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Timber Supply From Private Nonindustrial Forests

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TIMBER SUPPLY FROM PRIVATE NONINDUSTRIAL FORESTS

A Microeconomic Analysis of Landowner Behavior

By
Clark Shepard Binkley

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ABSTRACT

Historically, private nonindustrial forests have made significant contributions to the national timber budget. The Forest Service expects even greater reliance in the future on the timber supplied from these lands. Yet the economic basis for estimating timber supply from these diverse ownerships is weak.

This essay develops a microeconomic model incorporating both timber and nontimber objectives. The landowner is assumed to derive utility from nontimber forest outputS such as recreation and income for the consumption of other goods. Timber harvest decisions are made as though the landowner were maximizing utility subject to two constraints. First, total income equals an amount exogenous to the model plus receipts from timber sales and less the costs of holding land. Second, timber and nontimber forest outputs are linked by a multiple use constraint which describes the technically feasible combinations of timber and nontimber outputs. The supply equation derived from this model is a function of stumpage prices, size of the holding, income and other socioeconomic characteristics of the owner, and the tradeoffs between timber and nontimber outputs. Both theoretical and empirical results are obtained using this model.

The empirical results are based on two sets of data. First, the timber supply model is estimated using a Forest Service survey of New Hampshire landowners combined with stumpage price data. The measure of timber supply from that survey is dichotomous, measuring whether or not an owner harvested timber in a certain year. Consequently, the timber supply model is cast as a model of choice and a maximum likelihood logit estimator is used to obtain estimates of the model's parameters. Second, information from the Pilot Woodland Management Program is used to examine the underpinnings of the landowner decision model. Organized in 1955, the PWMP provided detailed forest management information to 50 New Hampshire woodland owners. The records of this program were reassembled and some of its cooperators were interviewed.

The results from the theoretical and empirical analysis have interesting implications for public policy towards private nonindustrial forests. The probability of timber harvest is strongly affected by stumpage price. Owners of large parcels are more likely to harvest timber than are owners of small parcels. Farmers are more likely to

harvest timber than are nonfarmers, and the response of farmers to price is over twice as large as the price response of nonfarmers. Then at any given price, both land parcelization and the trend from farm to nonfarm ownership will lead to reduced timber supply from private nonindustrial forests.

Income is negatively related to the probability of timber harvest. Reductions in the costs of holding land (e.g. property taxes), in effect, increase landowner income. Consequent!y, unless property tax reductions forestall land use changes which are detrimental to timber management, these reductions will reciuce timber supply.

The focus of concern for improving private land management should shift from timber management to forest management. Careful attention should be paid to the nontimber outputs from these forests which are public goods such as wildlife and its habitat, aesthically pleasing views, some forms of outdoor recreation, and so on. The role of private nonindustrial forests in providing nontimber forest products is largely unwritten.

ACKNOWLEDGEMENTS

A study of forest ownership is prerequisite to the appellation "forest economist," or so it has been said. That being the case I thought it prudent to complete mine early on. This *Bulletin* is the result.

Several associates, acquaintances and institutions have assisted this essay. First a Yale University Fellowship and then a position as an Acting Instructor in Forestry at the Yale University School of Forestry and Environmental Studies supported me and my family during my career as a graduate student. Research funds from the School of Forestry and Environmental Studies paid for the costs of travel to New Hampshire to colleCt the Pilot Woodland Management Program records. Funds for computation were ptovided by Yale University. The excellent software support of the Yale University Social Science Computing Facility eased the trying burden always associated with statistical analysis of a large data set.

Mr. Neal Kingsley of the Northeastern Forest Experiment Station provided selected data from his surveys of forest landowners in New England. The County Foresters in New Hampshire, under the direction of Roger Leighton, assisted in reassembling the records of the Pilot Woodland Management Program. After 32 years one would have expected much more attrition of the records. Perhaps because silviculcural experiments take so many years to complete, foresters are reluctant to throw out forms with numbers written on them, even if the data are "only economics."

This work is drawn largely, but not entirely, from my doctoral dissertation of a similar title. My doCtoral committee was chaired by Professor Albert C. Worrell and included Dr. Ernest M. Gould, Jr. of the Harvard Forest and Professor John M. Quigley, then of the Yale University Department of Economics. They provided valuable guidance both in this research and other matters economic. To Ernie I owe the kindling that initially fired my interest in this whole forestry business.

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Without the patient support of my wife Nadine and the unabashed joy of my young son Clayton this research would have never been possible.

Chapter 1

INTRODUCTION

The management of private forest land has long been a matter of serious social concern. Once timber prices rise to a level where investments in forestry can be justified on the same grounds as other business investments, the forest products industry typically responds with intensified timber culture on its land holdings. Although external effects (water and air pollution from land management activities, for example) continue to warrant public attention, the level of timber production seems to respond to ordinary market signals.

Nonindustrial private forest owners respond to economic forces in a more complex and less predictable way than do their industrial counterparts. Under the broad official definition, these ownerships include forest lands held by individuals or corporations who do not also own the requisite equipment to convert logs into lumber, pulp or other secondary forest products. In the United States private non-industrial ownerships range in size from one acre to over one million acres. Private nonindustrial forests occupy three fifths of the commercial forest land in the United States (USDA, 1978b, p. 8), or roughly 15 percent of the nation's coterminous land area.

This study examines the ancient problem of timber supply from these forests. Its principal objective is to quantify timber prices, land owner and ownership characteristics, and tradeoffs between timber and nontimber forest outputs that influence timber supply from this diverse class of owners. This study develops and tests a formal microeconomic model which describes how these owners make decisions concerning the quantity of timber to harvest. Although the problem is of national scope, the data supporting the empirical conclusions are drawn from New England in general and New Hampshire in particular.

1.1 *Scope and Limitations of the Study*

In 1976, the most recent year for which data are available, private nonindustrial forests produced about one half the nation's total roundwood harvest (USDA, 1978b, p. 80), so these forests are clearly an important domestic source of timber (SeCtion 2.4 below examines the question of how important in some detail).

Although this study focuses solely on timber production, timber is only one of the outputs from these forests. The nontimber goods and services produced by these lands (outdoor recreation, wildlife and wildlife habitat, aesthetically pleasing landscapes, watershed protection and so on) also contribute significantly to our national welfare (Worrell and Irland, 1975; National Academy of Sciences/National Academy of Engineering, 1973; United States Department of Agriculture, 1978). Because many of the nontimber outputs from these forests are handled outside the market system, the case for government intervention in their production is inherently stronger than it is for timber outputs. For example, private lands can help satisfy the expanding demands for public outdoor recreation. In fact, nontimber outputs from these lands may be more important than their timber production.

Nevertheless, the focus of this study is on timber supply, and only one part of that output is treated: the propensity to harvest timber. Some of the difficult issues surrounding long term timber supply from this class of owners relate to timber management practices on these lands (Section 2.2). Timber management and the propensity to harvest timber are related in two ways. First, an owner obviously can not harvest timber he does not own. The size, quality, amount, species distribution and merchantability of his growing stock available for harvest at any time depends, in part, on his past management decisions. The empirical analysis in Chapter 4 discusses this effect.

Second, the harvest of all or parts of a stand is a major means of creating a higher valued stand for the future:

> Paradoxical as it may seem, and repugnant as it may be to certain influential segments of public opinion, useful forests are created and maintained chiefly by the temporary destruction of judiciously chosen parts of them. The axe as well as other means of killing trees can be used for the construction as well as the destruction of the forest. The importance of cutting as a means of harvesting wood for human use should not obscure its role as the major means by which forests are established and tended (Smith, 1962, p. 12-13).

It is an old saw that the forester's most powerful tool is the axe.

Regeneration of a stand after harvest with desirable species at a reasonable level of stocking is perhaps the most critical aspect of timber management for insuring long term timber production. In areas where commercially desirable species are shade-tolerant and capable of advance regeneration under mature stands, this critical step may occur with little intervention by man. Some northern and central hardwoods, eastern and western hemlock, and the spruce-fir forest of Maine fall into this category. In other areas where commercially desirable species are intolerant and less desirable shade-tolerant species exist on the site, considerable effort is required to regenerate a stand of the desirable species. The southern pines and Douglas fir are examples of such intolerant species. Economic regeneration of desirable timber species is an important issue both for timber management and long term timber supply, but is not treated in this study.

1.2 Relationship to Other Research

Previous work on timber supply from private nonindustrial owners has taken one of two forms. One branch of analysis has attempted to relate ownership characteristics to the propensity to harvest timber. Barraclough's work (Barraclough, 1949; Barraclough and Rettie, 1950) is an early example of this type of study. More recently the Northeastern Forest Experiment Station (e.g. Kingsley, 1976a; Kingsley and Birch, 1977; Larsen and Ganser, 1973; Turner, Finley and Kingsley, 1977) has extended this type of survey to cover many of the northeastern states. This type of analysis uses data for individuals (called microdata), and relates harvest decisions to owner and ownership characteristics such as size of holding and income of the owner. Timber price is ignored as an explicit variable in the harvest decision.

A second branch of analysis estimates traditional supply curves using aggregate data with price as an explicit variable. Because of the aggregate data employed, incorporating ownership characteristics into the supply equation is impossible. Adams and Haynes (1980) estimate private nonindustrial timber supply equations for eight regions of the United States based on state level data for the years 1950-1974. They find that timber supply from these owners is not strongly affected by price. This conclusion is not supported by the analysis presented in Chapters 3 and 4 below.

Reliance on microdata for ownership characteristics while including price as an explicit determinant of the harvest decision distinguishes the present research from these twO approaches. In addition, the empirical analysis is based on a formal economic model of landowner behavior. Both the microdata approach with price as a supply determinant and the formal analysis of the harvest decision are unique to this study.

1.3 Outline and Summary

The remainder of this *Bulletin* consists of five chapters and three appendices. Chapter 2 provides the context for this research by reviewing the problem of timber supply from private nonindustrial owners. The so-called problem rests on twO important assumptions: future timber scarcity and poor management on these lands which, if rectified, could alleviate that scarcity. The data do not appear adequate to either support or reject the conclusion that, across the nation, the management on these lands is poor. The alleged symptoms of timber scarcity can be better explained by a simple model of optimal reduction of the old growth inventory.

Chapter 3 provides the analytic framework for the research. Assume the landowner derives utility from nontimber land outputS (recreation, wildlife, aesthetic values, etc.) and income for the consumption of other goods. He chooses his level of timber harvest as if he were maximizing utility subject to two constraints. First, his total income equals an amount exogenous to the model plus timber receipts and less land holding costs. Second, timber and nontimber outputs are linked by a multiple use constraint which determines the maximum amount of timber Output that is consistent with any given level of nontimber outputs.

Based on assumptions concerning the shape of the utility function and the multiple use constraint, some interesting theoretical results are obtained. Increases in income lead unambiguously to decreases in harvest. Reductions in land holding costs (such as property taxes) lead unambiguously to a reduction in harvest. Increases in the size of holding generally lead to increases in harvest. In this model, the effect of price on timber supply is ambiguous because of the utility tradeoff between income from timber and the value of nontimber forest outputs.

Chapter 4 reports the statistical estimation of this timber supply model. The measure of timber supply is a dichotomous variable indicating whether or not an owner harvested timber in a certain year. Because the dependent variable is dichotomous, standard statistical techniques such as ordinary least squares regression are not appropriate. Consequently the first part of Chapter 4 describes the statistical method that was used to estimate the timber supply model: maximum likelihood logit analysis. The second part of Chapter 4 describes the data set used in this study. It includes information on timber harvest behavior, stumpage prices and owner and ownership characteristics for a sample of private nonindustrial owners in New Hampshire.

The final part of Chapter 4 reports empirical results. Stumpage price has a strong positive effect on the probability that private nonindustrial owners will harvest timber. Owners of larger tracts are more likely to harvest timber than are owners of smaller parcels. Owners with higher incomes are less likely to harvest timber than are relatively less affluent owners, although the statistical significance of this relationship is weak. Farmers are more likely to harvest timber than are nonfarmers, and their response to price is significantly greater than that of nonfarmers.

