of timber harvesting by NIPF owners in that country. Finally, Conway et al. (2002) investigated the behavior of NIPF landowners in the Southern U. S., observing that risk perception associated with growing trees and landholding size were important predictors of timber harvesting, while absentee ownership (defined by location of residence greater than 50 miles from the land parcel) negatively influenced harvesting.

Notice from Table 1 that the coefficient on land ownership area was positive for all estimated harvest probability models. In fact, Dennis (1989) conjectured early on that changes in timber supply could nearly always be attributed to changes in total land area in production, rather than increases in per-acre volume or growing stock change that followed from forest management. Increased harvesting on larger landholdings has also been supported with an economies of scale argument by some authors (Dennis 1989, Hyberg and Holthausen 1989, Conway et al. 2002). The findings are interesting and relevant, as policy-makers now consider an important issue to be the current trend towards parcelization of NIPF land into smaller land units, as urbanization and economic growth spreads from city centers (e. g., Sampson and Decoster 2000). The bulk of research implies that increasing parcelization may indeed reduce timber availability over a range of prices.

The treatment of timber prices has not been consistent among studies investigating harvest responses of forest landowners. Dennis (1989, 1990) and Hyberg and Holthausen (1989) used aggregate prices in their models, while Conway et al. (2002) used actual returns for those who harvested and predicted prices for those who did not. Kuuluvainen et al. used annual prices from written contracts with the individual landowners for the years the landowner made a sale, and regional prices for the years the owner did not sell.

Not surprisingly, there has been considerable debate regarding the role that prices play in harvesting decisions. In his study of harvest behavior, Dennis (1989) argued that price-induced harvest changes depend on the relative strengths of substitution and income effects associated with changes in prices. If this is true, then it is possible for price to have a statistically insignificant effect on harvesting or the likelihood of harvesting. Other work has supported this, finding a lack of responsiveness of landowners to stumpage prices in various management decisions (de Stiegeur 1984, Brooks 1985, Alig 1986, Dennis 1989, Newman and Wear 1993, Conway et al. 2002, Klosowski et al. 2001). However, still others have identified a significant influence of price on management decisions, particularly for sawtimber harvests or for short term harvesting (Binkley 1981, Cohen 1983, Royer 1985, Hyberg and Holthausen 1989, Kuuluvainen et al. 1996). Kuuluvainen and Tahvonen (1999) find, using panel data of Finnish nonindustrial landowners, that price has a significant and positive short run effect on timber supply. Significant and positive short run impacts of price are also found in Bolkesjø and Baardsen (2002), who also show that elasticities of supply are fairly sensitive to future price forecasts of future timber prices. The price influence is also positive in all other work that finds significance of the effect, except for Hyberg and Holthausen (1989).

The decision to reforest land following harvest has also been a subject of much interest in empirical research, particularly in the U. S. where such behavior is not always undertaken upon harvesting. Royer (1985) was among the first to model and rigorously test the reforestation behavior of Southern U. S. NIPF owners. His results suggested that pulpwood prices, knowledge of cost sharing, income, and contact with professional foresters prior to harvesting were important predictors of pine tree planting on cutover timberlands. The positive relationship between pulpwood prices and reforestation implies that landowners are more responsive to price signals associated with short-term investments. Reforestation costs and farming as an occupation reduced the likelihood of reforestation. Brooks (1985) analyzed the effect of cost share on reforestation probability, finding that cost share payments significantly increased the likelihood of tree planting. Similarly, reforestation costs negatively influenced tree planting in the south central U. S., but stumpage prices had no effect on reforestation in his study. Romm et al. (1987) related forestry land investment in Northern California to a variety of owner and ownership characteristics. High income and full-time residence were significant predictors of investment behavior (e. g., reforestation) in their model. Mid-range income, absentee ownership, and age were shown to reduce forest investment, implying that forest policies when used to stimulate planting should target wealthier landowners who reside on their land, and should recognize regional differences in how landowners respond. Hyberg and Holthausen (1989) found that knowledge of cost sharing not only increased likelihood of harvesting, as mentioned above, but also affected the probability of reforestation. Stumpage prices, household income, and technical assistance also positively influenced tree planting, while reforestation costs led to decreased tree planting. Finally, Conway (1998) found that access to the resource, timber bequest intentions, and landowner debt to income ratio were important predictors of reforestation.

