Chapter 22.

Nonindustrial Forest Landowner Research: A Synthesis and New Directions

Gregory S. Amacher, M. Christine Conway, and J. Sullivan[1]

Abstract—*In this chapter, we review recent empirical work related to the economics of nonindustrial forest landowner behavior, discuss emerging problems involving these landowners, and suggest topics for future research. Before the late 1980s, most work in this area was aimed at identifying variables affecting reforestation or harvesting decisions. Recently, researchers have studied a broader range of subjects, including the relationship between nontimber preferences and decisions, such as bequests, examination of the influence of type of landowner on decisionmaking, and use of landowner-level responses in spatial landscape models. We propose that future research characterize reservation prices for various activities, evaluate the extent to which a landowner's behavior influences that of adjacent landowners, investigate the substitution between various types of decisions, and integrate landowner-level models into spatial landscape models.*

INTRODUCTION

Nonindustrial private forest (NIPF) landowners are an extremely important group of forest owners, accounting for about 70 percent of land ownership in many States. Not surprisingly, the behavior of nonindustrial landowners has been one of the most frequently visited topics in forest economics, rural sociology, and policy research. Several books and hundreds of papers have been written about this subject, and there are several good surveys of the early literature. The purpose of this chapter is to review the voluminous recent literature, and then propose new directions for future research.

RECENT LITERATURE

Nonindustrial landowners are of interest to forest economists because of their relatively low timber productivity. Given that these landowners control the majority of timberland in the South and elsewhere in the United States, the decisions they make are critical to future timber supplies. Many landowners are reluctant to invest capital in long-term ventures such as timber production. The lack of insurance covering such investments can also be a deterrent to timber investment by landowners. Furthermore, landowners are thought to place considerable value on nontimber benefits associated with standing forest stock. Much recent work has been directed to explaining these preferences.

The Government has responded to timber supply concerns by offering a variety of incentive programs to landowners, most taking the form of cost-share payments for reforestation efforts following harvest, or incentives for afforestation of lands held in other predominantly agricultural uses. Most program funding has gone to southern landowners, as detailed by Goodwin and others (2002).

[1]Associate Professor, Doctoral Candidate, and Associate Professor, Virginia Polytechnic Institute and State University, Department of Forestry, Blacksburg, VA 24061, respectively.

In this section, we discuss a core of recent econometric studies. However, 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 grew in scope, researchers increasingly examined the decision to participate in reforestation cost-share programs or the decision to leave timber and land as bequests. Twenty years ago researchers began to believe that nonindustrial landowners view their problem as one of maximizing utility rather than one of maximizing profits (Binkley 1981, Boyd 1984, Hyberg and Holthausen 1989, Max and Lehman 1988). It is this utility-oriented post mid-1980s literature that we primarily concentrate on here. Readers are referred to Boyd and Hyde (1989) and Hyde and Newman (1991) for a discussion of the earlier literature on nonindustrial landowners, and to Pattanayak and others (2002) for an excellent review of the timber supply literature as it is related to NIPF landowners.

The behavior of private landowners is far less predictable than industry behavior, because of the multiobjective nature of their ownership and the difference in time horizons for management decisions. NIPF landowners may not always respond to prices in the same way that forest industry does; this makes predicting timber supply from NIPF land quite difficult, as noted first by Dennis (1989) and Newman and Wear (1993). Newman and Wear estimated a restricted profit function for NIPF and industrial landowners in the Coastal Plain region of the Southeast. While the two ownership groups were found to respond similarly to input and output price changes, NIPF owners differed from their industrial counterparts with regard to the value attached to growing stocks for the amenity values they provide. As a result, Newman and Wear concluded that NIPF landowners can be characterized as profit maximizers, who have preferences for amenities. Hultkrantz (1992) compared results from econometrics studies in the United States and Scandinavia during the 1980s, showing that NIPF landowners respond to prices, costs, and interest rates in a way that is consistent with profit maximization. However, he also concludes that it is necessary to determine what specific land, ownership, and market factors drive the various management decisions made by these landowners.