Chapter 5 examines the model of landowner behavior in another way. In 1955 the Pilot Woodland Management Program was organized to provide detailed timber management information to 50 individuals who owned woodlands in New Hampshire. Chapter 5 uses the records for the program and interviews with its cooperators to examine the underpinnings of the landowner decision model. These data also permit exploration into the details of the timber market and associated land market.

The results from the theoretical and empirical analysis have interesting implications for public policy towards private nonindustrial owners. First, price seems to be an adequate inducement to harvest timber. The main question which remains, one outside the scope of the study, is the regeneration of the harvested stands. This problem has distinct regional characteristics which federal programs must recognize to achieve any significant success.

Second, at any given price both land parcelization and the trend from farm to nonfarm ownership will lead to a reduced level of timber supply. If increasing or maintaining timber supply from these forests is a desirable public policy objective, then these two phenomena must be considered. Shifts in both size of holding and type of owner are certain to affect the production of public goods on private forest lands and these effects should be dealt with in government policy or programs.

Third, the theoretical analysis suggests that reductions in the costs of holding land will reduce the amount of timber harvested. In the short run and for small reductions, property tax relief for forest land owners is likely to reduce timber supply rather than increase it. To maintain or increase timber supply, forest property tax relief programs must be designed to discourage land use change and should also be tied to timber management activities. In these programs consideration should be given to the public goods produced by private nonindustrial forest lands.

This *Bulletin* concludes with three appendices which describe the data used in this research. Appendix 1 covers the U.S. Forest Service New Hampshire forest ownership survey. Appendix 2 describes the stumpage price data and indices used in this study. Appendix 3 indexes the records from the Pilot Woodland Management Program. A copy of the existing records from this program are held at the Henry S. Graves Memorial Library at the Yale University School of Forestry and Environmental Studies.

Chapter 2

THE SO-CALLED PRIVATE OWNERSHIP PROBLEM

> Small holdings are supposed to represent a problem in the sense that they occupy a huge part of the productive forest land and yet comprise relatively little of the timber growing stock and prospective growth. To what extent they constitute a problem, or, to the contrary, to what extent their role in American land use has simply been misconceived by foresters, seems to the Committee a question badly needing a clear answer (Duerr, Vaux and Stoddard, 1954).

In the Vnited States this question has needed a "clear answer" since at least colonial times when the Pilgrims of Plymouth Colony restricted exports of forest products for fear of timber shortage. The "problem" has been remarkably persistent. In 1933, Henry Wallace, then Secretary of Agriculture, transmitted to the Vnited States Senate the first finding of the Copeland Report: "That practically all of the major problems of American forestry center in, or have grown oue of, private ownership" (*V.S.* Senate, 1933, p.v). The report goes on to cite poor silvicultural practices on both farm and industrial woodlands, an excess of cut over growth and the consequent impending timber shortage.

Stoddard (1961) begins his major study of the small private ownership problem by describing the progress in bringing public and industrial private forest holdings into management, and then comments:

> On most of the remaining smaller ownerships, that together account for more than half the commercial forest land in the United States, progress has been disappointingly slow. In several recent nationwide surveys by the U.S. Forest Service, by far the greatest proportion of the land in small forests has been classed as unsatisfactorily stocked for regrowth after cutting; only about one-third of the total acreage has received any application of forest practices. Clearly the smaller units are not producing timber anywhere near their growth capabilities. This situation is found on both the farm woodlands and on small tracts held by nonfarm individual owners. Foresters have recognized this lag for many years, and have developed a number of programs designed to

correct shortcomings. Improvement in management, despite the efforts expended, has not been readily apparent on any large scale (p. 1).

The Southern Forest Resource Analysis Committee (1969), studied future timber supply and demand in the South, finding that "Many private landowners have placed their woodlands under management, and the number will grow as stumpage prices increase" (p. 47). But they go on to say, "To meet the year 2000 wood requirements in the South, the biggest single need is to increase production on 72 million acres of forest in miscellaneous private ownership" (p. 47).

In 1973, the President's Advisory Panel on Timber and the Environment (1973) found that:

> A major goal of national forest policy must be to achieve, during the period 1990-2020, a relatively high timber harest from the nonindustrial private woodlands. Whether or not this goal will be attained depends largely on measures initiated in the 1970's and 1980's. The immense area, low stOcking, modest growth and modest rate of harvest of the 'other private' lands makes them the listless giant of forestry (p. 11).

In the most recent statement of our national forest policy, the U.S. Forest Service (USDA, 1976a) reiterates:

> The biggest opportunity to increase timber growth is on the 59 percent of all commercial timberland - 296 million acres - owned by farmers and miscellaneous private citizens. Much of their land is held for recreation, speculation or other nontimber objectives, and little timber management is practiced at this time. Average gtOwth per acre is 36 cubic feet - much below reasonably attainable levels. Good management could, in time, greatly increase the volume of timber produced on this land (p. 281).

The policy goes on to say:

> A strong effort will be made to encourage nonindustrial owners to better protect, develop, manage and utilize their timber resources (p.626).

The 1978 United States Department of Agriculture Interagency

Committee found:

> The 296 million acres of nonindustrial private land make up about three-fifths of the Nation's productive timber base. These private holdings in aggregate are critical to our wood supply - they also are the lands which most need improved management because they now yield only about half of their productive potential. (USDA, 1978, p. 2)

This report is significant for its emphasis on the nontimber outputs of these lands and the necessity for government programs to support the production of public goods (wildlife, water, and outdoor recreation) from these lands.

Under the joint sponsorship of the Weyerhaeuser Foundation and International Paper Company, Resources for the Future and the Society of American Foresters convened a conference on the private nonindustrial forestry "problem." The report of that conference (Sedjo and Ostermeier, 1978) characterized the "traditional view" of the problem in two parts: (i) insufficient future timber supplies and (ii) poor management on the private nonindustrial lands which, if rectified, could alleviate the alleged timber shortages. To provide the context for the analytic work reported in Chapters 3 and 4, the remainder of this chapter reviews some of the evidence for both of these propositions. As a backdrop for this discussion, section 2.1 describes private nonindustrial forests, their owners, and ownership characteristics. Section 2.2 discusses the quality of timber management on these lands. Section 2.3 treats the question of timber scarcity. Finally, section 2.4 examines the concomitant to timber scarcity: the current and projected future timber supply from private nonindustrial owners.

2.1 Who are the Owners o/Private Nonindustrial Forest Land?

Examining the private nonindustrial forest land base and its ownership characteristics provides a useful perspective on timber supply from these forests. Table 2.1 shows the status of commercial forest lands in the United States over the 25 years between 1952 and 1977. Before considering these data, nOte that the precise official definition of "commercial forest land" differs somewhat from the ordinary sense of the term. Commercial forest land is (USDA, 1973, Appendix III):

i. ten percent occupied by forest trees of any size or formerly having such cover,
11. not developed for nonforest use nor withdrawn administratively from timber production,
111. capable of producing 20 ft^3/acre/year 0.4 m^3/ha) of industrial roundwood in natural stands,
iv. found in parcel sizes of one acre or greater.

Timber production may be uneconomic on much of this land. For example, about one third of the BostOn SMSA qualifies as "commercial forest land" under this definition. Consequently, the area data in Table 2. 1 overstate to some unknown, but possible large, degree the actual land base for timber production in the United States.

TABLE 2.1
Commercial Forest Land in the United States
(million acres)

	1952	1962	1970	1977	% 1977	Change, 1952-1977 %!Year
Total	500.1	511.0	500.3	487.7		-0.1
Public	144.8	145.1	143.0	136.6	28.0	-0.2
National Forest	94.7	96.9	94.7	89.0	18.2	-0.2
State	20.0	20.8	23.5	23.6	4.8	+0.7
Private	355.4	366.0	357.4	351.1	72.0	-0.05
Industry	59.6	61.6	67.0	68.0	13.9	+0.5
Nonindustrial	295.8	304.4	290.4	283.1	58.0	-0.2

Source: USDA 0978b) Table 2, p. 8

Commercial forest land acreage has been roughly constant over the period, equaling about 500 million acres (Table 2.1). There has been a slight decline in public ownership which is likely to continue as more land is set aside for wilderness uses, utility corridors and highway rights-of-way. Most of the publicly owned forest land is held in the national forests, but significant timber-producing areas are held by other federal agencies (Bureau of Land Management, Indian reservations, the Department of Defense) and by state governments.

Private ownership of commercial forest land remained almost COnstant over the period. Ownership of timberlands by the forest products industry (those companies with the requisite plant and equipment to convert logs into lumber, pulp and other secondary forest products) grew by almost 10 million acres in the past twenty-five years. In aggregate the nonindustrial lands, which collectively comprise the majority of commercial forest land in the U.S., changed little in this period. The official and ordinary definitions of "commercial forest land" diverge to the greatest degree in the case of these lands which are the focus of this *Bulletin's* attention.

Most forest statistics divide the class of private nonindustrial forest owners into two groups: (i) farm owners and (ii) miscellaneous private owners (including individuals and corporations who do not own primary wood processing facilities). Table 2.2 shows the breakdown of commercial forest land area between these two groups.

TABLE 2.2
Private Nonindustrial Commercial Forest Land in the United States
(million acres)

	1952	1962	1970	1977	Change, 1952-1977 %/year
Farm	173.0	145.0	125.0	116.8	-1.6
Miscellaneous Private	122.8	159.8	165.4	166.4	+1.2

Source: USDA 0978b) Table 2, p. 8.

By official definition, farms must gain a small amount of income from agricultural products (at this writing, $50/year for farms of 10 acres or greater; $250/year for farms of less than 10 acres). There are two sources for statistics on farm forest ownership: the Forest Service data reported in Table 2.2 and the dicennial Census of Agriculture. Although they use the same definition of "farm," in 1970 the Census of Agriculture found some 19 million acres less forest land than did the Forest Service. The discrepancy probably relates to differences in the definition of "forest land" in the two surveys, but the precise source of the discrepancy has never been identified.

Miscellaneous private owners are all private nonindustrial forest owners who do not qualify as farmers. As a residual category they display a wide diversity of socioeconomic characteristics and forest ownership objectives. They are located in every region of the country, but concentrated in the east.

Although the tOtal area held by private nonindustrial owners as a group has not changed significantly between 1952 and 1977, the composition of ownership within this class has shifted greatly. Miscellaneous owners now comprise a majority of the class, and hold one third of the nation's commercial forest land. Farm ownership has declined at a rate of about 1.6 percent annually.

Existing data do not permit any further national level analysis of the forest land ownership patterns. The last comprehensive survey of forest land ownerships was completed in the late 1940s and even that survey assessed little more than the size of the holdings. The following provides some more detailed information on private nonindustrial holdings in New England.

One feature which distinguishes the two types of private nonindustrial owners is the farmer's use of the land to produce income. Nonfarm owners typically have a broader range of ownership objectives. At the same time that farm ownership of commercial forest land is declining, the importance of income from forest products to those farmers holding the remaining farm woodlands is also diminishing. This can be seen in Figures 2.1 to 2.3 which provide time series data on farm forestry for Vermont. Figure 2.1 shows the steady decline in farm woodland area since 1955. Figure 2.2 expresses these trends in percentage terms. Woodlands account for about 40% of the rotal farm area despite the steady decline in land devoted to farming in the state, so in gross terms the potential for forests to contribute to farm income has remained roughly constant during this century, Yet Figure 2.3 shows that the sales of forest products per acre of farm forest land (adjusted to 1967 dollars using the Consumer Price Index) has declined from about $10 in 1910 to only $1 in 1974.