Information-based empirical models of harvesting and reforestation decisions have also been adapted from other disciplines. For example, Straka and Doolittle

(1988) developed a "diffusion of innovations" approach, modified from the agricultural technology adoption literature, to assess how information about a new product or practice is communicated to individuals, and to determine how individuals respond to this information through changes in behavior. Based on their results, landowners who reforested were characterized as more innovative, with higher incomes, greater memberships in organizations, higher levels of education, and greater ownership of land. Greene and Blatner (1986) used discriminant analysis to model timber management behavior, finding that the propensity to manage timber depended on farming as an occupation, education, landholding area, and whether the landowner residing on their property. Like Romm et al. (1997), they also found regional differences in landowner decision-making.

Bequests

Harvesting, reforestation, and forestry assistance program participation are not the only important management decisions made by NIPF landowners. Early on, Royer (1985) argued that other decisions should be considered in landowner modeling. Although his argument was not immediately heeded, recently there has been a trend to examine other decisions NIPF owners make that have an influence on harvesting. Bequest motives represent one such decision. A landowner's willingness to bequeath standing timber to future generations is potentially important to future timber supplies as well as nontimber services produced from forests, since timber and land bequests affect the future contiguity and size of the forest sector. There has been some, but not extensive, empirical progress in this area (Hultkrantz 1991, Amacher et al. 2002a, Conway et al. 2002). Since many NIPF landowners in the U.S. are approaching retirement age (e.g., see Alig et al. 1990), their bequest decisions will clearly be important to the continued use of land in forestry production depending on the preferences of heirs. If heirs have preferences similar to their parents, then timber bequests from one generation to another may actually be more important in promoting long term timber investment than government incentives, according to Hultkrantz (1991). Royer (1985) found that plans to sell forest land within the next 20 years resulted in a 22 % decline in probability a landowner would reforest following a timber harvest. Conway et al. (2002) and Amacher et al. (2002a) related timber bequest intentions, in terms of whether a landowner planned to leave a timber bequest to heirs in the future, to a variety of land, owner, and market parameters. They determined that stumpage price, time spent in nonconsumptive recreational activities, and absentee ownership were significant and positive predictors of bequest motives for land and timber, while bequests were negatively correlated with landholding size.

Understanding bequests is important for policy design, especially for a social planner interested in achieving contiguous forest cover or achieving a certain level of old growth forests in the economy. The long run forest stock depends on bequests, as was shown by Amacher et al. 1999. Given that the long run forest stock contributes to welfare of the forest sector, particularly through production of nontimber benefits for society, it should be an important target of policy.

Quantifying the Participation in Nontimber Activities

Although forest economists have increasingly assumed that nontimber uses of land are important in modeling, it was not until recently that researchers attempted to measure these preferences empirically. Recent NIPF research has examined in more detail how landowners make tradeoffs between use of land for nontimber amenities and use of land for timber production, or use of land jointly for both. The substitution between harvesting and nontimber preferences has been of particular interest (Conway et al. 2002, Pattanayak et al. 2002), while the willingness of landowners to accept payments to forgo harvesting for wildlife habitat has also been estimated (Kline et al. 2000). Conway et al. assumed that harvesting and reforestation decisions are not determined independently of nontimber activity and bequest decisions. In their case, landowner nontimber activities are modeled explicitly as an endogenous variable by considering the choice of activity and the time spent in an activity. In other studies amenity values have been examined by assuming that landowners holding greater forest inventories were more likely to prefer use of forest for nontimber services (Binkley 1981). The choice of land devoted to forest habitat has also been considered as a nontimber-related choice nonindustrial landowners make (Pattanayak et al. 2002).

Conway et al. showed that nonconsumptive activities, such as hiking, camping, and observing wildlife, were positive indicators of timber bequest intentions, but recreational activities were not correlated with harvesting or reforestation behavior in their models. Kline et al. (2000) conducted a telephone survey of NIPF owners in western Oregon and western Washington to determine willingness of landowners to accept incentive payments and forgo harvesting for the purpose of protecting wildlife habitat. Their survey methods were based on single referendum methods used to value public goods. Willingness to accept was related to ownership objectives, socioeconomic characteristics, and incentive offered. Landowner age, education, income, multi-objective ownership, and incentive payment were positive predictors of willingness to accept, while size of landholding, sales income, and plans to cut trees were negative predictors of willingness to accept.

