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Likelihood of Timber Management on Nonindustrial Private Forests: Evidence From Research Studies

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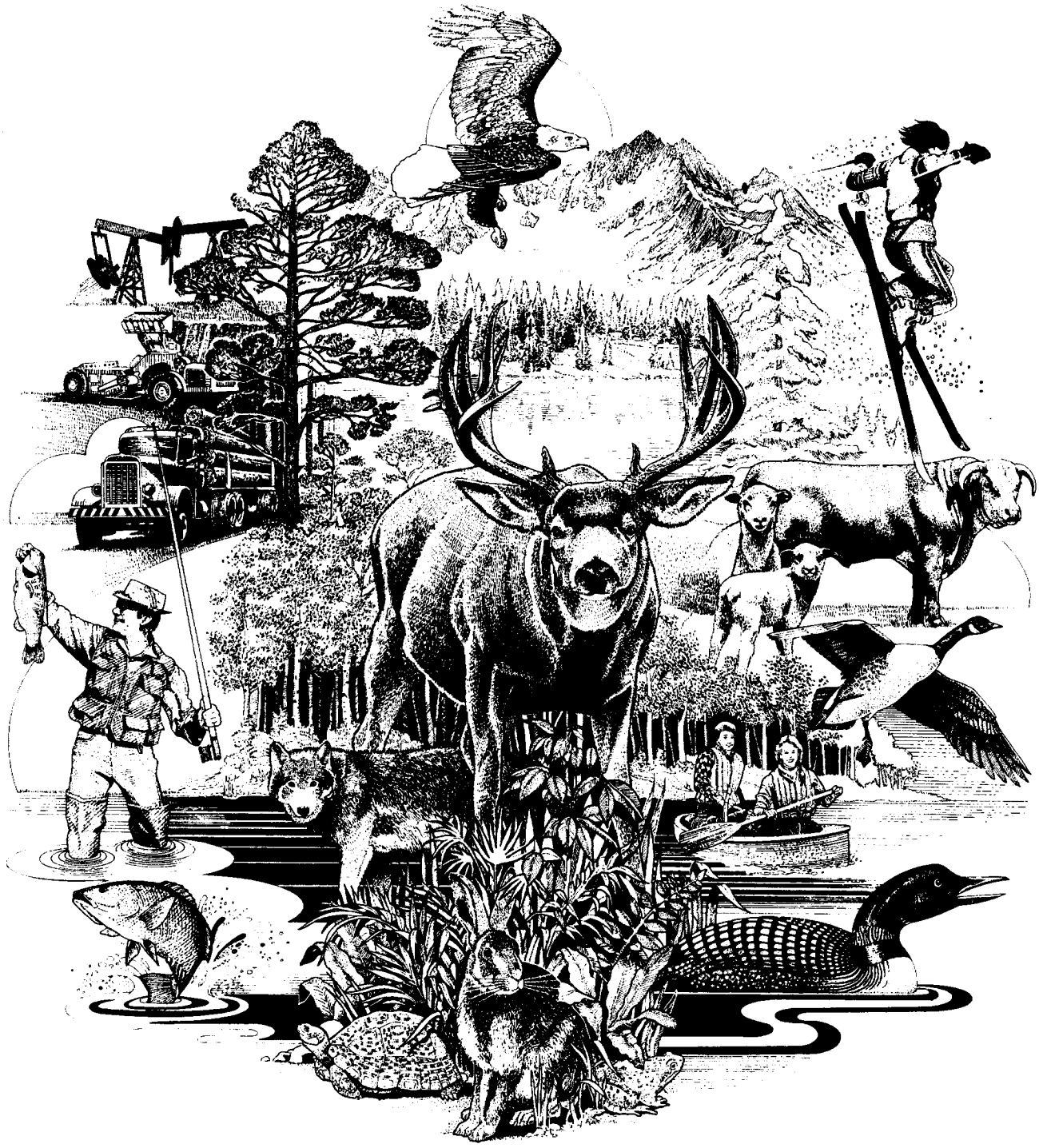

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ABSTRACT

Research on timber management tendencies by nonindustrial private forest owners, while sometimes conflicting, provides useful information to support policy analyses of timber supply and investment behavior. Numerous research studies regarding NIPF tree planting, intermediate stand treatments, and timber harvesting are reviewed. Conclusive research findings include that: (1) cost sharing correlates with increased tree planting, (2) cost-shared plantings are typically not liquidated when support payments end, (3) technical assistance with harvesting tends to increase stumpage revenues for owners and results in residual timber stands that are in better condition, and (4) technical assistance is correlated with increased harvesting.

The degree to which nonindustrial private forest (NIPF) owners manage their land for timber production is a key question in assessing future timber supplies. Information on management by NIPF owners is also important in analyzing policy options related to issues such as global climate change, wildlife habitat, and soil protection. Although much research has been conducted on NIPF timber management and response to government policies, the results sometimes appear to conflict and do not provide a clear understanding of the factors affecting NIPF timber management. These studies contain a great deal of information, however, and we can draw limited conclusions regarding timber supply and investment behavior. The importance of NIPF timber and the identification of significant investment opportunities on NIPF lands (USDA Forest Service 1988, in press) indicate the need for continued and expanded research in this area.

This paper reviews previous research on NIPF timber management behavior, including timber harvesting, in the United States. It synthesizes findings on availability of timber from NIPF land and the effects of government programs in augmenting supplies. One aspect of this issue—how NIPF owners respond to timber-related market signals—is particularly significant because recent timber assessments by the USDA Forest Service (in press) project increasing real timber prices. Response to market signals is also important because government programs are often designed in response to perceived market imperfections (Cubbage and Haynes 1988).
This synthesis of research results is intended to support analyses of the potential for increasing timber supplies from NIPF land. The review does not include studies on the social efficiency of policy instruments. Instead, it concentrates on studies designed to isolate determinants of timber management behavior by NIPF owners. The paper is organized into six sections. The first discusses NIPF research in general; the next three sections discuss NIPF planting, intermediate treatments, and harvesting; the following section examines other considerations for research into NIPF behavior; and the final section states conclusions and directions for further research.

Overview of NIPF Research

Previous research into timber management decisions by NIPF landowners ranges from survey-based studies of owners and their forests to sophisticated models for testing hypotheses about landowner behavior. The effects of stumpage prices and government programs on the timber supplied by NIPF owners have been examined by empirical tests of hypotheses as well as through descriptive surveys (Fecso and others 1982; Royer 1987). Landowner and tract characteristics have also been examined to facilitate understanding of the importance of other market and nonmarket goods (recreational value) on timber management decisions (Binkley 1981). Some researchers have used statistical methods to categorize NIPF owners according to the emphasis on timber management, based on owner characteristics and attitudes as well as land characteristics (Greene and Blatner 1986; Kurtz and Lewis 1981; Thompson and Jones 1981; Young and Reichenbach 1987). Tax incentives and technical assistance have often been examined through use of legal research and descriptive surveys (Siegel and Hickman 1988), but several recent empirical tests of hypotheses have been undertaken (Chang 1983; Cubbage and others 1985; Max and Lehman 1988; Skinner and Klemperer 1989).