In 1948, Solon Barraclough (Barraclough, 1949; Barraclough and Rettie, 1950) canvassed all of the owners of woodlots of more than 10 acres in 23 New England towns. Of the six New England states, only

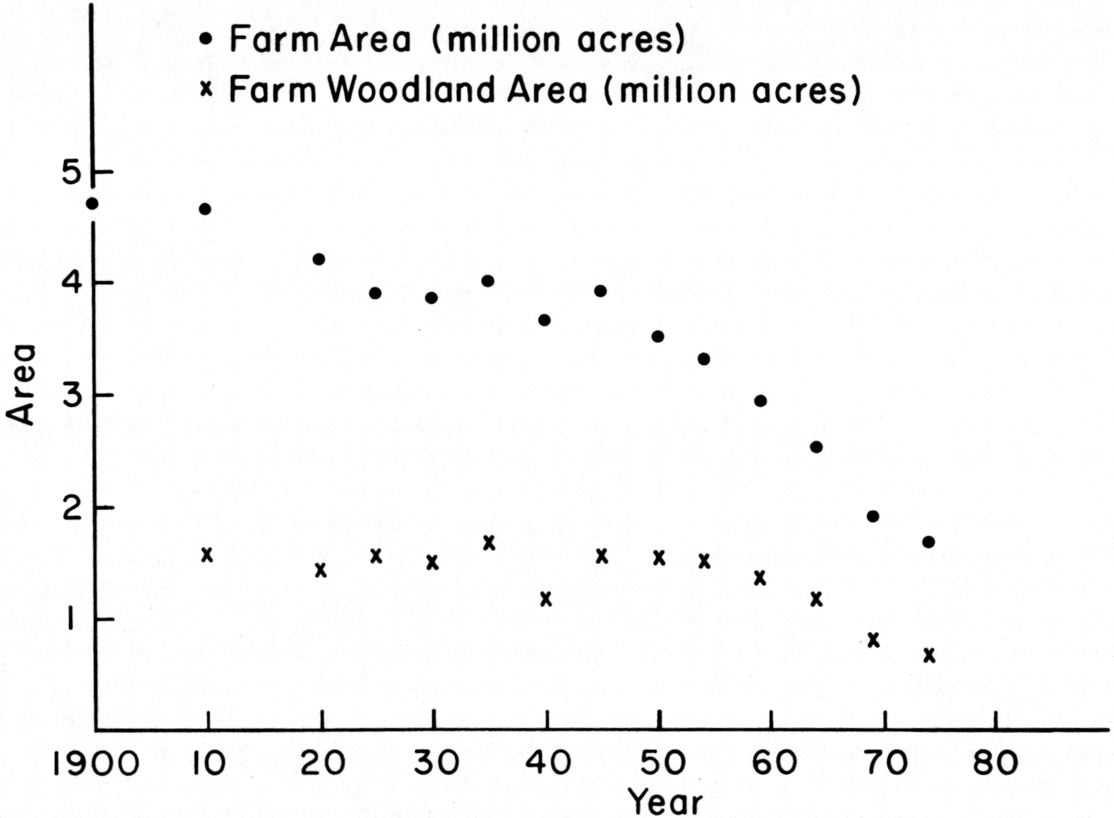

Figure 2.1 Farm and Farm Woodland Area in Vermont, 1900 to 1974

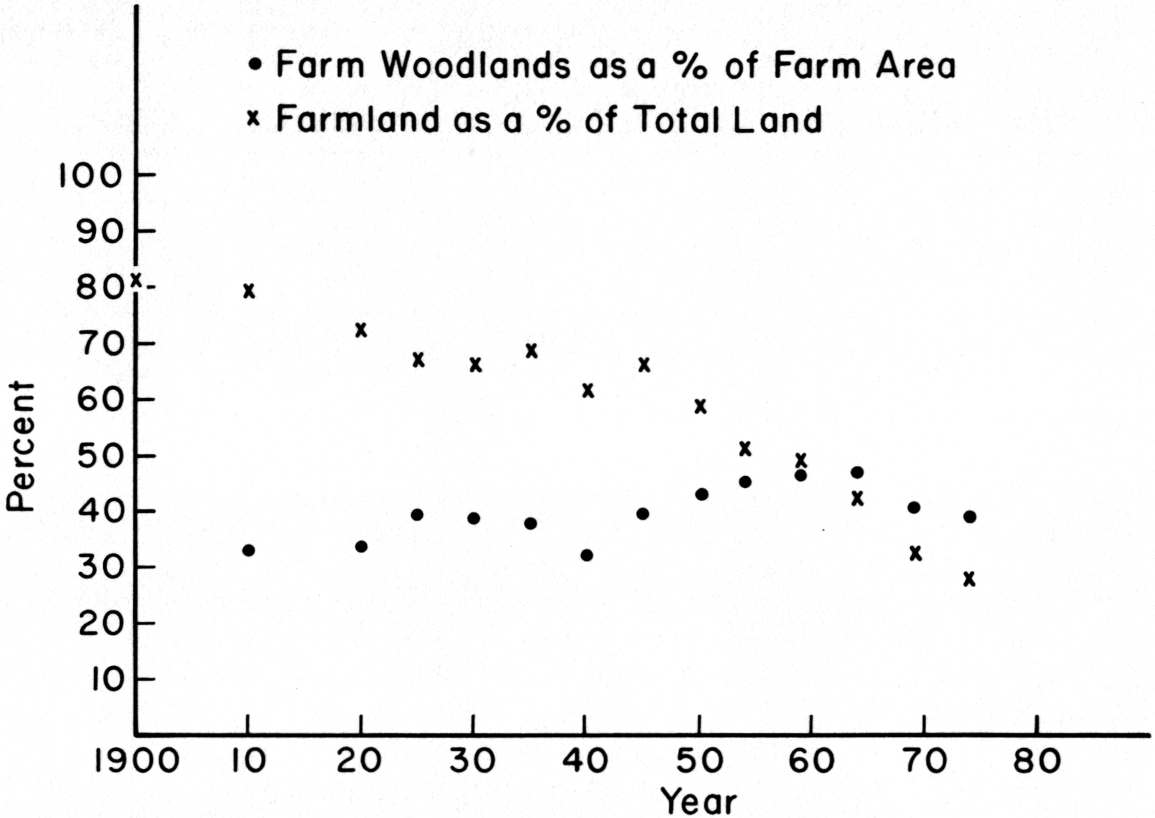

Figure 2.2 Farm Woodlands as a Percent of Farmland in Vermont, 1900 to 1974

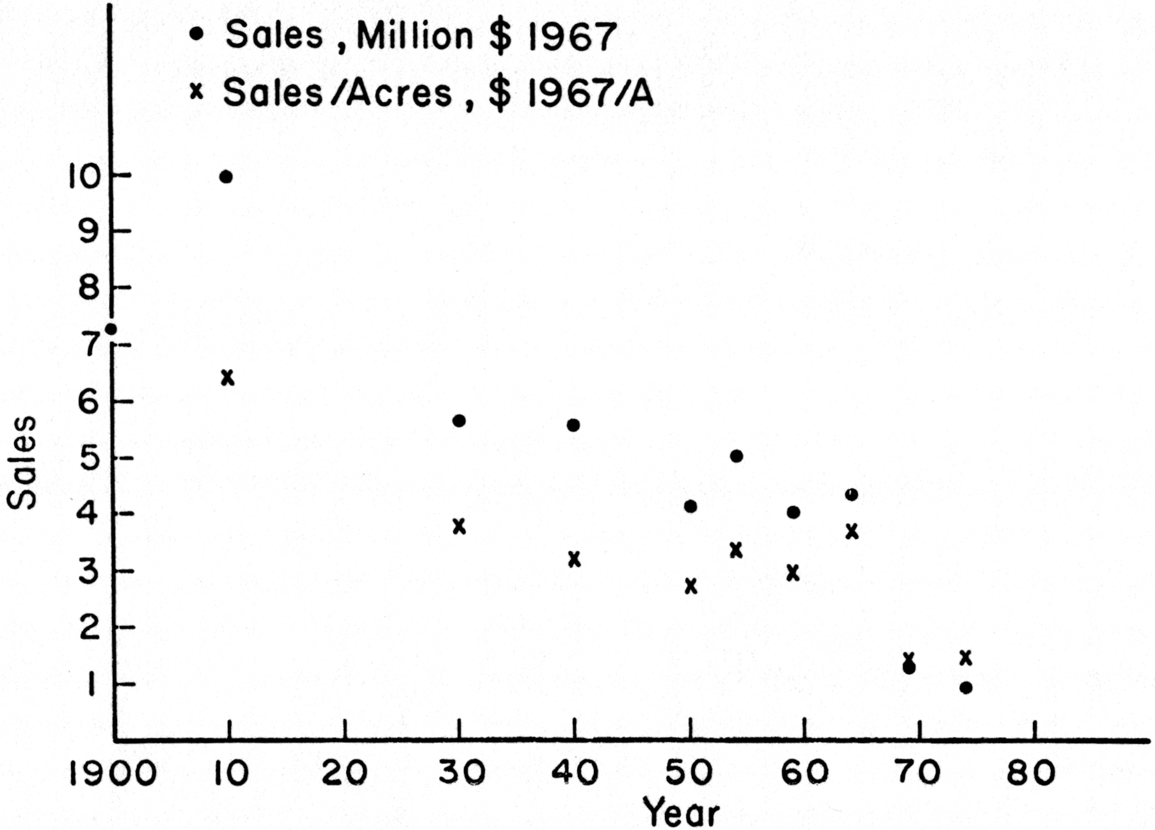

Figure 2.3 Sales of Forest Products by Vermont Farms, 1900 to 1974

Rhode Island was excluded from his study. In 1973, the Northeastern Forest Experiment Station (Kingsley, 1976a and Kingsley and Birch, 1977) surveyed the land owners in all New England states except Maine. Although these data are not entirely comparable some less aggregate comparative statistics can be developed from them.[2]

Table 2.3 presents this view of the trends in ownership of commercial forest land. The number of farm owners dropped from 22.2 percent of the total in 1948 to 4.5 percent in 1973. Within the class of miscellaneous private owners, businessmen and professional workers show the largest increase. On an area basis, the shift from farm to nonfarm ownership is not as pronounced, indicating that primarily farms with small woodlots left the farm ownership class during this period. This trend may be more a result of scale economies in farming than of forest-related factors. Individuals in business and professional occupations showed the largest increase in aggregate area owned, as well as in numbers of owners. Ownership by retired persons increased more in terms of area owned than in terms of numbers.

TABLE 2.3
Percentage Distribution of New England Private Nonindustrial Forest Land Ownership, 1948 and 1973

Type of Owner	Number of Owners		Acreage Owned	
	1948·	1973"	1948·	1973"
Business/Professional	21.5	44.5	26.7	48.0
Blue Collar	21.0	25.6	12.1	11.4
Retired	12.0	15.2	13.8	20.9
Other	23.3	10.2	30.5	7.0
Nonfarm	77.8	95.5	83.1	87.3
Farmers	22.2	4.5	16.8	12.6t

Source: Derived from
·Barraclough and Rettie (1950)
**Kingsley 0976a) and Kingsley and Birch (1977)
tIncluding Maine (Ferguson and Kingsley 1972), the area held by farmers was 13.1 percent in 1973

For Maine there are no data on the occupation of nonfarm owners of commercial forest land, but the recent forest survey in that state does divide ownership into farm and nonfarm classes (Ferguson and Kingsley, 1972). Although the data from Maine renders the 1948 and 1973 data more comparable, its inclusion does not appreciably change the distribution of commercial forest land area between the two classes.

By several measures, then, farm forestry is declining in importance. Frequently the statistical series do not provide enough detail ro separate farm ownerships from miscellaneous private ownerships. Nonetheless, projections of timber supply from private nonindustrial forests should account for the increasing importance of the latter because they are likely to place a greater emphasis on nontimber values of forest land. Similarly, policy measures geared to influencing either timber or nontimber outputs should recognize these trends in private nonindustrial ownership.