Predicting the Intensity of Forest Practices

While most of the above studies considered the probability of a landowner undertaking an action, there are some studies that have examined the intensity of these decisions. de Steigeur (1982, 1984), Cohen (1983), and Hardie and Parks (1996) examined the levels of management practices undertaken by forest landowners. Cohen (1983) finds that reforestation levels among U. S. landowners were positively correlated with stumpage prices, cost sharing, and household income, but reforestation costs and interest rates did not emerge as significant factors. de Steigeur (1984) was interested in whether government payments (specifically from the U. S. Forestry Incentive and Agricultural Conservation Payments programs) substitute for private investment through tree planting. In his model, investment level was influenced positively by income and negatively by interest rates. Government cost share payments were not significant, supporting his hypothesis that cost share payments have not significantly altered reforestation investment by NIPF landowners (Goodwin et al. 2002 also finds this to be the case using aggregate time series cross section data for several southern U. S. states). In another study of forest management investments by southern landowners, Hodges and Cubbage (1990) identified landholding area, technical assistance, and knowledge of government cost sharing as important determinants of reforestation intensity. Hardie and Parks (1996) explored intensity of reforestation in response to the U. S. Conservation Reserve Program payments in the South. Their results indicated that sawtimber price, cost share payments, household income, size of landholding, technical assistance and inheritance of the property were significant and positive predictors.

New Research Directions

The main point of this article is to use the existing body of work to propose several new and fruitful directions for empirical research of NIPF landowners. All of these topics have been studied very little but are important to future policy making.

Investigate Market Entry Potential of Landowners

As our discussion above shows, previous empirical landowner behavior models have primarily focused on estimating probabilities or levels of harvesting or reforestation, or on investigating the importance of nontimber services to harvesting decisions. There has been a separate set of theoretical work formalizing landowners' decisions to participate in harvesting activities when facing uncertainty in future prices (see Brazee and Mendelsohn 1988 for the original article on this subject, and Fina et al. (2001) for a discussion of recent literature). In this work, the existence of a "reservation price" is established for landowner decisions. Reservation prices for harvesting represent the minimum payment a landowner must receive before harvesting or selling their timber. A reservation price should exist in principle for all landowner market decisions, such as selling land, or switching land use from agriculture to forest production through reforestation and afforestation efforts. One might suppose, then, that reservation price strategies of landowners could be examined empirically by estimating the minimum payment landowners are willing to accept to enter into various institutional arrangements and decisions involving their land.

The empirical estimation of reservation prices, and the testing of reservation price strategies among landowners, both remain unstudied areas in empirical research. Yet these ideas are potentially important to predicting future timber supply. Consider areas impacted by urbanization or forest parcelization, where there are often large numbers of absentee landowners, and large numbers of landowners not actively engaged in harvesting or reforesting over long periods of time. The preferences of these landowners are important determinants of their reservation prices and hence their propensity to enter timber markets in the future. Thus, understanding the preferences of landowners who currently do not participate in markets, or have not participated at the time of data collection, is potentially important in predicting how forest markets shift as prices or other important factors change.

Estimating reservation prices poses a challenge, as they are time dependent unobserved, and obviously functions of both landowner preferences and market parameters. It may be more useful to identify variables that impact the reservation price strategies of landowners, and to estimate the willingness to accept for various decisions. Reservation prices for any individual landowner also depend on the age of timber held, as the before-mentioned studies identify a path of reservation prices over time for a landowner. Differences in preferences for harvesting and other forest management decisions will be realized through differences in the willingness to accept, and the path of willingness to accept. Landowner interest in nontimber uses, bequest motives, and risk will therefore affect estimated reservation prices.

Clearly, to understand how likely it is that different types of landowners will eventually harvest or sell land, or understand how various policies will affect the decisions of landowners to enter the market, we need to identify what are the most important factors comprising reservation prices and the offer acceptance strategies for different types of landowners. A comparison of estimated reservation prices and market prices for landowner activities is also needed. If researchers can estimate two types of (related) reservation prices, harvesting and land use, then we would have an additional tool to examine changes in timber supply with shifts in market prices. Most models assume that landowners are price takers. If an individual landowner's reservation price for harvesting is higher than the prevailing market price, then the landowner will not enter the market and might be less likely to shift land use from non-forest to forest production. Understanding the difference between the two, one of which is observed and the other which has to be estimated, will therefore give some indication of how much markets need to change before landowner harvesting changes to certain degrees.