Nontimber management goals are thought to be a major reason for private ownership of forest land (Binkley 1981, Birch 1992, Boyd 1984, Conway and others 2003, Hartman 1976, Newman and Wear 1993, Pattanayak and others 2002). Nonindustrial owners do not typically own forest land primarily for the purpose of producing timber (Alig and others 1990, Hodges and Cubbage 1990, Marler and Graves 1974). One explanation, noted by Alig an others (1990), is the effect increasing wealth has had on the desire to produce nontimber benefits. Nevertheless, landowners often appear to have an interest in joint production of timber and forest amenities (Conway and others 2003, Egan 1997, Kline and others 2000, Newman and Wear 1993, Pattanayak and others 2002). Worrell and Irland (1975) list difficulties NIPF landowners must overcome if they are to produce timber and amenities successfully. These include lack of knowledge, incompatibility of nontimber and timber production goals, and low-profit potential.

Public intervention is often viewed as necessary to induce landowners to manage their land for timber (Bell and others 1994, Boyd and Hyde 1989), and design of tax and incentive programs has been an ongoing concern (Amacher 1997). The U.S. Government has relied on incentives much more than governments of other countries. Many of these programs for reforestation date from the 1930s (Goodwin and others 2002). Recent incentives have taken the form of funds for research, extension, and technical assistance, as well as tax benefits and input subsidies such as sharing of costs for tree planting (deSteigeur 1984).

Landowner Harvesting Decisions

Harvest, reforestation, and program participation decisions of landowners are often explored by means of qualitative response models. In these models, the probability that a landowner will undertake some activity is related to prices, costs, interest rates, physical land characteristics, and landowner demographics and preferences. Binkley (1981) modeled the harvest behavior of NIPF landowners in New Hampshire. He found that stumpage price was a significant predictor of harvest behavior, and this suggests that the substitution effect of a price increase is stronger than the income effect (Dennis 1989). Boyd (1984) investigated the effect of reforestation cost sharing on the harvest decision, and found that the cost-share payment is not a significant harvesting predictor. Variables significant to harvesting 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. This suggests that wealthier landowners forego harvest for the amenity values their forest land provides. Stumpage price was negatively correlated with harvesting, while tract size, knowledge of cost-sharing programs, technical assistance, and farming as an occupation were positive predictors. Dennis (1989, 1990) found that harvesting decisions were influenced by income, education, and relative values landowners place on amenities and consumption, as represented by standing stock. The negative coefficient he obtained for the income variable also suggests, like others, that affluent landowners might be less interested in timber production. In a similar study of Finnish landowners, Kuuluvainen and others (1996) concluded that high stumpage prices, standing stock, and forest growth are all important indicators of timber harvesting by NIPF owners. Conway and others (2003) investigated the behavior of NIPF landowners in Virginia, observing that risk perception associated with growing trees and tract size are important predictors of timber harvesting, and that absentee ownership (defined by location of residence > 50 miles from the land parcel) negatively influenced harvesting.

It is suggestive that the estimated coefficient of the tract size variable has been positive for all of the harvest probability models discussed here. In fact, Dennis (1989) predicted that changes in timber supply would be attributed to changes in total land area in production, rather than to increases in per-acre volume. A higher probability of harvesting on larger tracts also is consistent with observed higher net prices; i.e., the market price net of logging costs (Conway and others 2003, Dennis 1989, Hyberg and Holthausen 1989). The current trend towards parcelization of NIPF land into smaller land units, as urbanization and economic growth spreads from city centers, may, therefore, have important implications for policy. The bulk of research suggests that parcelization may reduce timber availability over a range of prices.