A significant decline in holding size has accompanied the shift in occupation of New England forest land owners. A partial picture of this trend can be seen in Table 2.4, which shows the decline in the median size of holding between 1945 and 1973 for five New England states. These data are not precisely comparable because the 1945 data refer to only those holdings of less than 5000 acres and the 1973 data include all holdings. Consequently, the 1945 data underestimate the actual median size of holding by some unknown amount. Because there are very few holdings larger than 5000 acres in this region, the magnitude of the underestimate is likely to be quite small. Kingsley (1979) and Gould (1979) further discuss the discrepancies between these data. In all five states, the decline in the median size of holding over the 28 year period has been marked, ranging froma high of 84.4 percent in New Hampshire to a low of 67.1 percent in Vermont. Chapters 3 and 4 show how this decline in parcel size has significant implications for timber supply from private nonindustrial forests.

TABLE 2.4
Median Size of Forest Ownership
in Five New England States, 1945 and 1973

	1945'	1973	Annual % Charge
New Hampshire[b]	46.9	7.3	-6.4
Vermonc[b]	41.3	13.6	-4.0
Massachusetts[c]	37.0	7.7	-5.5
Connecticut[c]	37.6	8.3	-5.3
Rhode Island[c]	39.2	11.6	-4.3

Source derived from:
a. Barraclough (1949), pp. 151-154
b. Kingsley and Birch (1977), pp. 32-33
c. Kingsley (1976), p. 13

2.2 Timber Management on Private Nonindustrial Forests

McMahon's (1964) extensive review of the research on private nonindustrial timber management concludes that the level of investment in timber production is generally consistent with the economic objectives and constraints associated with this class of owner. In particular, he emphasizes the poor rates of rerurn which private nonindustrial owners can expect from timber management activities compared to the alternatives available to them, such as reducing outstanding consumer credit.

That observed levels of investment are consistent with existing objectives and constraints is a simple economic truism. But the question raised by the traditional view of the private nonindustrial forest "problem" is somewhat different: is timber management on these lands "good"? Two conundrums lurk behind this question. First, given the natural variability of North American forests, are existing data adequate to answer this question? And second, "good" compared to what?

Even cursory review of national forestry statistics indicates that compared to either the national forests or lands owned by the forest industry, the private nonindustrial forests have a greater percentage of their area nonstocked, carry a lower inventory of softwood sawtimber, have more stands poorly stocked and fewer well stocked, and contribute less of their growth to the national timber budget (see

Table 2.5). Industry lands grow about 40 percent more timber per " acre than do private nonindustrial lands although national forests grow about 20 percent less. These data or similar others are frequently cited to describe the apparent poor timber management on private nonindustrial lands (U.S. Forest Service, 1973, 1976; Presidents Advisory Panel on Timber and the Environment, 1973; Sizemore, 1973; Stoddard, 1961).

Yet what do these data imply? Very little about the quality of management on private nonindustrial lands, it seems. The available periodic reports on the status of forest resources 0958, 1965, 1973 and 1977 are the most recent) do not provide sufficiently specific data for a meaningful analysis (Zivuuska, 1978). For example, we know the sawtimber srocking by state, but very little about its quality, accessibility or merchantibility. And 'optimal' stocking depends on the species, site quality, and markets involved, yet this information is not available in a form amenable to a meaningful national description of timber management intensity.

TABLE 2.5
Comparison of Private Nonindustrial Forests with
Forest Industry and National Forest Lands

	National Forests	Forest Industry	Private Nonindustrial
Area (Million Acres)	91.924	67.341	296.234
Nonstocked (%)	3.6	2.2	4.5
Growing Stock <1500 *bf/A* (%)	21.1	40.4	57.7
Growing Stock >5000 *bf/A* (%)	49.1	27.3	12.9
Softwood Sawtimber (Mbf/A)	10.68	4.72	1.29
Growth in Growing Stock (ft^3/A)	28.4	51.7	36.3
Removals/Growth	.838	1.055	.673

Source: USDA (973) Appendix I, various tables

Furthermore, indicarors such as stocking are intermediate indicators of management, not measures of either Output or the effectiveness of turning 'resources utilized into products produced. Table 2.6 sheds some light on this problem, showing the ratio of actual to realized growth on three ownership types. The private nonindustrial forests are intermediate between the national forest and forest industry lands in achieving their biological potential to produce wood fiber.

Yet even this measure is crude at best and misleading at worst. There are ptoblems in measuring both actual and potential growth. In the former case, it is well known that the current annual increment of a tree depends on its age. Then the ratio of total to potential growth can only be interpreted in light of the age structure of the stand. Similarly, "potential growth" refers to the maximum mean annual cubic foot increment of fully stocked natural stands on the particular site in question. Depending on the interest rate used, it may not be economic to hold a stand to this point.[3] Alternatively, maximum economic yield could conceivably call for longer rotations. Consequently, achieving a 1: 1 ratio of actual to potential growth is not necessarily a desirable objective for timber management. Moreover, "full" stocking is not the economically optimal level in every situtation. Finally, the Forest Service definition of potential growth explicitly excludes the additional growth which might be attained under intensive management. Although it is conceptually useful to compare realized and potential timber production performances, the current measure of potential growth is inadequate for the task. Simple comparisons of actual to potential growth as currently defined indicate very little about the intensity or effectiveness of timber management.

TABLE 2.6
Current and Potential Growth
(ft^3/A/year)

Growth	National Forests	Forest Industry	Private, Nonindustrial
Current	30	52	36
Potential	73	83	72
Ratio	.411	.627	.500

Source: USDA (1973), Table 10, p. 17

Implicit in the question of good management is a benchmark of comparison. For this purpose Clawson (1979) uses the performance of industrial forests, acknowledging the possible differences in objectives between industrial and nonindustrial private owners. But even given the same objectives, the same piece of land, and identical knowledge of management opportunities, industrial and nonindustrial owners would probably manage their timberlands differently. One reason is capital gains taxation of timber income, a provision of the tax code which affects integrated industrial forest enterprises in a different way from nonindustrial forest owners and, in aggregate, benefits the former more than the latter (Sunley, 1976). Another is the existence of estate taxes for individuals. A third is that timber management should respond to market opportunities. For example, management of timberlands oriented to serving a specific mill should logically provide trees of the species, size, shape and quality which maximizes the combined profit of the forest and the mill together. A nonindustrial owner selling stumpage on the open market does not operate under that constraint.

Nevertheless, Clawson (1979) finds that when analyzed on a state-by-state basis, management as defined by aggregate measures is statistically similar on industrial and nonindustrial private lands. For forest lands in Georgia, McComb (1975) reaches the same conclusion.

A partial answer to questions about the quality of timber management on private nonindustrial lands may come Out of the current Forest Industry Council analysis of the potential for expanding timber production in the 25 states which contain 84 percent of the nation's commercial forest land.[4] Some of the Council's final results are analyzed in Table 2.7. Here we see that the greatest potential for increasing timber growth, while maintaining a 10 percent rate of return, lies on lands held within the national forest system and those held by the forest products industry. The least expensive incremental growth comes from national forests. The per acre improvements in management on private nonindustrial lands yield only three fourths as much physical output as those on national forests and cost 11.4 percent more. Economic efficiency seems to call for increasing the investment in timber production on the national forests and on forest industry lands before doing so on private nonindustrial forests. This conclusion is reinforced by strong institutional barriers to intensive timber culture on nonindustrial private lands, such as lack of expertise, small parcel size, lack of equipment, and frequent ownership changes which have been treated only tangentially in this discussion.

TABLE 2.7
Timber Growth Increases Resulting
from Investments Earning 10% or More

Ownership	Additional Growth Potential (ft^3/A)	Cost of Incremental Growth (\$/ft^3)
National Forest	33.2	0.88
Other Public	18.7	0.92
Forest Industry	33.3	0.91
Private Nonindustrial	24.9	0.98

Sources: Derived from National Forest Products Association (l980a), Tables 39 and 43

2.3 Timber Scarcity

The problem of timber scarcity is one of the oldest chestnuts in forestry. Duerr (1974) traces public concern with timber scarcity to medieval Europe. Wood was a necessity for fuel and shelter, and the tremendous difficulties of overland transportation proscribed trade or the use of distant supplies. To that time and place we owe many of the basic concepts and methods of modern forestry. For example, maximum sustained physical yield, a policy which Dowdle had deprecated as a "bag limit on trees," is still the basis for managing the timber on our national forests.

Timber scarcity has caused concern in the United States for many years. The most recent incarnation of this concern arose in the late 1800's when active timber management was practically nonexistent. Wild fires were destroying large areas of timber and taking lives as well. Logging practices were predicated on rapid exploitation of what seemed like a limitless reservoir of old growth timber. Timber famine was a disease whose symptoms included rising stumpage prices, an annual cut well in excess of growth, and very little concern for reforestation or other investments which would guarantee a future supply of timber. Clepper (1971) attributes, directly or indirectly, much of the support for the forest reserves, the Forest Service, and the whole conservation movement to the fear of timber scarcity.

Economists recognize that scarcity manifests itself in prices. Hence, precisely because timber is scarce, society supports a profession called forestry to worry about growing it. Then the main issue is not timber shortages but timber prices at various supply levels.

Since about 1800, softwood lumber prices have been rising in real terms at about 1.7 percent annually, and real softwood stumpage prices have increased at about 2.5 percent annually since 1900 (see, e.g. Duerr, 1973). Both Irland (1974) and Barnett and Morse (1963) interpret this fact as evidence of increasing timber scarcity. In a sense their interpretation is correct, but it may be more useful to consider the price trend in light of the dynamics of a competitive old growth timber economy. As the old growth is liquidated, one would expect precisely the pattern ofprices and exploitation which emerged. In the early stages of exploitation, the problem is much like that of operating a mine. In a mine with constant costs of extraction Hotelling (1931) showed that the price of unsevered natural resources will rise at the interest rate. Just as a lower quality of ore carries a lower royalty than a high grade ore (Herfindahl, 1967), the increased costs of accessing increasingly distant timber will tend to moderate stumpage price trends.

Exploitation proceeds without regard to the future because prices are too low to support investment in timber production. As the standing volume diminishes, prices, in real terms, rise. As they rise, investment becomes profitable on the beSt sites, which were frequently the first sites cut because of their location on valley botroms and their heavy inventories of high quality timber. The best sites are then converted ro growing timber on a sustained yield basis, generally carrying much less volume per acre than they did originally. Until all of the sites which can be economically converted to long run sustained yield timber production have been put under management, cut will exceed growth. Once the conversion of the old growth has taken place, the real price of stumpage should stabilize at the long run average cost of timber production. Rather than symproms of timber famine, these processes are the solution ro the problem of optimal stocking over time.

Of course, the forest products economy does not operate with the precision implied by this analysis. For example, there are undoubtedly lags between the time ofeconomic need for investment in timber production and the time that the required investment actually takes place. The long production period in forestry practically guarantees socially suboptimal timing of timber investments. Furthermore, during the period of low timber prices, land would be shifted from timber production to other uses. As stumpage prices rise, converting some of this land back to timber production becomes economically feasible. The intervening land uses, however, may make this reconversion slow, costly or impossible.

In the context of the model outlined above, these barriers to economic adjustment mean that stumpage prices are likely to overshoot· their long run level. A period of adjustment in the level of investment in timber management, amount of land devoted to timber production, inventory of growing stock and the concomitant supply-demand equilibrium for stumpage will follow. The simple model suggests that prices will stabilize once the old growth is fully liquidated, some 10 to 20 years from the present. With barriers to adjustment and imbalances in the age distribution of the inventory, prices will level to long run average costs only when the second growth timber economy is more firmly established than it will be in the next one or two decades.

2.4 Timber Supply From Private Nonindustrial Forests

In this context the contribution of private nonindustrial forests to current and projected timber supply can be assessed. Table 2.8 provides relevant data. In 1976, private nonindustrial forests provided slightly less than half of the timber harvested in the United States. The Forest Service projects a 42.7 Percent increase in domestic timber supply by the year 2000 and estimates that four fifths of this increase will come from private nonindustrial forests. Their share of the timber supply is predicted to rise from 46.8 percent to 57.0 percent, and both the national forests and forest industry lands are projected to decline in relative importance. In 2000 over three fourths of the domestic hardwood supply will be harvested from private nonindustrial lands, along with about half the softwood supply.