Differences between reservation prices and market prices should reflect costs incurred searching for buyers, differences in information between landowners and timber buyers, and specific characteristics of forest land that are valued in the market. However, differences will also depend on landowner preferences for use of their forests. Identifying the gap between reservation prices and market prices will improve the prediction of future land and timber sale activity, in that it will provide a means to determine what type of landowners exist at the economic "margin", that is, are closest to participating in sale activities. It will also indicate how far certain landowners are from participating in the market. These landowners would not typically be included in a sample of landowners who harvest in any given period.

It is this predictive capacity of empirical reservation price work that might offer the next contribution to timber supply modeling, or might be important to forecasting future changes in timber availability. In the U. S., most landowners in a given random sample have not harvested or "never" intend to harvest timber. Without knowing how far landowners are from the margin of harvesting activity, there is no way of knowing how far certain landowners are from participating in the market. The harvesting and reforestation choice models reviewed earlier require substantial data for landowners who have recently harvested. Moreover, in previous work it has been difficult to assume a price faced by those landowners who have not harvested or never intend to. The reservation price approach would be important if these types of landowners make up a significant portion of a region.

How might one go about estimating reservation prices for harvesting or converting land to forest use? One way is to use a revealed or stated preference approach where landowners are given various offers for undertaking a harvest or land use activity, and then asked to indicate whether they would accept or reject certain carefully chosen offers. There are two versions of this method that have recently been applied. One is to use referendum voting where a single price bid is offered. Landowners can either accept or reject this price. Kline et al. (2000) use this approach to consider how much landowners are willing to forego to preserve forests over a certain time period. The other method to assess reservation price strategies is to offer a range of prices through a payment table (see Welsh and Poe 1998), and then allow landowners to indicate how likely they are to accept these prices if offered. This approach has been taken very recently by Amacher et al. 2001, Vokoun et al. 2002, and Conway 2002 and allows one to identify thresholds for prices landowners would accept to participate in the market. Both methods can also be used to determine offers a given landowner would be willing to accept for harvesting under varying probabilities. Both methods therefore can be used to identify the most important predictors of reservation prices.[3]

Investigate Importance of Adjacent Landowners

Forest ecosystems exist as complex site specific interactions between plant and animal species. As Gong (2002) argues, economists must find ways to model how

[3] Empirical analysis of reservation prices could also be used to improve targeting of government policies in ways the previous literature has not addressed. For example, suppose a policy maker wished to achieve a certain acreage target for land in forests, perhaps in response to a carbon sequestration goal. Estimated reservation prices for land use decisions would indicate the minimum payment landowners would need to receive in order to achieve the land use target. This would obviously be a function of the preferences any landowner has for timber and nontimber uses of forests.

these interactions cut across the many stands that comprise any forest unit. Biologists have long recognized the importance of adjacent stands, arguing that trees of many age classes and species mixes are necessary for biodiversity or provision of wildlife habitat (Franklin and Foreman 1987, Giles 1978). The interdependence between forest stands may also be use-related. For instance, recreational opportunities of larger forest areas may be dependent on the interaction or coordinated management of several stands.

There is very little in the way of empirical economics research focusing on the affect of adjacent landowners on a given nonindustrial forest landowner's behavior. This is unfortunate, because a landowner's decisions can affect the welfare of adjacent or nearby landowners. One could easily imagine that the quality of nontimber benefits produced from forests, such as wildlife amenities, should depend importantly on the extent to which adjacent landowner decisions are or are not coordinated. Landowners may know this, making decisions with the effect on other landowners in mind, or landowners may anticipate the future management decisions of adjacent landowners.

There has not been much in the way of theory directed at understanding landowner decisions when stands are interdependent. This idea was originally discussed in Bowes and Krutilla (1985, 1989), who used a linear programming approach to maximize the rents associated with multiple stands under a single (government) owner. Swallow and Wear (1993) and Swallow et al. (1997) were the first to formulate explicit spatial interactions for nontimber amenity benefits between two adjacent stands. Koskela and Ollikainen (2001) evaluated the rotation age decision for a landowner making decisions for a single stand, under the assumption of a purely exogenous adjacent stand. There is also very recent literature on stand interdependence in other settings, such as species conservation. This work focuses on the idea that multiple stands are needed to sustain certain species (e. g., Csuti et al. 1997, Ando et al. 1998, Polasky et al. 2000). An increasing number of empirical studies on conservation, ecosystem management, and forest management also exist, but these are typically undertaken only from the viewpoint of a single (social) landowner (see e. g. Bevers et al. 1995, Albers 1996, Haight and Travis 1997, Montgomery 1995).