Although numerous approaches have been used in studying NIPF behavior, the following sections concentrate on those that attempted to surface or isolate determinants of timber management applications. Most of the many surveys of landowner behavior conducted since the 1940's have profiled the characteristics of owners and their tracts of land (Fecso and others 1982). They usually have not tried to simultaneously explore the effects of markets, policies, and owner characteristics.

Surveys of NIPF owners have described characteristics, activities, attitudes, perceptions, and intentions of owners, as well as characteristics of their forest holdings. Differences in sampling basis and/or geographic coverage complicate comparisons of results, but several general findings have surfaced:[1]

1. NIPF owners and forest holdings are diverse, both within and across regions.

2. Landowner intentions vary widely within and across regions.

3. NIPF owners are numerous, and many are absentee owners.

4. NIPF owners are older, on average, than the general population.

5. The turnover rate of owners is high relative to the rotation length in forestry, and landowners' intentions often change over time.

6. Many NIPF owners do not cite timber production as one of their primary land management goals.

7. Data from Forest Inventory and Analysis surveys indicate that NIPF owners do harvest significant volumes of timber. Historical rates of harvest (removals as a percentage of timber inventory) are comparable for industry and NIPF owners in the South.

Because NIPF owners are heterogeneous, the summary of survey findings reinforces the caution that only general and qualified observations can be offered when viewing the class as a whole. Thus, findings that are reported should be extrapolated only with great caution.

In analytical studies, two basic theories have been used to develop and test hypotheses about NIPF investment behavior for testing: utility and profit maximization. NIPF owners select among timber and nontimber opportunities to maximize perceived utility. Both financial and nonpecuniary benefits from land management are considered. The utility maximization assumption has also been extended to account for the infrequency of transactions (Rosen and others 1989). A profit-maximizing construct views the landowner as a firm and the forests as a factor of production.

Some differences in NIPF studies stem from the type of data used and the varied definition of the dependent variable representing a forest management practice. Conclusions about a planting subsidy, for example, may depend on whether the dependent variable is total acres planted or unsubsidized acres planted. Two general types of data have been used: microlevel data derived from owner surveys such as Boyd (1984), or data aggregated at the regional, State, or national level such as de Steiguer (1984). Also, studies have used time-series (de Steiguer 1984), cross-sectional (Royer 1987), or pooled cross-sectional and time-series data (Alig 1986).

Many independent variables have been tested in relation to determinants of NIPF behavior. Most recent research on NIPF supply has included prices and government programs as independent variables. Other variables examined include reforestation costs, interest rates, income, age, occupation, and tract size.

Landowner decisions that concern us in this paper are investment or disinvestment choices. Such decisions have typically been researched as: (1) the decision to *invest* in forest management, often centering on regeneration, which relates to long-term timber supply, and (2) the decision to *disinvest* (harvest timber), which relates to short-term timber supply (Alig and others 1984). The distinction is important because the two sets of decisions may not be directly linked, temporally or spatially, and the set of determinants may be different for disinvestment than for investment decisions. However, there is often an indirect linkage—a decision to reforest may require that a previous decision to harvest has been made.

NIPF Planting Activities

Historical Tree Planting

Prior to the mid-1930's, only a few thousand acres of NIPF land per year were planted or direct-seeded to trees. Planting by the Civilian Conservation Corps led to an increase in areas reforested during the late 1930's, but tree planting programs nearly stopped during World War II. NIPF planting and seeding efforts rose to over 1 million acres per year during the peak of the Soil Bank Program in the late 1950's (fig. 1).

[1] Based in part on findings in an unpublished report by Jack P. Royer, 1979. A report to the Forest Productivity Committee of the Forest Industries Council. Duke University, School of Forestry and Environmental Studies, Durham, NC.