TABLE 2.8
Timber Supply Estimates by Owner Class
(billion cubic feet)

	1976 Total	1976 %	2000 Total	2000 %	% of 1976-2000 Change
National forests	1885	14.8	2342	12.9	8.4
Other Public	977	7.7	1195	6.6	4.0
Forest Industry	3890	30.6	4263	23.5	6.9
Private Nonindustrial	5944	46.8	10323	57.0	80.7
Total	12698		18123		

Source: Table 8.5, p. 429 and Table 8.10, p. 438 USDA Forest Service (1980).

One major difficulty in forecasting long term timber supply lies in estimating the response of private nonindustrial owners to changes in price and other relevant independent variables. In conjunction with the most recent U.S. Forest Service timber assessment activities, Adams and Haynes (1980) estimate timber supply equations for private nonindustrial forests based on a time series of state level data. They conclude:

> Efforts to estimate indepedent supply equations for nonindustrial ownerships proved fruitless except in the two southern regions. The positive results in the south probably derive from the heavy dependence of wood and pulp products producers on stumpage from nonindustrial lands and the existence of active markets for nonindustrial timber. In all other regions, however, cut, price and inventory are poorly or even negatively correlated (p. III-62).

To derive their national timber supply estimate, Adams and Haynes constrain the regional nonindustrial private timber supply equations in various ways to conform to traditional economic expections concerning the "correct" signs for the several independent variables.

In short, the behavioral basis for estimating timber supply equations for private nonindustrial forests is weak. The next chapter develops a model for assessing the effect of price, landownership characteristics and nontimber values on the timber supply response for this important but perplexing class of forest owners.

Chapter 3

A MODEL OF LANDOWNER BEHAVIOR

> . the forest holding is not only a productive enterprise, but may also be a consumption good for its owner, in which case the theory of the household is as important as the theory of the firm when analyzing forest holdings. (Barraclough 1949, p. 10)

This chapter develops a formal economic model which characterizes the forest holding both as a productive enterprise and as a consumptive good in itself. The aspects of a "productive enterprise" occur because through timber sales the forest is capable of producing income which can be used for the owner's consumption of goods and services. Forest land is also a consumption good because it can produce direct utility to the owner through recreation, solitude, aesthetic pleasure, or other amenity values. In deciding how much timber to sell, the owner balances the value of the consumption made possible by the income derived from a timber sale against the amenity values lost by harvesting the timber.

The first section formalizes this decision process into a microeconomic model. Section 3.2 discusses the economic features of how land produces timber and nontimber outputs. The third section derives some theoretical results which are inescapable conclusions from the model's assumptions. The final section extends this model to a corollary analysis of land markets, and uses the results from that analysis ro gain some leverage on the problem of estimating the technical tradeoff's between timber and nontimber values.

3.1 The Formal Model

Suppose that a forest landowner derives utility from the consumption of noncimber land outputs, (e.g. recreation, aesthetic amenities) and all other consumption. He makes timber harvest decisions as though he were maximizing a utility function subject to two constraints. First, his total outlay cannot exceed his income which equals an amount exogenous to the model plus his receipts from timber sales and less his cost of holding land. Second, the combinations of timber and nontimber outputs are limited to those which are technically feasible given his initial endowment of land. In symbols, the problem is

$$(3.1) \qquad \max_{t} u(r, y)$$

subject to

$$(3.2) \qquad y = y^e + p^t t - cl$$

$$(3.3) \qquad r = g(t,l)$$

where

$u(r,y)$ = a utility function defined over r and y
y = net income available for consumption of nonland goods
y^e = income exogenous to the model
p^t = price of timber (stumpage price)
t = amount of timber cut
c = per acre cost of holding land
l = amount of land held
r = nontimber land outputs and consumption
$g(t,l)$ = a function relating timber to nontimber land outputs.

Equation 3.3 reflects the essential economic aspects of the forester's doctrine of multiple use applied to individual ownership. This relationship is notoriously difficult to estimate and the model simply postulates its existence. Section 3.2, below, discusses this function in greater detail.

Before stating additional assumptions concerning the shape of these functions (e.g. the signs of their derivatives) and solving this simple nonlinear programming problem, several limitations of this approach should be noted. First, the only income-producing output from the forest land is timber. No grazing or maple operations, for example, are assumed to take place. However, as long as these activities only affect the exogenous income y^e, and not the level of amenity outputs from the land, the model adequately accounts for them. Second, speculative gains associated with land ownership are not explicitly considered in the model. If current timber operations do not affect the perception of these gains, then this exclusion is not troublesome. Since in this model land endowment is fixed, such speculative gains would enter primarily through the costs of holding land c, and can be treated simply as a parameter of the model. Third, the land endowment is initially fixed and the only decision to be made is the amount of timber to cut. Section 3.4 relaxes this assumption to consider timber and land markets simultaneously. In a similar vein, the model is static: it considers only how much timber is cut and not how much is reinvested in timber management.

Several conditions on the functions u and g complete this formal model. Specifically, the usual assumptions concerning the shape of uare:

(3.4) $u_r > 0$
(3.5) $u_y > 0$
(3.6) $u_{rr} < 0$
(3.7) $u_{yy} < 0$
(3.8) $u_{ry} \geq 0$

Throughout this discussion subscripts are used to denote differentiation with respect to the subscript variable.

Relations (3.4) and (3.5) simply say that more is better. Utility is always increased through additions of either income or nontimber land outputs. Relations (3.6) and (3.7) embody diminishing marginal utility. That is, the value of addition of either utility-producing good diminishes as more of it is supplied.

The first four conditions are the usual assumptions (see, for example, Henderson and Quandt, 1971, p. 15- 16)concerning individual preferences. The relationship stated in (3.8) cannot be similarly extracted from those standard assumptions. Loosely stated, (3.8) says that at a higher income an individual will value increases in nontimber land values more than he will at a lower income. That is, nontimber land values are superior goods. Like all assumptions, the validity of this one can only be determined empirically. There is some evidence, for example, that wilderness values are consistent with this assumption (e.g. Stankey, 1972); therefore one might reasonably expect that nontimber land values in general behave this way. In any case, where this assumption is used in the analysis the implications of its violation are noted.

The additional conditions on g are:

(3.9) $g_t < 0$

(3.10) $g_l > 0$

(3.11) $g_{tt} \leq 0$

(3.12) $g_{ll} \leq 0$

(3.13) $g_{lt} \gtreqless 0$

Section 3.2 discusses these in greater detail.

The first of these conditions, (3.9), states that some timber values must be foregone to obtain additional nontimber values. Were this not the case, the owner would increase both outputs until he reached the point at which he could no longer obtain more of one without decreasing his output of the other. Then this part of the production function is addressed in the model. The second relation, (3.10), asserts that more land permits unambiguously higher levels of both timber and nontimber outputs. Relations (3.11) and (3.12) embody diminishing marginal productivity and land in supplying either timber or nontimber outputs.

The solution of this optimization problem can be found by substituting equations (3.2) and (3.3) into equation (3.1) and then solve the problem by differentiating the result with respect to it, setting this derivative equal to zero, and solving the resulting equation.

Solving the problem as outlined above yields

(3.14) $u_y p^t = -u_r g_t$

or at the optimum the marginal value from an additional unit of timber output equals the marginal value of the nontimber outputs which must be foregone to obtain that unit. This equation is an indirect timber supply equation and as such forms the basis for the empirical results obtained in Chapter 4.

3.2 *An Aside on g, the Multiple Use Constraint*

Although "multiple use" is a basic tenet of American forest policy (embodied formally in law by the 1960 Multiple Use-Sustained Yield Act), its application to any specific area of forested land has been notoriously difficult. In fact, partly because of its shortcoming as a prescription for management, the Public Land Law Review Commission adopted a recommendation for "dominant use" zones in the

National Forests. That their recommendation was overwhelmingly rejected by both preservation and commodity-oriented groups is testimony to at least the political appeal of the "multiple use" concept.

Of course, multiple use is an easy term for economists since almost every resource is employed to produce more than a single good. The allocation of a resource between competing goods depends on the tradeoffs technically possible in the production of the goods and the relative prices of those goods. But as Vaux (1976) points out, our knowledge of these technical tradeoffs in forestry, particularly for timber and recreation or amenity values, is very poor.

In the absence of facts, assumptions must suffice. Consider a simple model of production and explore the implication of alternative assumptions for the results. Suppose that the initial endowment of land is allocated between the production of timber and nontimber outputs. Suppose further that the timber output is in direct proportion to the quantity of land allocated to that use. Finally, assume that the production of nontimber outputs can be characterized by a Cobb-Douglas production function. Then the technical production possibilities can be found by solving these three equations:

(3.15) $t = a l^t$

(3.16) $r = b (l^r)^d$

(3.17) $l = l^t + l^r$

where a, b and d are parameters and the superscripts t and r index the allocation of land l to timber and nontimber outputs.

Solving these equations provides the function g used in the model in Section 3.1, above:

(3.18) $r = b(l - \frac{t}{a})^d$

Figure 3.1 shows the shape of this function for alternative values of d.

The derivatives of this function which are of interest to us are

(3.19) $r_t = -\frac{bd}{a}(l - \frac{t}{a})^{d-1}$ $\quad < 0$ if $d > 0$

(3.20) $r_{tt} = \frac{bd(d-1)}{a^2}(l - \frac{t}{a})^{d-1}$ $\quad < 0$ if $d > 1$

(3.21) $r_{tl} = -\frac{b}{a}d(d-1)(l - \frac{t}{a})^{d-2}$ $\quad > 0$ if $d < 1$

(3.22) $r_l = bd(l - \frac{t}{a})^{d-1}$ $\quad > 0$ if $d > 0$

(3.23) $r_{ll} = bd(d-1)(l - \frac{t}{a})^{d-2}$ $\quad < 0$ if $d < 1$.

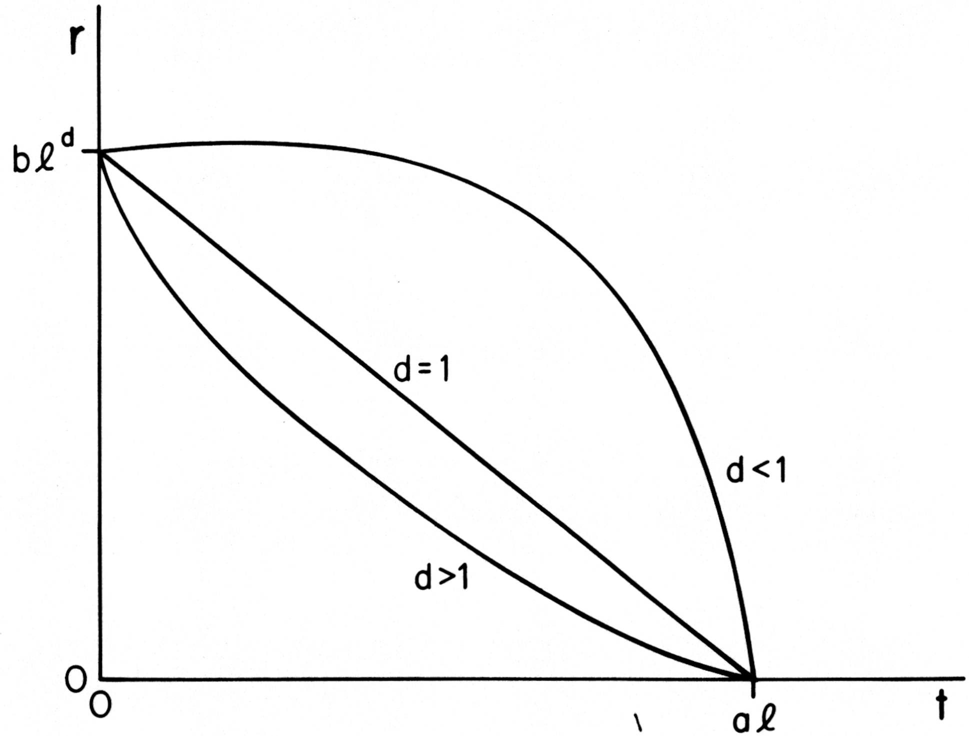

Figure 3.1 Production Possibilities for r and t

Equations (3.19), (3.20), and (3.21) show that $0<d<1$ conforms to the assumptions of section 3.1 above. That is, there are no scale economies in the production of nontimber values from land.