There is some recent work that explores empirical possibilities for nonindustrial forest landowner cooperation of various forms. Uusivuori and Kuuluvainen (2001) examine the impact of capital market imperfections on incentives for forest landowners to enter into cooperative stand management as a way of hedging risk, finding that profits can be increasing functions of cooperation. Jacobson (2002) shows that forest landowners may be willing to jointly manage land under various ecosystem management strategies, such as preservation of wildlife corridors. Sample (1996) reports that difficulties will arise with joint forest management among landowners, especially when there is heterogeneity of the landscape or landowners have diverse preferences. Klosowski et al. (2001) shows that landowners in the Northeastern U. S. may be willing to cooperate and make decisions jointly, but only if economic incentives exist for coordinated management. They also show, using conjoint analysis, that property tax reductions may not be sufficient to encourage coordination. Kurtilla et al. (2001) examine gains from cooperation for many types of management schemes, including various types of strategic behavior. Eid et al. (2001) compute and compare the net present values of various landowner cooperative schemes, finding that monetary gains to cooperation may be small. Gains are higher for larger properties, but according to Sample (1996) cooperation may be difficult in these cases. Moreover, in North America, there has been much written about absentee landowners who live far from their properties, making it even more difficult to coordinate actions on their land. Information is also important to coordination. Jacobson demonstrates that landowners are less interested in pursuing joint management of forest land if they are not privy to information regarding the benefits of coordination (Jacobson 2002).

The extent that landowners account for the effects of their management on other landowners is a new and emerging empirical question. Recently, Amacher et al. (2002b) demonstrate in a game theory framework that the behavior of landowners who either do or do not coordinate, or who behave in a manner that anticipates other landowners' actions, could be socially costly in many situations. As the authors demonstrate, the impact of one landowner's decision on the forest ecosystem used by another landowner can represent a type of economic "externality" associated with private forest management.

Only a social planner who managed the entire forest ecosystem would have incentives to solve for the economically efficient rotation age of each stand, conditional on all other stands. The challenge for policy therefore becomes finding an instrument that encourages multiple landowners to act as if they were sole owners, managing their stands in concert. Such an instrument would obviously need to target the individual landowner, and thus it may not be feasible to implement in practice. It certainly is not feasible now given our current understanding of landowner behavior.

In light of this difficulty, the purpose of empirical work should be to identify how serious lack of coordination among landowners can be. Most previous work cited above has focused on *whether* landowners will cooperate. A fruitful line of research would be to link adjacent stand effects to observed and planned landowner decisions. This might be achieved through a survey targeted at groups of landowners, determining to what extent they view their decisions as important to adjacent landowners, and how much they anticipate the behavior of others when making harvesting, reforestation, and land use decisions.

As the work by Amacher et al. (2002b) and Koskela and Ollikainen (2001) suggest, most of the social costs associated with lack of coordination in adjacent landowner cases come from a landowner's ability to effectively commit to an action with regard to their neighbours. For example, a landowner may agree not to harvest a specific area of wildlife habitat because an adjacent landowner has also committed to doing so, and both landowners are hunters of late successional wildlife species. However, in periods of high prices, one landowner may have an incentive to harvest after such an understanding is reached, particularly because as we argued above, the reservation prices of landowners are specific to each person's preferences and therefore likely to differ. Understanding how landowners react to one another, if are they do at all, will also have a role in defining how landowners respond to policies targeting use of their forest land.

Investigate Further the Substitution Among Landowner Decisions

The discussion of existing literature suggests that we have considerable understanding about the harvesting and reforestation decisions of nonindustrial forest landowners, and some emerging understanding of other decisions and substitution between various decisions. What this newer work teaches us is how other decisions impact harvesting and reforestation, and why it is important not to examine one decision, such as harvesting, in isolation from other decisions. Rather, timber supply and landowner market participation depend on the interaction of all relevant decisions landowners make. Take, for example, the case of nontimber activities. Landowners with preferences for nontimber benefits that are complementary with harvesting would behave quite differently than landowners who valued nontimber services that are substitutes with harvesting. Moreover, in an empirical model explaining landowner behavior, the correlation between these decisions would imply the resulting model must be estimated accounting for potential endogeneity. Estimating harvesting without knowing how the landowner chooses or values nontimber services leads to biased results.