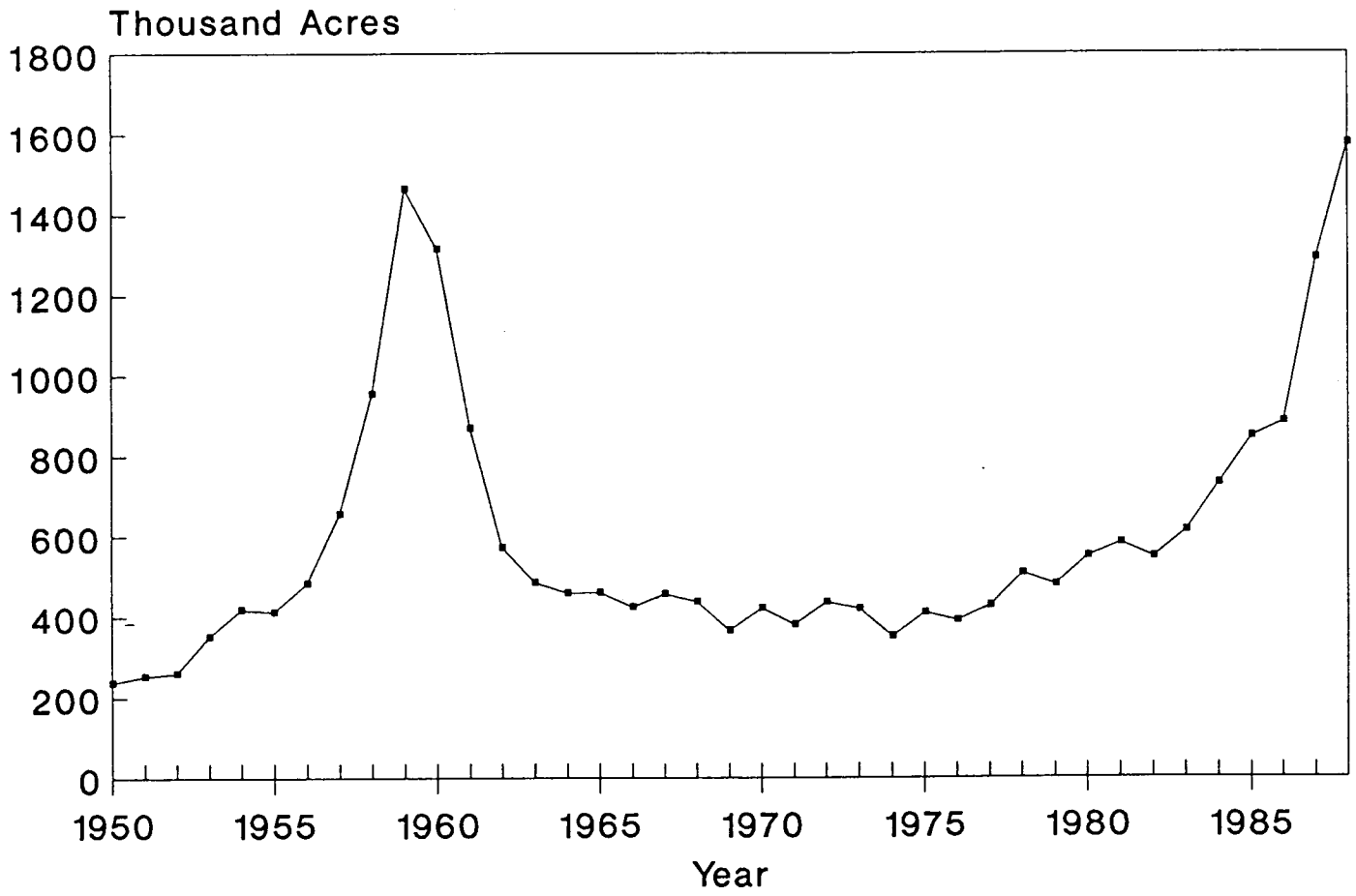

Figure 1 – Nonindustrial private forest planting, 1950-1988. (Source: Analysis of Timber Situation, USDA Forest Service; Annual Planting Reports, USDA Forest Service.)

Following a decline after the Soil Bank Program, NIPF reforestation has increased since the mid-1970's, with accelerated rates since the early 1980's. This same period saw the expansion of State and Federal incentives, including cost-share programs, reforestation tax credits, and forest management assistance programs. NIPF planting in recent years, boosted by the Conservation Reserve Program (CRP) authorized in the 1985 Food Security Act, has reached record levels, once again surpassing over 1 million acres per year. As in earlier times, most of this tree planting has been in the South. Spikes when plotting trends of NIPF tree planting correlate with major subsidy programs such as the Soil Bank or CRP.

About half of the acres planted by NIPF owners have been done under cost-sharing programs (Royer and Moulton 1987; USDA Forest Service, in press). The amount of planting done with technical assistance alone, not using cost sharing, is not known but has been estimated to be between 40 and 60 percent of the non-cost-shared acres. This implies that only 20 to 30 percent of NIPF planting is accomplished without any form of government assistance, cost-sharing, and/or technical assistance. Although unassisted planting has been increasing in recent years, few of the studies have included this time period and the reasons for the increase are uncertain (USDA Forest Service, in press).

Discussion of Research Studies

NIPF tree planting relates to supply by contributing to the growing stock available for long-term supply. Several studies have found a positive relationship between available growing stock (inventory) and timber harvested, indicating that planting may have an effect on short-term supply as well as on long-term supply (Adams and others 1982; Newman 1987; Wear and Newman 1989). The response of NIPF owners to market signals can be viewed in terms of response to prices and costs. While owners have not been shown to respond to prices when planting, research suggests they do respond to costs. The confusing results here tend to imply a theoretical or data problem, or may imply that landowners with relatively high discount rates respond within a short planning horizon. Government programs affect the number of acres planted by NIPF owners.

Previous research on planting decisions by NIPF landowners indicates a weak or nonexistent response to stumpage prices, as represented by both current prices and expected prices (table 1). Alig (1986), Boyd (1984), Brooks (1985), de Steiguer (1984), Royer (1987), Royer and Moulton (1987), and Royer and Vasievich (1987), using different approaches and different data sets, did not find stumpage price to be significant. Cohen (1983) and Hyberg and Holthausen (1989) did find stumpage price to be significant in the decision to plant. The finding by Hyberg and Holthausen (1989) is even more unusual when it is noted that sawtimber prices were significant in Georgia in this study, while pulpwood prices were insignificant. In tests where both sawtimber and pulpwood prices were used, coefficients for variables representing pulpwood prices were larger than those for sawtimber prices, although neither coefficient for price variables was statistically different from zero (Royer 1987; Royer and Vasievich 1987). The price data used in all studies were aggregate regional data.

A second aspect of the market response of NIPF landowners can be examined by looking at the response to variations in reforestation costs and interest rates, the latter of which are considered as a proxy for the cost of time. Increasing reforestation costs were found to reduce the acreage planted or the probability of planting by NIPF landowners (Brooks 1985; Hyberg and Holthausen 1989; Royer 1987; and Royer and Vasievich 1987). A negative effect would indicate a reluctance by NIPF owners to incur the upfront costs of reforestation. Royer (1987) posits that a high owner sensitivity to cost, coupled with effectiveness of technical assistance, implies that professional assistance from private or public foresters aimed at low-cost reforestation alternatives would seem to pay high dividends. Costs were not found significant in studies by Royer and Moulton (1987) or Cohen (1983), but these results were not discussed

Table 1--Summary of tree planting research on nonindustrial private forests

	Variables affecting tree planting decision										
	Price		Refor.	Cost	Tax	Tech.	Interest rate			Farm	
Researcher	Sawtimber	Pulpwood	costs	share	incentives	assist.	Short	Long	Income	occup.	Size
Alig (1986)	0			+					+		
Brooks (1985)	0		-	+							
Cohen (1983)	+		0	+				0			
de Steiguer (1984)	0						0		+		
Hyberg & Holthausen (1989)	+		-	+		0			0	0	0
Romm and others (1987)									+		
Royer (1987)	0	0	-	+		+			+	0	0
Royer & Moulton (1987)	0	0	0	+	+	+			+	0	
Royer & Vasievich (1987)	0	0	-	+					+	0	

Variables tested and significant are represented by (+) and (-); those tested and insignificant are represented by (0). Only selected independent variables may be displayed for comparison purposes for some studies.

in those study reports. The reforestation cost data used in all studies were regional costs, derived from records of the 1982 Forestry Incentives Program (FIP) or from southwide surveys.

Interest rates represent another cost to the landowner. In a study by Miranda (1988) both long-term and short-term interest rates (government bond rates and 3-month Treasury Bill rates) were highly significant in planting models. In this study the short-term rates represented the opportunity cost of investing in forestry, while long-term rates represented the use of forestry as an inflationary hedge. The effect of interest rates on investments in forestry was also examined by de Steiguer (1984) and Cohen (1983). De Steiguer (1984), however, found no significant effects using Treasury Bill rates and a geometrically distributed lag, and Cohen (1983) found no effects using a 10-year corporate bond rate.