The treatment of timber prices differs among these studies. Dennis (1989, 1990) and Hyberg and Holthausen (1989) used aggregate prices in their models, while Conway and others (2003) used actual returns for those who harvested and predicted prices for those who did not. Kuuluvainen and others (1996) used annual prices from written contracts with the individual landowners for the years in which the landowner made a sale, and regional prices for the years in which the landowner did not sell. Not surprisingly, there has been considerable debate about the role that prices play in harvesting decisions. Dennis (1989) argues that stumpage price increases induce both income and substitution effects, and this implies that the effect of price on probability of timber harvesting depends on the relative strength of each effect. He further suggests that the influence of price on harvesting is necessarily ambiguous. Other work has supported this, finding a lack of responsiveness of landowners to stumpage prices in various management decisions (Alig 1986, Brooks 1985, Conway and others 2003, Dennis 1989, deStiegeur 1984, Klosowski and others 2001, Newman and Wear 1993). While these studies are numerous, others have identified a significant influence of price on management decisions, particularly for sawtimber harvests (Binkley 1981, Cohen 1983, Hyberg and Holthausen 1989, Kuuluvainen and others 1996, Royer 1985). The price influence is positive in all but Hyberg and Holthausen (1989).

Landowner Reforestation Decisions

The decision to reforest land following harvesting may be important for meeting long-term softwood timber production goals. In the South, most tree planting takes place on cutover timberland (Royer 1985, 1987). Royer (1985) modeled the reforestation behavior of southern NIPF owners. His results suggested that pulpwood prices, knowledge of cost sharing, income, and contact with professional foresters were important predictors of pine (*Pinus* spp.) tree planting on cutover timberlands. Higher reforestation costs and farming as an occupation reduced the likelihood of reforestation. Brooks (1985) found that cost-sharing payments significantly increase the likelihood of tree planting. Similarly, higher reforestation costs negatively influenced tree planting in the Southcentral United States. Stumpage prices had no effect on reforestation in his study. Romm and others (1987) relate forestry land investment in northern California to a variety of owner and ownership characteristics. High income and full-time residence emerged as significant predictors of investment behavior, (e.g., reforestation) in their model. Midrange income, absentee ownership, and greater landowner age preclude forestry investment. Hyberg and Holthausen (1989) found that knowledge of cost sharing not only increases likelihood of harvesting, as mentioned above,

but also affects the probability of reforestation. Stumpage prices, household income, and technical assistance also positively affected tree planting, while higher reforestation costs led to decreased tree planting. Finally, Conway and others (2003) and Amacher and others (1998) found that access to the resource, timber bequest intentions, and the ratio of landowner debt to income were important predictors of reforestation for Virginia landowners.

Models of timber management and reforestation behavior based on information have also been used to study landowner decisions. For example, Straka and Doolittle (1988) developed a "diffusion of innovations" model, of a kind widely used in agricultural technology adoption studies, to assess how information about a new product or practice is communicated to individuals, and how individuals decide to accept or reject it. Their model is used to determine the rate of reforestation among NIPF owners. The specific research question they were concerned with was whether owners who spend resources to regenerate are more likely to be innovative than those who do not. They found that landowners who reforest were more venturesome and innovative, with higher incomes, and were more likely to belong to organizations, had higher levels of education, and owned more land.

Landowner Decisions to Participate in Programs

Many studies of participation in forestry assistance programs were undertaken in the 1990s (Bell and others 1994, Crabtree and others 1998, Esseks and others 1992, Nagubadi and others 1996). Bell and others (1994) analyzed landowner participation in Tennessee's Forest Stewardship Program. Individuals most likely to participate had a household income of $50,000 or greater, had previous experience with forestry, actively sought information regarding land use programs or practices, supported conservation, and had unmanaged forest, pasture, or cropland as primary land uses. Bell and others concluded that a Government should concentrate resources on promoting education, rather than increasing the amount of cost sharing, if the goal is to promote forest management. Esseks and others (1992) found that Conservation Reserve Program (CRP) participation was positively correlated with involvement of landowners in technical assistance and forestry experience, and was negatively correlated with income. Nagubadi and others (1996) studied cost-sharing program participation in Indiana. Tract size, membership in forestry organizations, age, and residence on the land emerged as important determinants of program participation.