3.3 *Some Theoretical Results*

The indirect supply equation (3.14) can be examined in conjunction with the assumed functional shapes to ascertain the response of the owner to changes in the variables of the model. This is done by differentiating (3.14) with respect to the variable of interest, and then solving the resulting expression for t, the direct timber supply equation. (Throughout this section, $p \equiv p^t$ to ease the notational burden.) In following this section, the reader will want to remember that g is a function of t; u is a function of r and y; y is a function of y^e, p, t, c, and l.

Price. Differentiating equation (3.14) with respect to p and rearranging gives

$$(3.24) \qquad t_p = -\frac{g_t u_{ry} y_p + p u_{yy} y_p + u_y}{u_{rr} g_t^2 + p u_{ry} g_t + g_{tt}}$$

The sign of this expression is ambiguous. An increase in timber prices will lead to increased timber output only if the income gained from the increased harvest more than offsets the utility losses associated with the reduction of nontimber production.

Exogenous Income and Cost of Holding Land. These two variables are treated together because both enter the model by affecting the net income available for other consumption. We can explore the effect of both of these variables on timber supply by differentiating (3.14) with respect to y and observing that (i) $t_ye = t_y$ since $y_ye = 1$ and (ii) $t_c = (-l)\, t_y$. That is, if increasing the exogenous income decreases the cut, then increasing the cost of holding land will increase the cut. Differentiating (3.14) with respect to y gives

$$(3.25) \qquad t_y = -\frac{u_{ry} g_t + u_{yy} p}{u_r \, g_{tt}}$$

which has an unambiguous negative sign if u_{ry} is positive as posulated in Section 3.1 above. If u_{ry} is negative, then an increase in income will possibly reduce the marginal value of nontimber outputs enough to lead to an increase in harvest, irrespective of the assumed diminishing marginal utility of income.

In addition, t_c is positive so marginal reductions in land holding costs lead to a *lower* timber harvest. This result is contrary to the conventional argument that decreasing land holding costs such as property taxes will lead, *ceteris paribus*, to greater timber supply. But the two arguments emphasize different aspects of the problem.

The first argument regards land as fixed. As long as the amount of land held does not change, property tax reductions will lead to decreases in timber supply. For either small property tax changes or in the short run for large property tax changes, land holdings are reasonably considered to be fixed. In the second argument, land can be bought and sold. In the long run, property tax decreases will increase the amount of land held by any individual and will therefore lead to increases in timber supply. These two factors — the effect of size of holding on timber supply and the long run adjustments in the land market — are treated in the remainder of this chapter.

Size of Holding. Differentiating (3.14) with respect to l yields

$$(3.26) \qquad t_l = - \frac{u_{ry} y_l g_t + u_{yy} y_l p}{u_{rr} g_t^2 + u_r g_{tt} + u_{ry} g_t p}$$

which is positive as long as y_l is negative, as is generally the case, and as in the model presented in Section 3.1 above.

Now consider a model in which land holding costs vary with the size of the holding, i.e. $c = c(l)$. Then $y_l = -(c_l\, l + c)$. If c_l is negative then y_l may be positive. This opens the possibility that t_l will be negative. In this special case, increases in the size of holding will lead to declines in timber output.

A significant part of the costs of holding land are proportional to the market value of the land, such as *ad valorem* property taxes and the opportunity costs of the capital represented by the land. Armstrong (1975) finds that the market price of land in Vermont inclines with the size of the holding, so c_l is negative. Using his results and assuming that the costs of holding land are proportional to land price, we can determine the size of holding l^* where further increases in the size of holding may lead to decreases in timber supply. This value has been tabulated in Table 3.1. Note first that the critical value of l^* is extremely unstable with respect to the fractional land holding costs. Secondly, the size of holding where the negative relationship between timber supply and size of holding may set in is quite large. As an empirical matter, then, it is unlikely that the timber harvest from private nonindustrial forests will, *ceteris paribus,* increase with decreases in the size of holdings. In fact, quite the opposite results will generally pertain.

3.4 A Corollary Model 0/ Land and Timber Markets

Since land price is an explicit argument of the model and landowner choice posited in Section 3.1 above, one can simply enlarge this analysis to the problem of jointly determining the forest owner's timber supply equation and land demand equation. Let us modify the net income constraint (3.2) somewhat to reflect explicitly the relationship between the market value of land and the cost of holding land:

(3.26) $y = ye + ptt - (\alpha pi + c) l$

where pi = price of land

α = fractional land holding costs (taxes, interest, etc.).

The forest land owner's nonlinear programming problem is then characterized by (3.1), (3.26), and (3.3) and the additional conditions on the derivatives of u and g which were discussed in Section 3.1 above.

TABLE 3.1
Conditions for Negative Relation
Between Timber Supply and Size of Holding

	Land holding costs as a percent of market value		
	5%	10%	15%
a	-12.30	-24.60	-36.90
b	114.4	288.9	343.3
'-(acres)	3510	41800	3520

Source: See text

Notes: (i) $c(l) = a + b/\ln(l)$

(ii) If $l > l^*$ then $\frac{d}{dl}[c(l)\, l] < 0$ and therefore $y_l > 0$

(iii) $\frac{d}{dl}[c(l)\, l] = -b/[\ln(l)]^2 + b/\ln(l) + a$

This equation has two roots. In the three cases examined in this table, the lower root occurs about $l = 3.$, and then for $l < 3.$ $y_e > 0$. Armstrong's (1975) study includes only parcels 10 acres or larger so inferences from these data for parcels less than 10 acres are unwarranted and the root at $l = 3.$ can be ignored.

Again, solving the problem by substituting, differentiating with respect to t and l, and solving the resulting homogenous equations gives

(3.27) $u_y p^t = -\, u_r g_t$ and

(3.28) $u_y[p^t t_l - (\alpha p^l + c)] = -\, u_r(g_l + g_t t_l)$.

The condition for the timber supply equation is as before if the optimal amount of land is owned. The land demand equation states that the owner will buy land until the utility lost from the cost of the land just equals the utility from the nontimber values which that land affords. The cost of the land equals the purchase price less the timber income available from the land purchased. This model could be implemented empirically on a data set for which information on both the land and timber markets were available.

Alternatively, the model can be turned around to make inferences about the shape of g, the multiple use function. Suppose that one observes in the land markets that p^l is some funtion of timber prices and an imputed "price" of nontimber land values. The latter is presumably related to land characteristics such as proximity to lakes or streams, existence and quality of views, and the size, stocking and species of timber. That is,

(3.29) $p^l = f(p^t, p^r)$

where p^r = price of nontimber outputs.

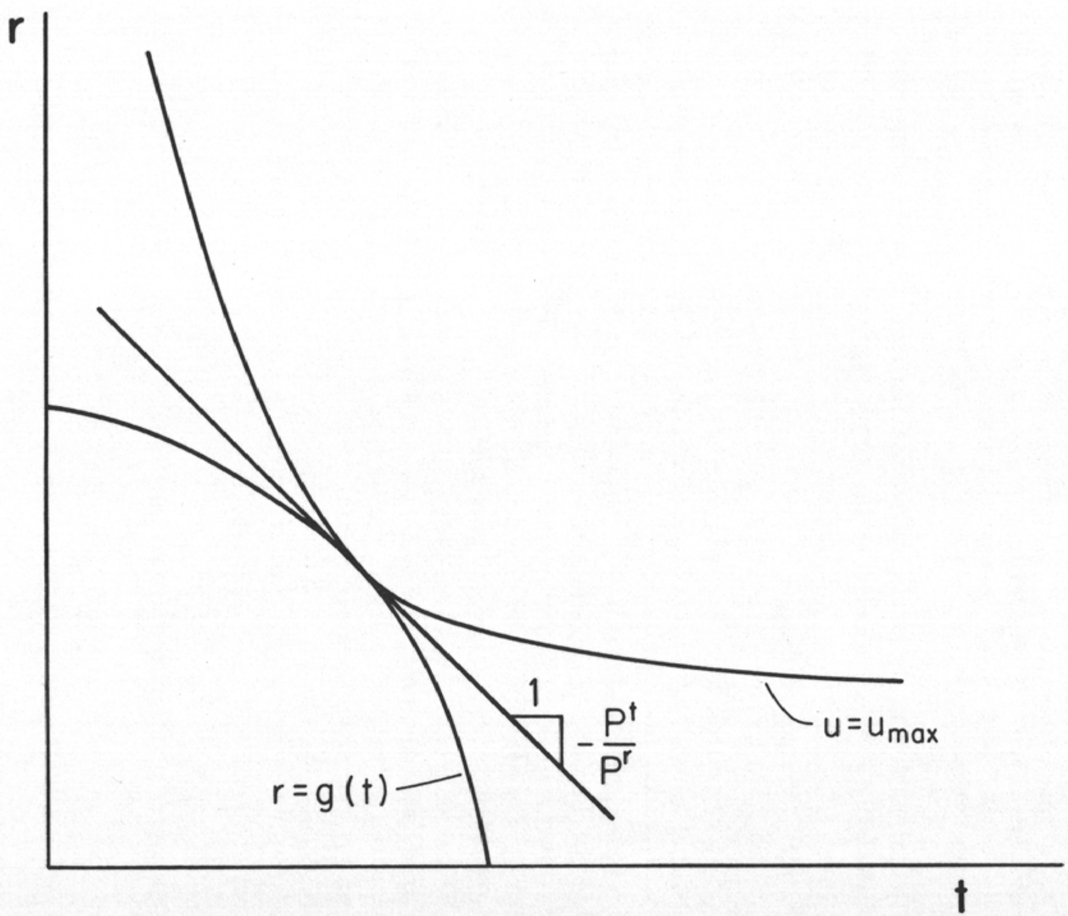

Figure 3.2 Land Prices, Timber Output and the Slope of the Multiple Use Function

At the optimum, the utility function will be tangent to the multiple use constraint, and the slope of the utility function will equal the negative ratio of timber price to nontimber price. This situation is depicted in Figure 3.2. In symbols,

$$(3.30) \qquad g_t = \frac{u_r}{u_t} \bigg| \; u = u_{max} = -\frac{p^t}{p^r}.$$

In principle one can solve (3.29) for p^r (observing p^t and p^l) and therefore g_t can be inferred from (3.30). Hence, land prices theoretically provide a method for estimating the slope of the multiple use function g.

Chapter 4

STATISTICAL ESTIMATION OF THE TIMBER SUPPLY MODEL

The desiderata for estimating the timber supply model of Chapter 3 are data on the amount of timber offered by an individual (say, annually), the stumpage price associated with the amounts offered, owner and ownership characteristics, and information on the technical tradeoffs between timber and nontimber outputs. Unforrunately, data directly in this form are not available, and collecting such information was beyond the scope of this research, so existing data were adapted for the purposes of this study.

The recent survey of forest land owners in New Hampshire (Kingsley, and Birch, 1976) provides data on owner and ownership characteristics and timber harvest behavior. These were processed and combined with stumpage price data to form the basis for the statistical estimates of the timber supply model. Originally, data from the Pilot Woodland Management Program (PWMP) were ro be used to estimate the technical tradeoffs between timber and nontimber outputs through the relationship between timber management activities and land prices (discussed in Section 3.4 above). However, as explained in Chapter 5, these data proved inadequate for this purpose. Consequently, the timber supply equations presented here do not explicitly consider the tradeoffs between timber and nontimber outputs.

This chapter first describes a formal model of choice which links the model developed in Chapter 3 to the type of data available. Section 4.2 discusses the data and specific variables used in this analysis. Statistical results are presented in Section 4. 3. The final parr of this chapter summarizes the results.