Regional price and cost data were used in all of the studies, even those in which the forest management data related to individual landowners. One problem with this data is that regional prices may not reflect what a landowner received or was offered for the timber. A second concern is whether current or lagged prices adequately represent an NIPF owner's expected revenues from forest investment activities. In the one case where price expectations were explicitly modeled, stumpage price was not significant (Brooks 1985). If these prices or proxies do not reflect owner expectations, then conclusions regarding the effects of prices on planting are rendered even more tenuous.

The second explanation could be that landowners have short planning horizons and are less concerned with the returns from planting, while responding more strongly to current costs. The lack of response to stumpage prices, combined with the stronger (though insignificant) response to pulpwood prices, and the negative response to reforestation costs indicate that NIPF owners more strongly discount future revenues than immediate costs. Stumpage prices, which occur farther out in the rotation, appear to be discounted more, particularly relative to input costs, which are more immediate and more easily compared with alternative rates of returns for capital funds.

Recent studies have generally concluded that the price of stumpage has little influence on NIPF planting rates, although numerous studies indicate that government programs have significant influence. Current programs include Federal cost sharing—through the Forestry Incentives Program (FIP), the Conservation Reserve Program (CRP), and the Agricultural Conservation Program (ACP)—and State cost sharing, public assistance foresters funded by both State and Federal governments, and reforestation tax incentives. Past programs affecting NIPF landowners include the Soil Bank Program and Federal capital gains tax incentives.

Researchers reporting positive effects of cost-share programs on planting decisions by NIPF landowners include Alig (1986); Boyd (1984); Brooks (1985); Cohen (1983); Hyberg and Holthausen (1989); Royer (1987); Royer and Moulton (1987); and Royer and Vasievich (1987). The variable representing cost sharing was significant in all cases, including those in which a dummy variable representing a knowledge of cost-sharing availability was used. In one study, the effects of the different programs were isolated, and both ACP and FIP had a positive influence on reforestation (Cohen 1983).

Regardless of their financial position, landowners respond positively to cost sharing. Royer (1987) examined the effects of knowledge of cost sharing by owners with incomes above and below $25,000 per year and found this variable significant at both income levels. Whereas NIPF studies typically have not investigated the demand for different degrees or percentages of cost sharing, Romm and others' (1987) results indicate that a reasonable reduction in cost-sharing percentage may not reduce the use of such forestry incentives. Research has also shown that government cost-sharing programs are focused on more productive land, where potential yields and returns are high (Mills and Cain 1979; Risbrudt and others 1983).

Several studies have examined the capital substitution issue, but results have been inconsistent. Capital substitution occurs when government payments merely substitute for private investment that would have occurred anyway. De Steiguer (1984) found no significant correlation between government payments and non-cost-shared or autonomous reforestation investment.[2] However, Cohen (1983) concluded that a significant amount of substitution was occurring. While not specifically testing capital substitution, Royer (1987) concluded from his tests that significant substitution was not occurring. Brooks' (1985) findings regarding strength of cost-sharing coefficients also suggest that much of the effect is additive, such that cost-sharing serves as an inducement to plant trees. Yoho and James (1958) indicated that ACP payments had a strong effect in stimulating forestry practices in Michigan. The results on this issue are not conclusive.

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[2] Correlations reported throughout the paper refer to ones of statistical significance.

Other government programs that are provided to NIPF landowners include technical assistance and tax incentives. Several recent studies that explicitly modeled the effects of technical assistance on the reforestation decision found that landowners who received technical assistance in harvesting were more likely to reforest than owners who did not get assistance (Boyd 1984; Royer 1987; Royer and Moulton 1987). The effects were stronger among landowners with incomes greater than $25,000 per year (Royer 1987). Royer and Kaiser (1985) reported that investments in pine regeneration increased markedly when professional foresters were retained by NIPF owners, but that professional foresters were consulted on less than 40 percent of the land harvested.

Three studies were unable to support the hypothesis that use of technical assistance significantly increased planting. Hyberg and Holthausen (1989) did not find technical assistance to be significant in affecting reforestation, which is somewhat surprising since technical assistance is used with cost sharing and cost sharing was significant in this study. Skinner and Klemperer (1989) report that, within the range of the data gathered, variation in technical assistance did not prove to be a significant predictor of NIPF tree planting accomplishment in the South. Hodges (1989) evaluated determinants of forest management investments and found that a technical assistance variable for public foresters was not significant for either the Southeast or Midsouth regions, but that private forester assistance was a significant variable for the Southeast. No studies have been conducted to assess the effects of technical assistance alone. Cost sharing and technical assistance occur together for government-subsidized tree planting, and thus separating out the influence of each is difficult.

Tax incentives significantly increased the probability of planting by NIPF owners in one study (Royer and Moulton 1987). Tax incentives were considered as one activity and were not broken out by type (reforestation credit or amortization) or by jurisdiction. In an empirical analysis of the effects of the capital gains tax on reforestation, Chang (1983) found that changes in capital gains taxation did not significantly affect reforestation behavior. Guertin and Rideout (1987) and Murray (1988) analyzed the recent changes in Federal tax laws and found that the new laws meaningfully reduce the expected returns from reforestation. Actual landowner response to the recent tax changes is not known. The few empirical studies in this area do not permit definitive conclusions about effects of tax incentives on investment.

Other influences on planting include personal income, occupation, and tract size. Most studies that included personal income found it to be positively correlated with reforestation (de Steiguer 1984; Romm and others 1987; Royer 1987; Royer and Moulton 1987; Royer and Vasievich 1987) except Boyd (1984) and Hyberg and Holthausen (1989) did not find a significant correlation. Earlier landowner surveys had indicated that planting was affected by owner occupation. However, most recent studies did not find a significant difference in planting rates or probabilities between farmers and nonfarmers (Boyd 1984; Hyberg and Holthausen 1989; Royer 1987; Royer and Moulton 1987; Royer and Vasievich 1987).

Summary of Research Results

Previous research on planting behavior has led to several conclusions, but many questions remain unanswered. Government programs correlate with increased planting by NIPF owners, increasing potential future timber supply. Cost-sharing programs increase the probability of planting, and the land that is planted is above minimum program standards. Landowner income is highly correlated with increased planting. The questions that have not been answered conclusively include the effects of timber prices on NIPF investments in planting, the effects of technical assistance alone, the effects of tax incentives, and the substitution of public for private investment funds.