Romm and others (1987) investigated NIPF landowner propensity to invest in forestry or respond to public policies and programs. They suggest that public programs for nonindustrial private forestry cannot be targeted effectively unless the program's purpose is defined narrowly. Hyberg and Holthausen (1989) believe that incentive programs can actually reduce timber supply. They argue that as landowner wealth increases, landowners may substitute amenities for timber production, reducing their future harvesting. Kluender and others (1999) feel that incentive payments often do not lead to additional production from NIPF land, and that cost-share programs have not kept real prices from rising. Brockett and Gephard (1999) studied the Tennessee Greenbelt Program. This program provides preferential property tax treatment for landowners who do not develop their land. Their land is then valued in its current use, rather than in its "highest and best" use. Brockett and Gephard conclude that tax incentives are too small to affect long-term behavior of NIPF landowners faced with pressures to develop their land. They argue that such tax programs simply reward landowners for making forestry investments they would already make without the tax relief.

Landowner Bequest Decisions

Harvesting, reforestation, and forestry assistance program participation are not the only important management decisions made by NIPF landowners. Royer (1985) argued, for example, that "additional modeling efforts should address other forestry decisions to provide a more comprehensive look at the landowner behavior." Bequest motives are also critical to meeting timber demand, since timber and land bequests affect the future contiguity and size of forest cover. There has been some, but not extensive, progress in this area (Amacher and others 2002, Conway and others 2003, Hultkrantz 1992). Since many NIPF landowners in the South are approaching retirement age (Alig and others 1990), their bequest decisions will become very important to the continued use of forest land. In fact, timber bequests from one generation to another may actually be more important in promoting long-term timber investment than Government incentives, according to Hultkrantz (1992). Royer (1985) found that plans to sell forest land within

the next 20 years resulted in a 22-percent decline in probability that a landowner would reforest following a timber harvest. Conway and others (2003) and Amacher and others (2002) related timber bequest intentions (plans 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, absentee ownership, and tract size are significant predictors, among others. Except for tract size, each of these variables positively affected the probability of bequests. Increasing tract size negatively influenced the likelihood of leaving timber to heirs.

Landowner Participation in Nontimber Activities

Recent NIPF research has examined in more detail the nontimber amenity tradeoffs that forest landowners face. In particular, researchers have become interested in the substitution between harvesting and nontimber preferences (Conway and others 2003, Pattanayak and others 2002) and willingness to accept payments to postpone harvesting and capture wildlife benefits (Kline and others 2000). Conway and others assumed that harvesting and reforestation decisions are not determined independently of nontimber activity and bequest decisions; i.e., that they are not separable (e.g., see Koskela 1989). The nontimber activity decision is modeled explicitly as an endogenous variable by considering the choice of activity and the time spent in an activity. In other studies, forest inventory or land area in forests has been used as a proxy for amenity preferences (Binkley 1981, Pattanayak and others 2002). Conway and others (2003) examined actual use, finding 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. Kline and others (2000) conducted a telephone survey of NIPF owners in western Oregon and western Washington to determine willingness of landowners to accept incentive payments and forego harvesting (for the sake of protecting wildlife habitat). Willingness to accept was related to ownership objectives, socioeconomic characteristics, and incentive offered. Landowner age, education, income, multiobjective 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.

Predicting the Intensity of Forest Practices

Most of the above studies were efforts aimed at estimating the probability that a landowner undertakes an action. There are some studies that have examined the intensity of either harvesting or reforestation. For example, deSteigeur (1982, 1984), Cohen (1983), and Hardie and Parks (1996) examined the levels of reforestation landowners undertake on their land. Cohen (1983) found that reforestation implemented by Southern U.S. landowners was positively correlated with stumpage prices, cost sharing, and household income, but reforestation costs and interest rates did not emerge as significant factors. De Steiguer (1984) considered whether Government payments (specifically the Forestry Incentive and Agricultural Conservation Payment) programs substituted for private investment through changes in tree planting. He showed that planting 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 and others (2002) also finds this to be the case using aggregate time series cross-section data for several Southern U.S. States. Finally, Hardie and Parks (1996) examined the intensity of reforestation in response to CRP 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 have highly significant positive coefficients.