The problem becomes even more complicated when one considers the interaction of land use, nontimber activities, and timing of harvesting. Existing rotation-based models, nearly all of which follow from Hartman (1976), show repeatedly that landowners who value nontimber services for old growth timber would naturally choose longer rotations than landowners purely interested in timber income production. One aspect of the problem that these studies ignore is that there are always opportunities for NIPF owners to substitute forestland for time. That is, obtaining more land or shifting use on existing land to forest production compensates for holding forests of younger ages. The extent to which forest landowners respond in this manner would depend on the nature of nontimber amenities (i. e., how they arise over time as the forest stock changes), and the willingness and cost to the landowner of adding land or changing use on existing land. Landowners may consider it equivalent to either forgo harvesting for amenities, or simply bring more land into forest production. Only by specifying and considering a landowner's problem of forest use in equilibrium with other land use opportunities will researchers be able to assess the substitution possibilities that might arise. Tahvonen and Salo (1999) provide a model which considers various substitutions between stands and preferences for amenities and timber harvesting, but thus far, the data have not existed for an empirical assessment.

Stand interdependency is also potentially important here. If a landowner has access to adjacent land as a substitute for nontimber goods production (such as hunting or maintenance of wildlife habitat quality), then this interdependence between stands will impact the harvesting decision. Interestingly, a Scandinavian-U. S. comparison would be especially useful here – in Scandinavia, access to adjacent land is very different by law than access in the U. S. Obviously, an important factor here is also the timing of decisions across landowners, and for the same landowner. Provencher (1997) provides some support for this substitution. He argues that linearity in econometric specifications of nonindustrial timber harvesting decisions is a troublesome assumption, as it imposes certain restrictions on substitutability across decisions and activities for a landowner; therefore, specifying models in this way may not lead to a complete picture of how landowner decisions and important variables are related.

Integrate Landowner Behavior into Large Scale Policy Models

As we discussed above, many studies exist where authors have sought to estimate the probability that landowners undertake some activity, such as harvesting or reforestation. There is now a growing literature that considers land use change over time in spatial models. At the heart of land use change are the decisions that landowners make. However, many of these spatial models are not based upon actual landowner data defining responses of land use to external market changes. The challenge now is to integrate landowner response models into larger scale landscape models for meaningful policy analysis (e. g., Wear and Bolstad 1998).

The consequences of forest fragmentation is one potential research problem we could study with spatial models. Fragmentation of parcels into smaller units has been associated with either changing landowner characteristics or the current structure of taxation. Arguments are often made that parcelization of land into smaller pieces will eventually decrease timber supplies through reduced land access and higher wood costs (Sampson and Decoster 2000). Fragmentation may also reduce nontimber benefits by disrupting contiguous wildlife corridors. These changes would lead to a different type of forest industry organization, and they could also lead to changes in landowner composition on a large land area scale. Recall that recent work also establishes that landowner characteristics are changing. Increasingly, nonindustrial private landowners do not reside on their property, and these landowners have been shown to have different preferences for land and timber sales than the historically-abundant resident landowners. As we noted earlier, landowner differences are often realized through changes in bequest motives, reservation prices driving their market entry decisions, and the willingness to leave timber as a bequest.

A new layer of understanding for forest fragmentation can be achieved by first integrating models for predicting landowner behavior into spatial land use models. Landowner decision making would then be an endogenous factor driving the spatial realization of land use change. The benefits from greater integration of landowner responses into landscape models would be better predictions for how landscapes change in response to market changes or demographic changes in landownership, and better predictions of the pattern and size of environmental benefits and costs associated with landowner and market-driven change.

Examine Welfare Implications of Information Asymmetries

One assumption of nearly all previous empirical work is that markets are perfect in terms of the information available to landowners, although there has been theoretical research showing otherwise. In empirical work, it is implicitly assumed that landowners have the same information as timber buyers regarding prices for harvesting, and they know with certainty the market desirability of their land. There is some emerging new evidence that suggests otherwise. Hardie and Larson (1994) discuss a model where there is an asymmetry of information between buyers and sellers of timber with regard to the market. Munn and Rucker (1994) showed that landowners with access to consultants tend to obtain higher prices for timber harvesting than those landowners who participate in markets but do not have such representation. Most recently, Sullivan et al. (2002a) show, using a sample of winning timber sale bids, that the competitiveness of a timber sale, i. e., whether it was negotiated or based on elicited bids, affects the marginal valuation of forest land characteristics by the timber buyer.