Intermediate Treatment Activities

Historical NIPF Intermediate Treatments

Intermediate stand treatments such as thinning and release of crop trees could increase yields on an estimated 20 million acres of NIPF land (USDA Forest Service, in press). However, few NIPF acres receive intermediate treatments (fig. 2). In most years since 1968, the annual treated acreage has ranged from approximately 250,000 to 425,000 acres. Even on land that was planted using cost sharing, several studies show that followup treatments are needed. In a review of plantations established under the ACP (Kurtz and others 1980) and the Soil Bank Program (Alig and others 1980), over one-third of the planted stands needed thinning to correct for overstocking or to prevent the spread of disease.

Discussion of Research Results

Two studies at the State level of the use of intermediate treatments by NIPF owners showed that owner characteristics and attitudes were more significant than either output (stumpage) price or income in predicting use of intermediate treatments in forest-land

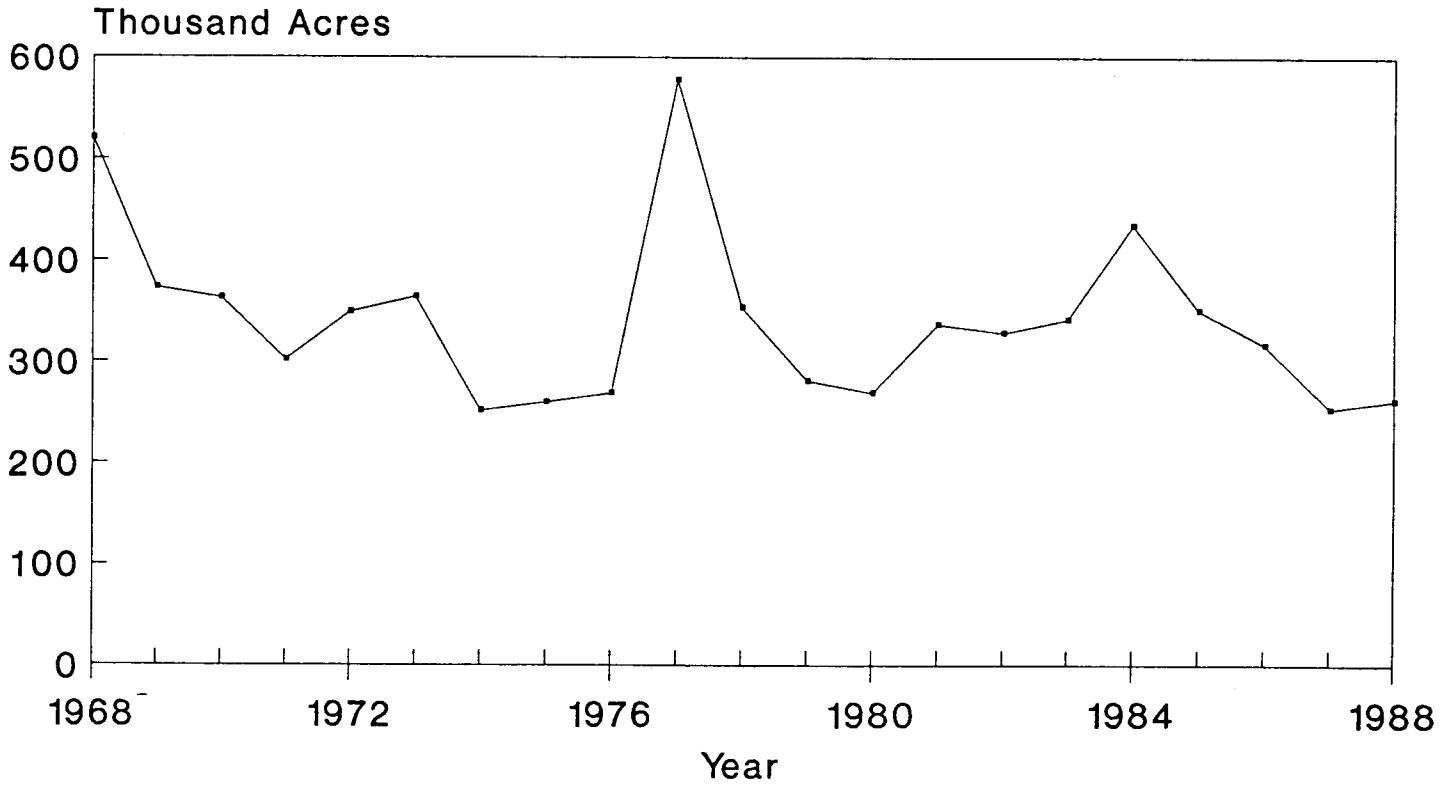

Figure 2—Nonindustrial private forest timber stand improvement, 1968-1988. (Source: Analysis of Timber Situation, USDA Forest Service; Annual Planting Reports, USDA Forest Service.)

management. In one study, Boyd (1984) included planting along with intermediate improvements as timber stand improvements. Boyd (1984) analyzed North Carolina data and Holmes (1986) analyzed Connecticut data, and both found tract size to be significantly and positively correlated with the decision to apply intermediate treatments. Knowledge of cost sharing was found to be significant by Boyd but not by Holmes, but Holmes did find technical forestry assistance to be significant. Price, income, occupation, and distance from tract were not significant, whereas education, previous harvest activity, use of technical assistance, and wildlife concerns were significant and positive (Holmes 1986). Again, use of current prices to represent expected timber returns may not adequately reflect owners' expectations. The likelihood of an owner improving a stand decreased as owner age increased. Holmes also found that owners often improved wildlife or recreation values while they were improving timber values.

Summary of Research Results

Research results on the likelihood of NIPF owners applying intermediate timber management treatments are more limited than those for forestation and harvesting. Available findings for two State-level studies suggest that owner characteristics and management concerns are more important than expected stumpage prices in the decision to apply intermediate treatments. The limited number of studies addressing these questions permits no definitive conclusions about correlation of intermediate treatment activities with changes in costs or stumpage prices.

NIPF Harvesting Activities

Historical NIPF Harvesting

Harvests from NIPF lands have constituted from 47 to 52 percent of the total U.S. timber supply since 1950. In 1986, the NIPF percentage of total U.S. softwood harvest was about 40 percent, while NIPF ownerships contain about 30 percent of the softwood timber inventory (USDA Forest Service, in press). NIPF's share of hardwood harvest was approximately 75 percent, compared with their stocks or timber inventory comprising about 70 percent of the total hardwood inventory. This indicates that NIPF land has supplied a greater proportion of timber harvest per unit of timber inventory than some other ownerships. Harvests by NIPF owners are shown in figure 3.

Discussion of Research Results

Timber harvest from NIPF lands contributes to short-term timber supplies, although harvest methods resulting in higher quality residual stands can also contribute to long-term supplies. As was the case for planting, conclusions regarding market responses are limited. However, general conclusions on the effects of government programs on supplies can be made, including the effects of technical assistance on residual stands and timber revenues.