4.1 Analytical Approach

It is a truism that the owner harvests timber if and only if the utility from harvesting is greater than from not harvesting. The indirect utility function implied by equation (3.14) in Chapter 3 can therefore be used in a "stochastic utility" model of choice. This type of model was pioneered by McFadden (973) to estimate the split of demand between transportation modes, and the method has subsequently been used by Quigley (1976) to analyze housing demand and by Hanushek and Quigley (1977) and Lerman (1977) to model intraurban location decisions.

The model can be developed as follows. Index the collectively exhaustive and mutually exclusive choices by i which run from 1 to n (here n=2). As before, the utility of the i^{th} alternative depends on the characteristics of the alternative and those of the forest owner who makes the choice. Owner k chooses alternative i if and only if the utility for i is greater than that for all other alternatives:

(4.1) $U^k(x^i) > U^k(x^j) \; \forall \; j \neq i$ where $x^i, x^j =$ vectors of characteristics for alternatives i and j.

Now suppose that the choice is not completely determined, but that some error enters into the choice process, either because the owner has imperfect information or because we cannot measure all of the attributes relevant to the choice. So

(4.2) $U^k(x^i) = V^k(x^i) + \epsilon^i$

where ϵ^i is the stochastic disturbance term and its distribution is left unspecified for the moment. Then the probability of choosing alternative i is

(4.3) $P\{U^k(x^i) > U^k(x^j)\} = P[\,V^k(x^i) + \epsilon^i > V^k(x^j) + \epsilon^j] =$
$P\{V^k(x^i) - V(x^j) > \epsilon^j - \epsilon^i\}.$

McFadden (1973) proves that if ϵ^i and ϵ^j are independent with a Weibull distribution, then

(4.4) $P^k_j = \dfrac{\exp\{V^k(x^j)\}.}{\exp\{V^k(x^i)\}}$ where $P^k_j =$ probability of owner k choosing alternative j.

That is, the probability of individual k choosing alternative j follows a logistic distribution. If V is specified to be linear in its parameters (but not necessarily a linear function of the characteristics themselves), then computer software to derive the maximum likelihood estimates of the coefficients is widely available. Statistical hypothesis tests can be posed in that framework as well.

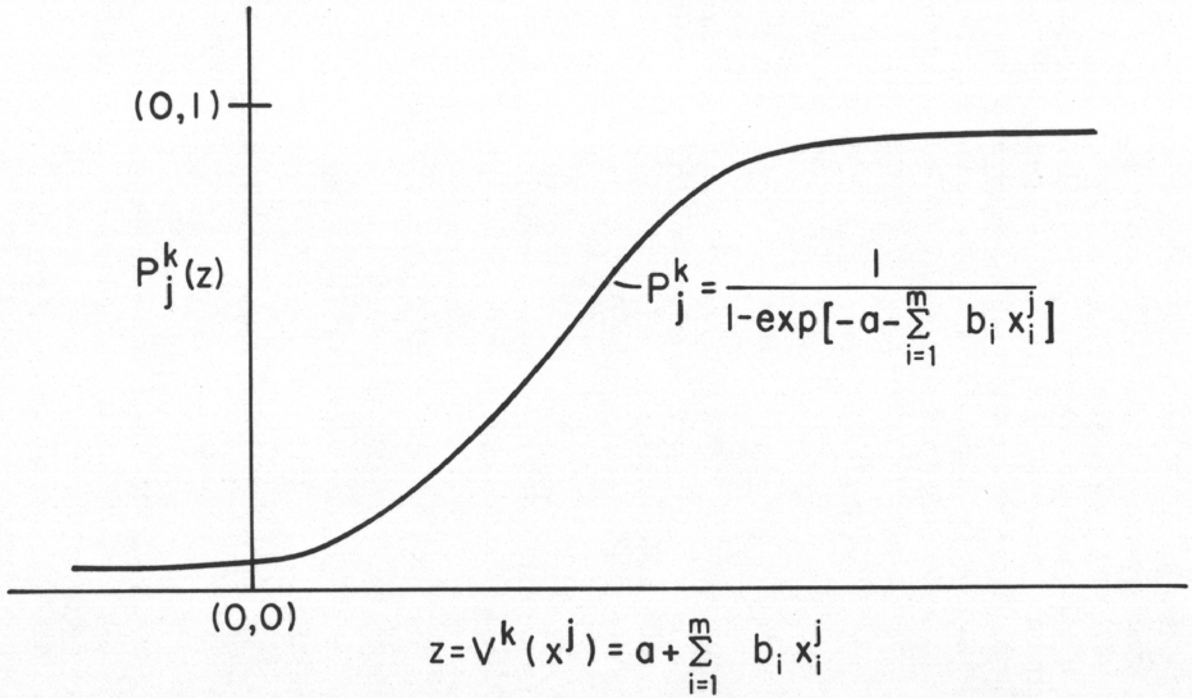

Figure 4.1 Logistic Model of Choice

Figure 4.1 shows the statistical model graphically. The probability of harvest is constrained to lie between 0 and 1. These extreme values are reached only assymptotically as V grows very small or large, respectively. The slope of the logistic probability of harvest function depends on the location along the z axis where it is measured. In particular, note that the rate of change of the probability of harvest with respect to some particular characteristic x_i depends on both the coefficient b_i for that characteristic and the probability of harvest. Simple calculus shows

$$\frac{dp}{dx} = b_i\, p(1-p). \tag{4.5}$$

Since the factor $p(1-p)$ is maximized at $p = .5$, the effect of a change in one variable is maximal when all the variables interact to make the owner just indifferent to harvesting. This is an intuitively logical result. Supply elasticities can be computed in the usual way (i.e., the elasticity with respect to x equals $\frac{dp}{dx}\frac{x}{p}$). Remember that this is the elasticity of the probability of harvest and not the quantity harvested as is usually the case. For the results reported below, the elasticities are computed at the mean values of the independent variables. This is not necessarily the point of maximum rate of change in the probability of harvest.

4.2 *Variables, Data Sources and Alternative Samples*

In conjunction with their responsibility for surveying timber resources, the Northeastern Forest Experiment Station has interviewed by mail a random sample of commercial forest landowners in New Hampshire (Kingsley and Birch, 1977). The owners were selected by virtue of their owning the land where a forest inventory plot is located. Of 562 owners, 367 responded (65.3 percent response rate). The high response rate is probably due to the extensive follow-up work by Forest Service personnel and the prestige of the Forest Service. No difference between respondents and nonrespondents was found in terms of average size or parcel or place of residence (Kingsley and Birch, personal communication). Other details of that survey are presented in Appendix 1.

Some of the respondents were eliminated from this analysis because their response was unsuitable for at least one of the following reasons:

(i) Ownership was other than private nonindustrial
(ii) They said that they had not harvested timber because "woodland immature — trees too small"
(iii) The year of acquisition was unknown
(iv) They had harvested timber, but the year of last harvest was unknown
(v) The last harvest was prior to 1947

The effect of applying these conditions was to eliminate 135 of the 367 respondents, reducing the survey sample size to 232. Of the respondents eliminated from the analysis, 59 were not identifiably private nonindustrial (reason (i) above), and 76 had one or more of the other defects.

Table 4. 1 summarizes the acronyms used for the variables in this study, and indicates the expected sign of the relationship between each variable and the probability of harvest. These expectations were developed from the theoretical model presented in Chapter 3. Table 4.2 presents summary statistics for the variables used in this analysis. The remainder of this section discusses each of these variables and explains in detail their derivation and the sources of error in their measure.

TABLE 4.1
Summary of Independent Variables

Acronym	Variable	Expected Relationship to Probability of Haevest
HR	Probability of Harvest	
STPI	Sawtimber price index, current dollars/Mbf	+/-
RSTPI	Sawtimber price index, 1967/Mbf	+/-
TPI	Pulpwood/sawtimber price index, current dollars/Mbf	+/-
RTPI	Pulpwood/sawtimber price index, $1967/Mbf	+/-
AREA	Forested area owned, Acres	+
LAREA	Natural log of AREA	+
AGE	Age of respondent, years	?
RINC	Income, constant dollar assumption, in thousands of dollars	
NINC	Income, current dollar assumption, in thousands of dollars	
ED	Number of years of formal education	?
C	Constant term	?

TABLE 4.2
Descriptive Statistics for the 1973 Sample

Variable	Mean	Standard Deviation
HR	.1128	.3162
AREA	465.4	1115.
LAREA	4.885	1.644
AGE	48.80	14.61
ED	13.75	4.751
NINC	18.61	13.93
RINC	17.40	13.15
STPI	26.51	8.249
TPI	19.85	5.720
RSTPI	21.38	4.627
RTPI	16.11	3.260

N= 232

The Dependent Variable. The dependent variable is dichotomous, measuring whether or not an owner harvested timber in a given year. The ownership survey used in this analysis did nOt determine every year that a respondent harvested timber but rather only the year he last harvested timber, ifhe did so at all. Knowing only the year ofIast harvest presents a problem for the model of choice postulated in Section 4.1 above. One must know in which years the respondent had the choice ofharvesting timber and the Outcome ofthe choice in each year. The problem is further complicated because the serial correlation between the annual probabilities of harvest is unknown: can an owner harvest timber every year, or if he has harvested timber one year does that reduce the likelihood of harvest in subsequent years? On one hand, some individuals harvest timber annually. On the other hand, the collectively most common methods of harvesting in the sample (diameter limit, dearcutting and land clearing, which were used by cwo thirds ofthe owners who harvested timber) leave the residual stand in such a condition that it probably could not yield more than one cut of merchantable material in the 27 year study period.

Of course, larger ownerships can contain more than one stand and more than one harvest would be possible even ifsingle stands were cut clear. Herrick (1975) found that the median size logging job in the nonheast was about 100 acres. In the sample, 41.8 percent of the respondents held parcels less than 100 acres in size. Consequently, these owners of smaller parcels probably harvested timber only once if at all. In sum, no single assumption concerning the frequency of harvest represented in the sample seems tenable.

Two additional statistical problems arise. First, conventional maximum likelihood logit estimation assumes the probabilities between observations are uncorrelated. In this sample the annual probabilities of harvest for a single respondent may be serially correlated, but the correlation is unknown. Second, in the sample used in this study we observe only the last realization of the choice process rather than the entire history.

To get around these problems, three different choice sets were defined using different assumptions concerning the relationship between annual harvest probabilities. First, 1973 alone was taken as the year of possible harvest. That is, all respondents were assumed to have the choice of harvesting in 1973, and the observed sequence of O's (no harvest) and l's (harvest) and the realization of the choice process for 1973 alone. This sample is called the "1973" sample.

Using this sample has the advantage of avoiding any explicit assumption about the relationship between harvest probabilities for the various years. By avoiding any assumption about the temporal relationship between harvests, the sample ignores the choices made about timber harvests prior to 1973. Therefore the only price variation observed in the 1973 sample comes from price differences between counties in 1973. Similarly, the sample size is limited to the 232 respondents. The next two samples use assumptions about the temporal dependence among harvests to produce a time series of choice realizations for each respondent. The resulting data sets combine the time series for all respondents and consequently have a larger sample size and greater variation in price than does the 1973 sample.

The second choice set assumes that only one harvest could take place during the study period, 1947-1973. Then the dependent variable takes on a value of one in the year of harvest and zero in all the preceding years. Data for a respondent is eliminated from the data set for the years following his harvest. If he did not harvest at all, zeroes are recorded up to 1973, the year of the survey. The year the respondent had acquired his land is also recorded, and all years prior to the year of acquisition are also eliminated from the data set. If the land was acquired prior to 1947, the first year of the price series, the dependent variable is constructed to cover the period from 1947 to either the harvest year or 1973 if no harvest took place.

This choice set has the advantage of a much larger sample size and greater variation in observed prices since both time series and cross-sectional data are incorporated in the sample. Its disadvantage is the strong assumption that only one harvest can take place. Note that if price affects the probability of harvest, then using this sample will consistently understate the effect of price on the harvest probability. If price influences the harvest decision, then in years when prices were high a second or third harvest could have occurred when we assume that none took place. In the remainder of this discussion this sample is called the "one harvest" sample. Table 4.3 gives sume descriptive statistics for it.