Sociological Studies

Although this section has focused on econometric studies, one cannot ignore the large body of literature that seeks to identify sociological factors associated with NIPF ownership. This line of research developed in the 1970s (Egan 1997) and stemmed from the heightened awareness that forest landowners often hold land for nontimber benefits and embrace multiple ownership objectives. Some recent studies have appeared in the forestry literature. These include a paper by Bliss and others (1997), who found that the views of nonindustrial owners regarding forestry and environmental issues are similar to those of the general public, contrary to previous conjectures. Bourke and Luloff (1993) also provided evidence that NIPF landowners and the public have common concerns with respect to forests and management policies. Johnson and others (1997),

who considered how NIPF owners view forest regulations, found that possible future regulations were not important in landowners' most recent harvest decisions. Bliss (1994) argued that researchers tend to focus too exclusively on the timber supply question and should instead focus on landowners as individuals. Egan (1997) agrees, arguing that the success of forestry assistance programs is dependent on understanding the many objectives of NIPF landowners.

NEW RESEARCH DIRECTIONS

The preceding review of recent work hints at many new and fruitful areas for landowner research. In this section we comment on several topics that have not been studied but have important policy implications.

Investigate the Price Acceptance Behavior of Landowners

Although there are some exceptions, previous empirical landowner behavior models have largely focused on estimating probabilities and levels of harvesting or reforestation. A separate set of theoretical literature describes how landowners approach the decision to participate in harvesting activities [see Fina and others (2001) for a recent review of this literature]. In this work, the existence of a "reservation price" is established for each landowner. A reservation price for harvesting represents an offer or payment a landowner must receive before harvesting and selling his or her timber. Although reservation prices have intuitive appeal for the timber harvesting decisions, the reservation price approach should in principle apply to other landowner market activities, such as selling land, or converting land use from agricultural uses to forest production through reforestation and afforestation efforts.

To date, there has been little empirical testing and estimation of reservation prices among nonindustrial landowners. Yet, such research might be important to predicting future timber supply obtained from any given landowner or collection of landowners. This is especially true for landowners and markets affected by urbanization or forest parcelization. Many of these landowners are usually absentee, or are not actively engaged in harvesting or reforesting at any one time. The preferences of these landowners are important determinants of their reservation prices and hence their propensity to enter timber markets in the future.

Estimating reservation prices represents a challenge, as they are unobserved and obviously functions of both landowner preferences and market parameters. Only when the landowner is offered a bid (or observes a market price) that exceeds his or her reservation price, will the landowner choose to harvest. Similarly, if the landowner is offered some payment or incentive to plant trees on currently open or agricultural land, the landowner will undertake such an activity only if the payment is greater than the minimum he or she is willing to accept for the change in land uses. This willingness to accept is equivalent to a reservation price for land use activities, and like the timber sale reservation price, it will depend on preferences of the landowner, market characteristics, and income derived from forest and agricultural activities.

In some cases, landowners who do not harvest will never do so, either because their reservation price path over time is consistently higher than prevailing market prices and offers, or because their preferences are such that their reservation prices are above the practical range of market prices. Reservation prices capitalize landowner preferences for timber and nontimber products and income or wage possibilities. Thus, differences in attitudes about harvesting and other forest management activities will be realized through differences in reservation prices across landowners. For example, landowners with very high reservation prices might be those who have higher incomes, attach higher values to nontimber benefits, or those who associate higher risk with establishing forests. In addition, expectations about the path of future prices (price risk) may influence reservation prices for harvesting timber. Ownership type (absentee or onsite owners) and ownership objectives (land speculation or forest management preferences) may also have substantial influences on reservation prices. The decision to accept any price for harvesting timber and the decision to switch land use should depend on variables such as these.

To understand how likely it is that different types of landowners will eventually harvest, or understand how various policies will affect the decisions of landowners to enter the market, we need to identify the most important factors affecting reservation prices for different types of landowners. A similar problem arises when one considers the participation of landowners in land use decisions. It is well known that frequent land sales in already fragmented areas may be

contributing to increased parcelization and decreased prospects for sustainable forest management, or production of amenities that require contiguous forest blocks. As with timber, a landowner's reservation price for land will give some indication of whether the landowner will participate in the land sale market. Reservation prices for land sales are also important indicators of landowner behavior and market outcomes with respect to timber harvesting.