Effects of stumpage prices on harvesting have been shown to be generally positive and significant. According to studies by Adams and Haynes (1980), Binkley (1981), Boyd (1984), and Holmes (1986), increases in stumpage prices result in increases in

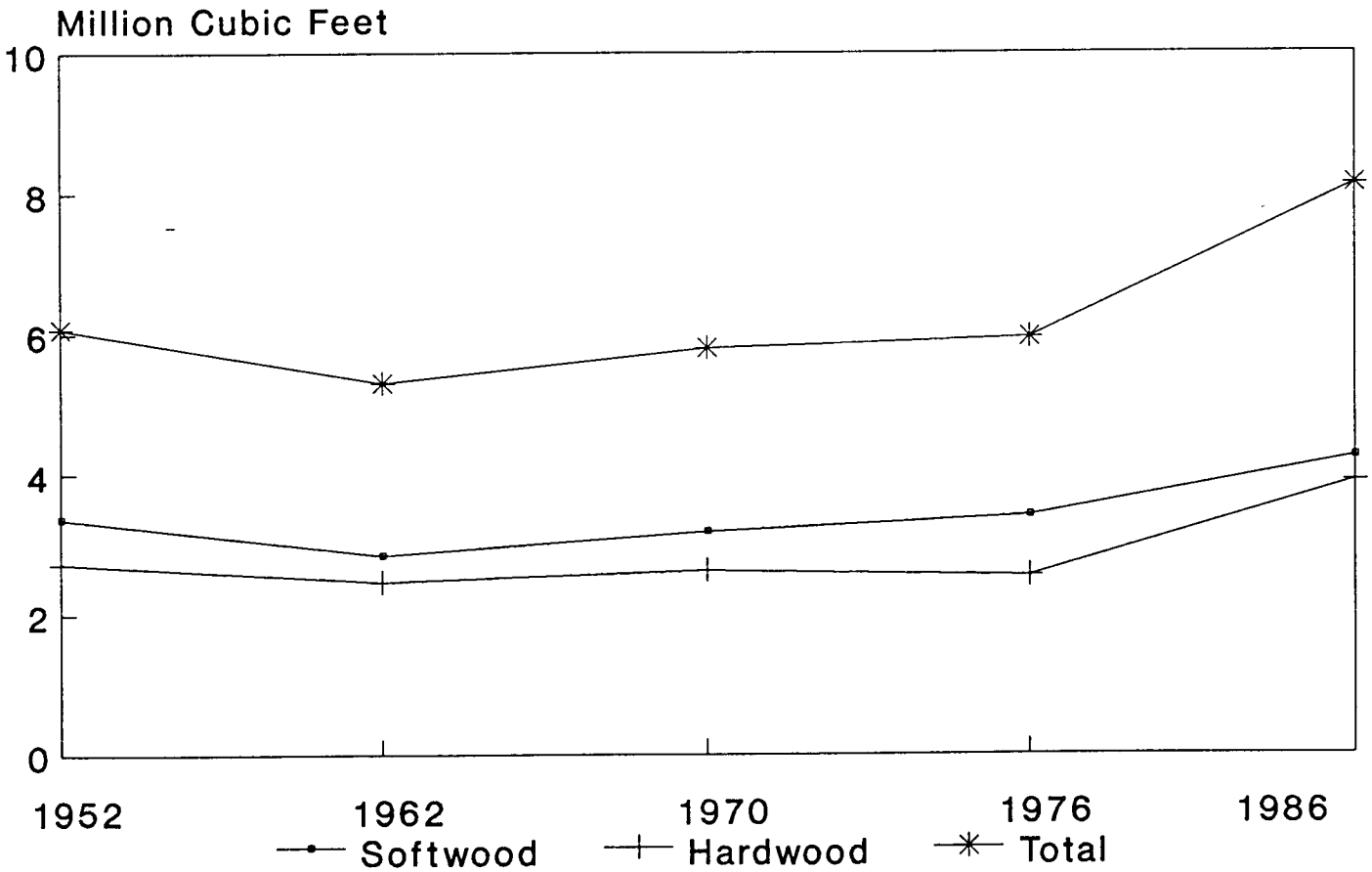

Figure 3—NIPF growing-stock removals, 1952-1986 (Periodic). (Source: 1989 RPA Assessment Data Base, USDA Forest Service.)

Table 2--Summary of harvesting research on nonindustrial private forests

Researcher	Variables affecting timber harvesting decision							
	Price	Refor. costs	Tech. assist.	Cost share	Income	Tract size	Farm occup.	Education
Adams & Haynes (1980)	+							
Binkley (1981)	+				-	+	+	+
Boyd (1984)	+		+	0		+	+	+
Holmes (1986)	+		+	0	-	+		
Hyberg & Holthausen (1989)	-	+	+	+	_	0	+	
Wallace & Silver (1983)				0				

Variables tested and significant are represented by (+) and (-); those tested and insignificant are represented by (0). Only selected independent variables may be displayed for comparison for some studies.

harvesting by NIPF landowners (table 2).[3] One study found that price increases reduced the probability of NIPF harvesting (Hyberg and Holthausen 1989). This is the same study that found price significant in planting; contrary to all of the other planting studies. Some research also indicates that NIPF owners harvest more in response to nominal prices than to real prices (Binkley 1981; Holmes 1986). As Holmes indicates, this may indicate a lag in realized price inflation by NIPF owners.

These results should be interpreted with caution because of necessary assumptions regarding representations of price data, a situation similar to the analysis of planting behavior. Again, regional price data were used to represent actual landowner returns from a harvest.

The main government program affecting NIPF harvesting activity is the provision of public technical assistance foresters. Use of these foresters by landowners has been shown to be highly correlated with the probability of NIPF harvesting (Boyd 1984; Boyd and Hyde 1989; Holmes 1986; Hyberg and Holthausen 1989). Technical assistance is provided through State Foresters and supported with State and Federal funding. The extent of assistance differs by State; for example, only price information and referral services are offered in Florida, while timber marking on small tracts is provided for a nominal fee in Georgia and Kentucky. Holmes (1986) notes that caution should be used in interpreting the results of the effects of technical assistance on harvesting. Holmes states that an increase in the number of foresters providing assistance will not necessarily lead to an increase in harvesting, because joint demands for technical assistance and harvesting are derived from demands for wood products.