These studies collectively suggest that there may be information externalities of varying degrees present in timber markets. Empirical work should seek to identify the costs to landowners from not having perfect information. The implications for how timber markets respond to changes in economic variables, such as prices, will depend on how competitive timber markets are. Thus, the existing literature where landowner responses to external market variables are estimated, and which assumes that landowners make decisions having perfect information, may be flawed.

There is much scope for future empirical work examining the implications for landowner behavior and timber supply when there are information differences. If we are able to study this, then we will have a better understanding of the social costs to landowners and markets associated with information asymmetries, and a better understanding of the scope for government intervention in these cases.

Assess Willingness of Landowners to Enter into Institutional Arrangements

The emerging literature regarding landowner cooperation discussed earlier, and the volume of existing research that links government intervention to landowner behaviour, beg the question of whether there is potential to introduce programs that foster cooperation. The answer depends generally on the willingness of NIPF landowners to enter into institutional arrangements. One new idea, called forest banking, has recently been examined by Sullivan et al. (2002b). This program is provides forest landowners with an opportunity to enroll their land into a cooperative, where an institution separate from the landowners manages the land for sustainable timber and steady income production. The landowner foregoes making future management decisions in return for annual payments by the institution.

The program studied by Sullivan et al. is currently being implemented in the U. S. by the Nature Conservancy. Sullivan et al. found that landowners may be willing to enrol in forest banking arrangement at bid levels that are consistent with local land rents. They further found that landowner preferences for bequests and nontimber amenities, as well as the gender of the main household decision maker, were the most important factors in predicting enrolment into such programs. They used a single referendum approach, discussed earlier in connection with reservation prices, to assess the willingness to accept for landowners to enter into forest bank programs.

Much more can be accomplished here by assessing the willingness of landowners to enter into different arrangements. For example, one might consider the case where landowners could enrol their forests into a common management scheme, in which the group of enrolled landowners shared income from forest management. This amounts to landowners foregoing some management or property rights associated with holding forest land. Obviously, landowners with high quality forests who do not value nontimber amenities might be less interested in this type of arrangement than those with poorer quality land, or those very interested in providing for nontimber amenities to the forest stock. Another question is whether governments should respond with interventions that encourage greater coordination of landowner decisions or encourage sharing of property rights over large numbers of landowners. In this case, the government could act in a way that minimizes transactions costs associated with forming the agreements.

Insurance markets could also be considered a form of institutional arrangement impacting forests. Certainly, forest landowners would respond to risk associated with holding forests differently if their investments could be insured against unforseen future shocks (such as fire or pests). Yet this is a relatively unstudied issue. As economists, it would be interesting to determine the extent to which landowners would behave differently when insurance markets are available versus when they are absent, and then determine how much worse off landowners are holding forests in markets that are incomplete regarding insurance. This work might be based upon referendum studies that seek to estimate either a compensating or equivalent variation under various cases of market insurance provision.

Finally, important future institutional arrangements that will impact NIPF landowners are those related to carbon sequestration and the development of carbon markets. World involvement in these arrangements is virtually ensured through existing agreements, such as the Kyoto Protocol. This agreement calls for reductions in country-based carbon emissions, which is in theory to come from offsets, where polluters arrange for land set asides with forest landowners. An important research issue here concerns the minimum payments landowners would need to receive before being willing to arrange for carbon set asides with polluting entities. In a referendum-based survey, payments to landowners could be structured as either annual or single payments, where landowners would essentially waive their rights to harvest for some determined length of time. Obviously, the importance of timber and non-timber services to the landowner would be important to these willingness to accept measures.

Landowner behavior in these cases could follow from the previously discussed theory of reservation prices. In the context of carbon payments, reservation prices would be defined as the minimum payment a landowner would accept to give up agricultural production and undertake forestry use on an acre of land. The reservation price will therefore depend on each landowner's preferences for agricultural and forest uses, as well as expectations of returns from and risks associated with these uses in the future. Reservation prices in this case would also capitalize landowner preferences involving non-income amenities associated with holding agricultural land or forests (for an agricultural example, see Taverneir et al. 1996). Ultimately, estimating these prices would allow a government to determine minimum payments needed to sequester certain yields of carbon. If nontimber preferences are strong for a landowner, then the cost to the government of providing incentives for sequestration would be considerably lower than lost agricultural returns landowners lose from shifting cropland into forests.

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