A comparison of reservation prices and market prices for landowner activities is also needed. 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. Understanding the difference between the two, one of which is observed and the other of which has to be estimated, will, therefore, give some indication of how much markets need to change before landowner harvesting changes by certain amounts. The difference between reservation prices and market prices should reflect costs incurred searching for buyers, differences in information possessed by landowners and timber buyers, and specific characteristics of forest tracts that are valued in the market. 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 be the next contribution to timber supply modeling, or to forecasting changes in timber availability. Most landowners in a given sample may not harvest. In some cases, this may be because their reservation prices do not coincide with market prices, or in other cases their timber may not be mature enough to harvest. In the former case, without knowing how far landowners are from the margin of activity, there is no way of knowing how far landowners are from participating in forest harvesting. The harvesting and reforestation choice models reviewed earlier require substantial data about landowners who have recently harvested. Landowners who do not intend to harvest at the time of data collection, i.e., at prevailing market conditions, and those who have not harvested in the past, are often treated in different ways with respect to the prices they are assumed to face.

How does one estimate reservation prices for harvesting or for converting land to forest use? One way is to use a revealed or stated preference approach in which landowners are given various offers for undertaking a harvest or land use activity, and then asked to indicate whether they would accept or reject the offer. Two versions of this method have been applied recently. One version employs referendum voting—a single price is offered and landowners can either accept or reject this price. Kline and others (2000) make use of this approach to determine when landowners will choose to preserve forests over a certain time period. The other version is to use a payment table to offer a range of prices, and then allow landowners to indicate how likely they are to accept these prices if offered them. This approach is taken by Amacher and others (2001). The advantage of these methods is that they can be used to identify thresholds for prices that landowners would accept to undertake some activity. They can also be used to determine market prices a given landowner would be willing to accept for harvesting under varying probabilities. Thus, both methods can be used to identify the most important predictors of reservation prices.

Empirical analysis of reservation prices could be used to improve targeting of Government policies in new ways. For example, suppose that a policymaker 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. Typically, economists assert that the compensation for converting a unit of land to forests should equal returns from the current use foregone by switching. The importance of reservation prices in this decision is often overlooked, but it is important when the landowner attaches a value to the nontimber benefits produced by forests. For example, a landowner's preference for nontimber goods could lower the reservation price for shifting land to the extent that it is smaller than the foregone returns from the current use. A landowner for whom this is true would be willing to accept a payment that is smaller than the foregone financial returns in order to switch land from a nonforest use to forests. Any Government program seeking

to influence land use behavior at minimum cost should, therefore, focus on reservation prices, and not just on lost returns, as reservation prices better reflect the opportunity cost of switching land use.

Investigate Importance of Adjacent Landowners

Forest ecosystems cut across the many stands that constitute any forest unit. Biologists have long known this and have argued that trees of many age classes and species mixes are necessary for conservation of biodiversity or contiguous habitat for certain animal species (Franklin and Foreman 1987, Giles 1978). Forest stands are also linked by human needs and actions. For instance, the recreational opportunities presented by larger forest areas may be dependent on the interaction or coordinated management of several stands.

Economic models have rarely acknowledged the interdependence among stands, but it is a fact of nonindustrial forest management that management decisions made by the owners of one stand can affect the welfare of other landowners holding adjacent stands. One can easily imagine that the quality of nontimber benefits obtained from forests, such as wildlife amenities, should depend importantly on decisions made by adjacent landowners. It is, therefore, reasonable to expect that landowners may make decisions concerning their forests with the effect of their decisions on adjacent landowners in mind, or in anticipation of management decisions of adjacent landowners.

There are very few analytical treatments of the economics of stand interdependence. Stand interdependence was originally discussed by Bowes and Krutilla (1985, 1989), who proposed a linear programming approach for maximizing the rents associated with multiple stands under a single (Government) owner. Swallow and Wear (1993) and Swallow and others (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 who makes 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 contexts, such as species conservation.