Technical assistance leads to higher current returns and higher future revenues (Budelsky and others 1989; Bullard and Moulton 1988; Cubbage and others 1985; Henly and others 1988a; Hubbard and Abt 1988; Jackson 1988). Hubbard and Abt analyzed the differences between public forestry assistance and private consulting assistance but did not find any differences in harvest revenues. They concluded that the existing system of public foresters and consulting foresters was workable because each served a different set of landowners. Providing public forestry assistance results in a welfare transfer from taxpayer to timber owner. Such assistance, however, has high benefit/cost ratios both for the individual landowners and for society (Cubbage and others 1985). Jackson (1988) found in a study of Montana owners that users of technical assistance were more likely to employ Best Management Practices.

[3] Newman's (1987) econometric analysis of the U.S. South's softwood stumpage market confirmed the complementary role of solidwood in pulpwood supply that had been reported earlier in Sweden (Johansson and Lofgren 1985). Newman did not separate out NIPF owners, but his results lend support to results in earlier studies (e.g., Adams and Haynes 1980) pertaining to inelastic price elasticies in stumpage supply equations based on existing data.

Cost sharing reduces reforestation costs, resulting in shorter optimal economic rotations, and possibly in increased current harvest levels. (There is no direct cost sharing provided for harvesting activities.) Wallace and Silver (1983) specifically examined the rotation question and were unable to demonstrate statistically that FIP had any effect on annual removals or annual growth in the coastal plain of Georgia. These authors noted, however, that the short time period between the start of the program and their examination would cast doubt on their results. Two other studies failed to detect a correlation between cost sharing and harvesting (Boyd 1984; Holmes 1986). Hyberg and Holthausen (1989), on the other hand, found that the knowledge of cost-sharing programs was positively correlated with an increase in the probability of harvesting by NIPF owners.

One study shows that earlier cost-sharing programs contributed to potential amounts harvested by increasing timber inventories, particularly in the South (Alig and others 1980). Reviews conducted in 1976 and 1979 of the cost-sharing programs showed that 89 to 90 percent of the ACP and FIP plantings were retained well after payments had ended, indicating that most of the timber will be available to contribute to future harvests (Alig and others 1980; Risbrudt and others 1983). In addition, Alig and others found that 74 percent of the land that was not retained in plantations from the ACP program of the 1960's contributed harvest volume when the land use was altered.

Researchers have also examined effects of landowner income and education, occupation as a farmer, and tract size on harvesting rates. The results show that income is a significant factor affecting the harvesting decision. In the Northeast and in the Southeast, higher income owners are less likely to harvest timber than are lower income owners (Binkley 1981; Holmes 1986; Hyberg and Holthausen 1989). Higher education, which may be highly correlated with income, also appears to be negatively correlated with harvesting (Binkley 1981; Boyd 1984).

Tract size strongly influences the practicality of forest treatments, so subdivision of tracts to provide vacation property can be expected to increase property maintenance costs and reduce harvesting (Healy 1985). Smaller parcels are less likely to be harvested than are larger parcels (Binkley 1981; Boyd 1984; Holmes 1986). A survey of forest-land owners in New England revealed a larger average size of forest holding for owners who harvested timber (Kingsley 1976). In only one study, using owners in Georgia, was tract size found insignificant (Hyberg and Holthausen 1989).

Among NIPF owners, farmers are often considered to be more responsive to pecuniary opportunities than are nonfarmer NIPF owners, and many surveys separate the two ownership types. The proportion of timberland owned by farmers has been decreasing for several decades (Sheffield and Knight 1984), which may affect timber supply if farmers are indeed more likely to harvest timber from their lands. Research by Binkley (1981), Boyd (1984), and Hyberg and Holthausen (1989) indicates that farmers responded more strongly to timber prices and are more likely to harvest than nonfarmers.

Summary of Research Results on Harvesting

Relatively few studies have empirically examined the determinants of harvesting by NIPF owners. Studies have been conducted at a State level, and the question of the exact nature of short-run timber supply relations for NIPF landholdings has not been conclusively answered. In four out of five empirical studies, prices were positively correlated with the probability of harvesting, but the results must be viewed cautiously. Larger tract size and farm occupation were positively correlated with increased harvesting, while higher personal income was negatively correlated. Most empirical studies indicate positive effects of government programs on harvesting and on short-term supply. Use of technical assistance is highly correlated with increasing harvests and also results in better residual stands and higher owner revenues. The effects of cost sharing and tax incentives have received less empirical attention, and not enough is known to draw definitive conclusions.

Other Considerations in NIPF Research

Surveys, studies, and analyses have revealed much about NIPF owners, their timberland, and their timber management. Notable contradictions and inconsistencies across studies, however, demonstrate that analysts need much more information to confidently project changes in aggregate timber management and timber supplies. Several authors have drawn conclusions that extend beyond their analyses, while others have faced theoretical, modeling, and/or data limitations. These limitations should be considered carefully when planning research into NIPF behavior. Several of the most important considerations within the context of this paper are discussed below.

Theoretical Assumptions

The diversity of NIPF timber producers discourages the use of mainstream economic analysis in studying timber markets. NIPF landowners have a broad range of objectives for managing a variety of forest types and forest uses. Because standard methodology in applied economics relies on consistent objectives and technologies across producers for aggregating to the market supply level, more precise timber supply models will require innovative methodologies to address these NIPF issues.

NIPF behavior has increasingly been modeled in a utility-maximizing framework, as compared with a profit-maximizing one. One key difference is the significance of nontimber goods and services in a landowner's decision to implement certain land management practices. The value of nontimber outputs relative to timber products seems to be growing as society becomes more affluent.

Analysts have often assumed that NIPF owners have full information about prices, costs, and yields (Larson and Hardie 1989). Reason suggests great uncertainty created by forest hazards, volatile end-product markets, the diversity and changing composition of landowners, and changing policy environments. Forest investment analysis under uncertainty has recently been reviewed by Cathcart (1988). The theory has yet to be extended to regional timber investment or supply analysis. Recent research by Carlen and Lofgren (1986) suggests that uncertainty about the life of forest policy instruments may also influence land management decisions by landowners. This type of question is germane to studies of planting subsidies and land conversion policies such as the Conservation Reserve Program under the 1985 Farm Bill in the United States.

Previous analysts have also assumed certainty and constancy of interest rates. Temporal changes in interest rates strongly influence the attractiveness of long-term forestry investments. Increases in the market rate of interest in recent years have affected both the supply of and demand for forestry products. Imperfect capital markets also can influence landowner behavior if the consumption and production decisions of forest owners are not separable (different interest rates on borrowing and savings), including the effect of farmer's age on such decisions (Loikkanen and others 1986).

Most studies assume that the market value of land for use in timber production fully reflects the present value of future harvests, but that assumption may be wrong. The time required to produce a timber crop exceeds the typical business planning horizon, and there is evidence that the market value of immature timberland may not reflect the present value of the timber crop that will be produced. NIPF owners, therefore, may not be able to capture full returns of their timber investment without waiting until the timber is merchantable.

Modeling Framework

Modeling of regional NIPF timber investments has typically been isolated from other aspects of land management. Interactions between timber harvesting and other forest products and land uses have been ignored or omitted from timber market models. This approach ignores the simultaneous nature of investment, harvesting, and land use decisions and the linkages between investment, inventory, and prices. Modeling of continuous quantity within the same specifications as discrete choices, such as selling versus not selling timber (Loikkanen and others 1986), may find greater application in researching such linked land management decisions. In studies of other sectors, especially agriculture, mathematical programming has placed investment in a market context (Hazell and Norton 1986). This approach holds promise for using available forest inventory and management treatment data in existing aggregate timber demand models.

Previous models of timber investments have often considered timber the sole product of forestry enterprise and have focused on even-aged management regimes. Experience suggests that landowners simultaneously produce and consume several forest products and that uneven-aged silvicultural systems can be important means of providing multiple outputs from the forest (Haight and Monserud 1990). While some economic analyses have been completed on hunting recreation, the general topic of joint forest production remains largely unexplored. A recent South Carolina study found that joint production was statistically related to adoption of silvicultural practices, while cost or ease of silvicultural practices were not statistically related (Haymond 1988). Further development of markets for nontimber forest outputs (such as leasing land for hunting) is likely to increase the importance of joint forest production.

NIPF timber management options are also influenced by the dynamics of land use. For example, increased urbanization can affect management options for forest lands (Alig and Healy 1987). Forestation of marginal croplands, particularly in the South, depends upon agricultural as well as timber markets. Government policies in other sectors, especially those directed at surplus agricultural production, and externalities (such as design of Conservation Reserve Program to reduce soil erosion), will have important impacts on timber supply (USDA Forest Service 1988). Forest management activities such as harvesting may also predispose a tract of land to subsequent land use conversion.

Another impact on NIPF management that has not surfaced in investment modeling is government regulation (Henly and others 1988b). Boyd and Hyde (1989) did not find a statistically significant increase in total inventory or total standing volume per acre in Virginia attributable to the State's Forestry Practices Act. They reported that effects of newer, more environmentally sensitive forest practice legislation in Washington and Oregon raise doubts about legislation that does not sharply focus on NIPF owners in locations where forest regeneration is least likely.

Data Considerations

Much of the analysis described above requires data on decisions by forest owners. A central problem of previous research in this area has been the lack of high-quality data. Few studies have been based on samples from which reliable inferences could be drawn for a particular geographic area. Furthermore, the use of proxy variables has weakened hypothesis tests considerably. Periodic and systematic surveys of landowners are essential to develop the data necessary to evaluate the effects of markets, policies, and owner characteristics on landowner decisions. The composition of the broad NIPF class has been changing rapidly (Alig and others 1986), so concurrent changes in private forest investment strategies may occur (Yoho 1985).

Tax rolls and timber deeds on file in county court houses have commonly been used to draw samples from which microlevel data are obtained. These sample frames have limits, however, and dependence on them perpetuates the problem of having highly fragmented and narrowly focused data. Because forestry-related behavior of landowners in regions such as the South is so critical to the Nation's timber supplies, broad area sampling applicable to whole regions seems justified for NIPF. Once established, the area sample could be used periodically to develop time-series and cross-sectional data on landowner characteristics, behavior, markets, public programs, and forest resource conditions. This information could then be used to estimate the parameters affecting landowner timber management decisions. Potential benefits of additional data acquisition are difficult to evaluate, but the importance of NIPF land for forest resource supplies and the value of data-rich studies like that of Fecso and others (1982) suggest that the investment in systematic area sampling would be worthwhile, particularly in the South.

Simultaneous modeling of the levels of timber harvest, intensity of timber management, and land area devoted to timber growing has not been possible. Methodological shortcomings and data deficiencies have forced analysts to separate the overall problem into smaller, more tractable components. In the concluding section, we recommend research that is needed to provide more comprehensive and integrated models.

Conclusions

Findings from previous research indicate that stumpage price increases will not necessarily lead to increasing timber supplies from NIPF lands. Future supplies depend on a complex of market and policy factors that influence planting rates, intermediate treatments, and harvesting rates. Analysts must be careful in attempting to isolate determinants of NIPF behavior because the ownership class and the motivations of its members are diverse. Data on NIPF owners' behavior and on changes in behavior are weak. Traditional optimization approaches to investment decisions often do not yield testable formulations (Adams and Haynes 1986).

Conclusive research findings on timber management and the effects of government programs on NIPF timber management include:

1. Cost sharing correlates with an increased probability of tree planting by NIPF owners.

2. Landowner income is positively correlated with increased tree planting and negatively correlated with increased harvesting.

3. Cost-share plantings are concentrated on relatively productive acres.

4. Most cost-share plantings are not liquidated when support payments end.

5. Technical assistance is highly correlated with increased harvesting.

6. Technical assistance with harvesting has tended to increase revenues for owners and has left residual stands that are in better condition.

7. Large forested tracts tend to be harvested more often than smaller ones.

While NIPF owners do respond to public incentives, data are insufficient to demonstrate the full extent of the response. Major questions remain about: (1) effects of expected prices on planting and intermediate treatments, (2) effects of cost sharing on harvesting, (3) income effects, (4) effects of technical assistance alone on all three forest management activities, and (5) capital substitution in government programs. A clearer understanding is needed of relationships between landowner decisions about planting, stand treatments, and harvesting.

The needs outlined above frame a research agenda. When new studies are begun, considerable thought should be given to both the unanswered questions and the theoretical modeling and data considerations. Many previous studies have been too narrowly focused or have drawn too narrow a sample to address regional or national questions. Several important topics for further research in the area of NIPF timber management behavior are:

- The linkages between policy variables and timber investments, framed in a decisionmaking context encompassing harvest, forestation, and land use choices.

- The implications of risk perception in timber investments.

- The implications of joint forest production in timber investments.

- Economic and demographic factors involved in forest type and land use changes.

- Repeated sampling of NIPF owners and land management to measure changes in timber supply.

- Analysis of local and regional timber market imperfections.

The reliability of projections of timber supply requires estimates of NIPF owner responses to investment opportunities under various market conditions, social settings, and policy options. An improved model of forest investment behavior must: (1) translate acres with potential for silvicultural treatment into acres likely to receive treatment, and (2) assess the associated influences of markets and private and public programs in allocating land and capital. This improved model would also promote more realistic projections of timber supplies and more knowledgeable formulation of programs.

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