The extent to which a landowner takes into account the effects of his or her management on other landowners is unknown, but it is an important question. The behavior of landowners who do not coordinate, or who anticipate actions of other landowners, could be socially costly. In fact, 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 forest ecosystem as a whole would have incentives to solve for the economically efficient rotation age of each stand, conditional on its impacts on all other stands. The challenge for policy, therefore, becomes finding an instrument that encourages each landowner to act as if he or she were a sole owner, managing all of his or her 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. The most efficient instrument would also depend on the types of property rights arrangements governing ownership and management of forest land. It certainly seems difficult to identify such an instrument at this stage given our current understanding of landowner behavior.

In light of this difficulty, empirical work should be directed at determining how serious lack of coordination among landowners can be, and also how various property rights arrangements (full or partial) affect incentives for landowners to coordinate actions. The most promising line of research would seem to involve linking 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. Most of the social costs associated with lack of coordination may come from a landowner's ability to effectively commit to an action with regard to his or her neighbors. 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 because both landowners are hunters of late-successional wildlife species. However, in periods of high prices, one landowner may be inclined to harvest after such an understanding is reached. This is because each landowner's reservation price is specific to each person's preferences. Understanding how landowners react to one another, if they do at all, will help us understand how landowners respond to policies targeting use of their forest land.

Investigate Substitution Between Landowner Decisions

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. Timber supply depends on the interaction of all relevant decisions landowners make. Take, for example, the case of nontimber activities. Interest in those that are complementary with harvesting influence behavior very differently than would interests in nontimber activities viewed as substitutes by the landowner. If we do not know how landowners choose between nontimber activities, then we will have an incomplete picture of harvesting behavior. The problem becomes even more complicated when one considers the interaction of land use, nontimber activities, and timing of harvesting. For example, landowners may consider it equivalent to either forego harvesting for amenities, or simply bring more land into forest production. Stand interdependency is also potentially important. If a landowner can substitute nontimber goods on adjacent land for production of these goods on their own land, such as hunting or maintenance of wildlife habitat quality, then this will also affect harvesting decisions. Obviously, an important factor here is the timing of decisions. Provencher (1997) provides some support for the existence of 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 and, thus, may not give a complete picture of the relationships between landowner decisions and important variables.

Integrate Landowner Models into Large-Scale Policy Models

Many studies have sought to estimate the probability that landowners undertake some activity, such as harvesting or reforestation. There is now a growing literature about landscape models (e.g., Wear and Bolstad 1998). Many of these models are not based on 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 that can be used for policy analysis.

Landscape models may be used to understand forest fragmentation. Fragmentation of parcels into smaller units has been associated with changing landowner characteristics and the current structure of estate 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. Fragmentation may also reduce nontimber benefits by disrupting wildlife corridors. These changes would also lead to a different type of forest industry organization, and could also lead to changes in landowner composition on large land area scales. Recall that recent work also establishes that landowner characteristics are changing. Increasingly, nonindustrial private landowners are absentees, and absentee landowners are known 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 differences in reservation prices for harvesting or the willingness to leave timber as a bequest.

Clearly, fragmentation and parcelization can be understood by first integrating models for predicting landowner behavior into spatial land use models. Landowner decisionmaking would then be an endogenous factor driving the spatial realization of land use change. The benefits from greater integration of landowner responses into landscape predictions will be better prediction of landscape change in response to market changes or demographic changes in landownership, and better prediction of the pattern and size of environmental benefits and costs associated with landowner and market-driven change.

Expand Our Understanding of Information Asymmetries Involving Landowners

One assumption made in nearly all empirical work is that markets are "perfect" in terms of the information available to landowners. For example, 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. However, new evidence suggests that landowners may not have perfect information. Hardie and Larson (1994) discuss a model in which buyers

and sellers of timber have asymmetric information 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 who do not have such representation. Most recently, Sullivan and others (2002), who studied a sample of actual timber bids, concluded 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 in the timber price by a timber buyer.

These studies collectively suggest that information externalities may be present in timber markets. Empirical work should continue to identify the costs to landowners of 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 on landowner responses to external variables, which assumes that landowners make decisions on the basis of perfect information, may be flawed. There is much scope for future empirical work examining the implications of information differences to landowner behavior and timber supply. Such work will give us a better understanding of the social costs associated with information asymmetries, and a better understanding of the scope for Government intervention in these cases.

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