TABLE 4.3
Descriptive Statistics for the One Harvest Sample

Variable	Mean	Standard Deviation
HR	.03749	.1900
LAREA	5.183	1.625
AGE	44.10	14.74
ED	14.27	3.549
NINC	20.91	14.06
RINC	15.01	10.50
STPI	16.35	4.589
TPI	13.28	3.285
RSTPI	17.09	3.180
RTPI	14.03	2.858

N = 2881

The third choice set was constructed under the assumption that every respondent could harvest as often as annually. The dependent variable equals one in the year of last harvest and zero in all of the following years. Data for the respondent is eliminated from the data set for all years preceding the year of last harvest. Zeros are recorded from the year of land acquisition to 1973, if the respondent harvested no timber during the period.

This choice set shares with the one harvest sample a large sample size and considerable variation in prices arising from the combination of time series and cross-sectional data. Its disadvantage arises from the strong assumption that annual harvests are possible. The sample resulting from this assumption is called the "many harvest" sample and Table 4.4 presents some descriptive statistics for it.

TABLE 4.4
Descriptive Statistics for Many Harvest Sample

Variable	Mean	Standard Deviation
HR	.05315	.2308
LAREA	4.662	1.489
AGE	47.64	14.46
ED	14.30	3.667
NINC	20.31	13.98
RINC	15.81	11.16
STPI	17.99	6.066
TPI	14.22	4.298
RSTPI	17.16	3.775
RTPI	13.69	3.055

N = 2032

Before closing this section, a summary of the meaning of the three different samples and an empirical comparison of the alternative assumptions are in order. Table 4.5 shows the value of the dependent variable under the alternative samples for three hypothetical respondents, A, B, and C. For simplicity, suppose all three respondents acquired their land in 1970. The 1973 sample considers 1973 alone. The one harvest and many harvest samples are essentially logical converses of one another. Were the logit estimator modified to account for the peculiarities of this problem (unknown correlation between harvest probabilities and observation of only the last year harvested), the resulting estimates would probably lie in the range formed by these three samples.

TABLE 4.5
Values of the Dependent Variable Under
Alternative Samples for Three Respondents[1]

	Sample[2]								
	1973			One Harvest			Many Harvest		
Year	A	B	C	A	B	C	A	B	C
1973	1	0	0	1	x	0	1	0	0
1972	x	x	x	0	x	0	x	0	0
1971	x	x	x	0	1	0	x	1	0
1970	x	x	x	0	0	0	x	x	0

1. Respondent — Year of Last Harvest

Respondent	Year of Last Harvest
A	1973
B	1971
C	never harvested

2. x — Not Applicable

The practical implications of the three samples can be seen in Figure 4.2 and 4.3. Figure 4.2 shows the number of respondents reporting their last harvest in each year. Of the 232 useful responses, 119 or 51.3 percent reported a harvest sometime during the study period. Figure 4.2 also shows the nominal sawtimber price index.

Figure 4.3 shows the proportion of the sample harvesting under the one harvest and many harvest assumptions. The peaks and troughs (i.e. turning points) of the two series generally coincide. The many harvest sample lies above the one harvest sample until the latter part of the study period. Section 4.3 below presents results for each of the three samples which permits more extensive evaluation of the empirical implications of the alternative assumptions.

Stumpage Prices. Ideally, one should know the price faced by the owner in each year that he decided whether or not to sell timber. Since those data were not available, county level annual average price indices were used in this study. That is, for each year in which the respondent is assumed to have a choice between harvesting or not, the price he faces is the average stumpage price for a "market basket" of species and products in his county of residence in the year in question.

Before describing those price indices, note the "errors in variables" problem. Broadly stated, if the independent variable measures with a

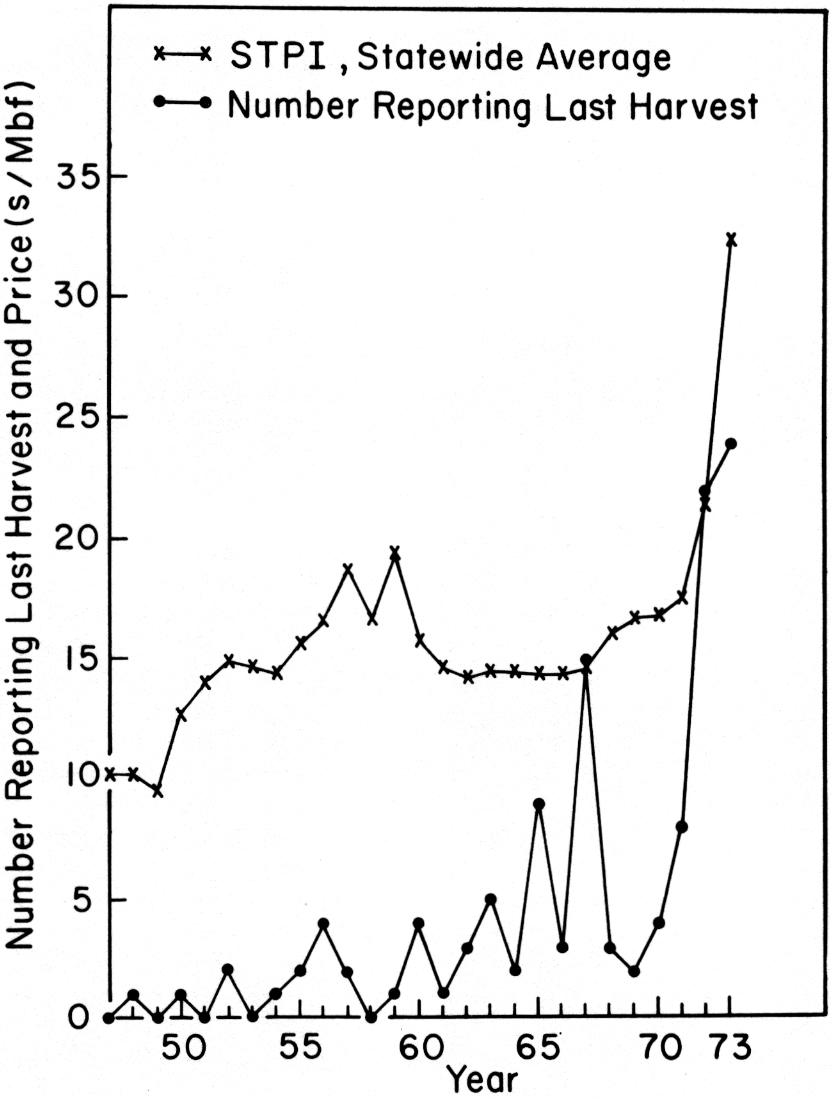

Figure 4.2 Number of Last Harvests and STPI by Year, 1947 to 1973

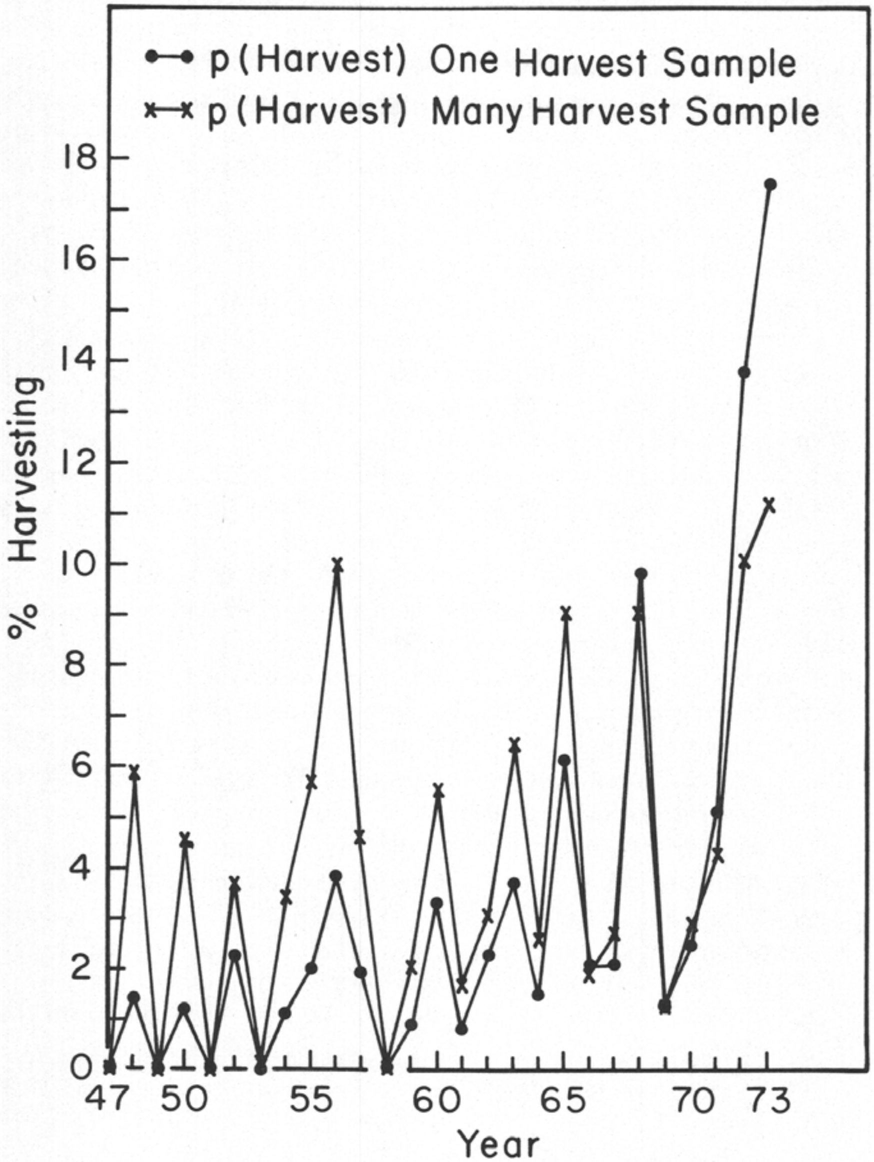

Figure 4.3 Probability of Harvest by Year for the One Harvest and Many Harvest Samples.

random error the conditions which are hypothesized to affect the dependent variable, then the statistical significance of the coefficient for that variable will be biased towards zero. As a result, the probability of incorrectly rejecting the hypothesis that the coefficient is nonzero is greater than the level of significance the test would indicate. The stumpage price measured by statewide or countywide annual averages is likely to differ from that faced by the landowner when he chose to sell or not to sell timber. Consequently, accepting the hypothesis that the price coefficient is nonzero is strong evidence that price affects timber supply from private nonindustrial owners.

The price data used in this study were derived from the New Hampshire *Forest Market Reports*, published annually by the Cooperative Extension Service in Durham, New Hampshire. For each county, data are collected by the county foresters from loggers, mill operators, and other primary forest products buyers in January of each year. Prior to 1960, only statewide averages were published and these are assumed to hold throughout the State.

Since the species and products sold by the respondent are not known, price indices which reflect a mix of species and products were used. The price indices are a weighted average of prices for the seven most important timber species. The weights are the removals of each species in the year in question. Four price indices were constructed: a sawtimber price index and a joint sawtimber/pulpwood price index in both constant and current dollar forms. The constant dollar forms were derived from the current dollar indices using the consumer price index 0967 basis) since timber income is hypothesized to affect owner decisions through the value of the consumption it makes possible. All the indices are in units of dollars per thousand board feet. Appendix 2 discusses the price indices in greater detail. Figure 4.4 shows the four price indices by year over the study period.

Owner and Ownership Characteristics. Other variables from the ownership survey used in the analysis include owner income, size of the forest holding, occupation and age. Income was measured categorically in five classes. These discrete data were transformed into continuous ones using the midpoints of the interior intervals and judgment for the highest and lowest brackets based on discussions with the Forest Service personnel responsible for the survey. Both procedures introduce error into the measurement of income, and

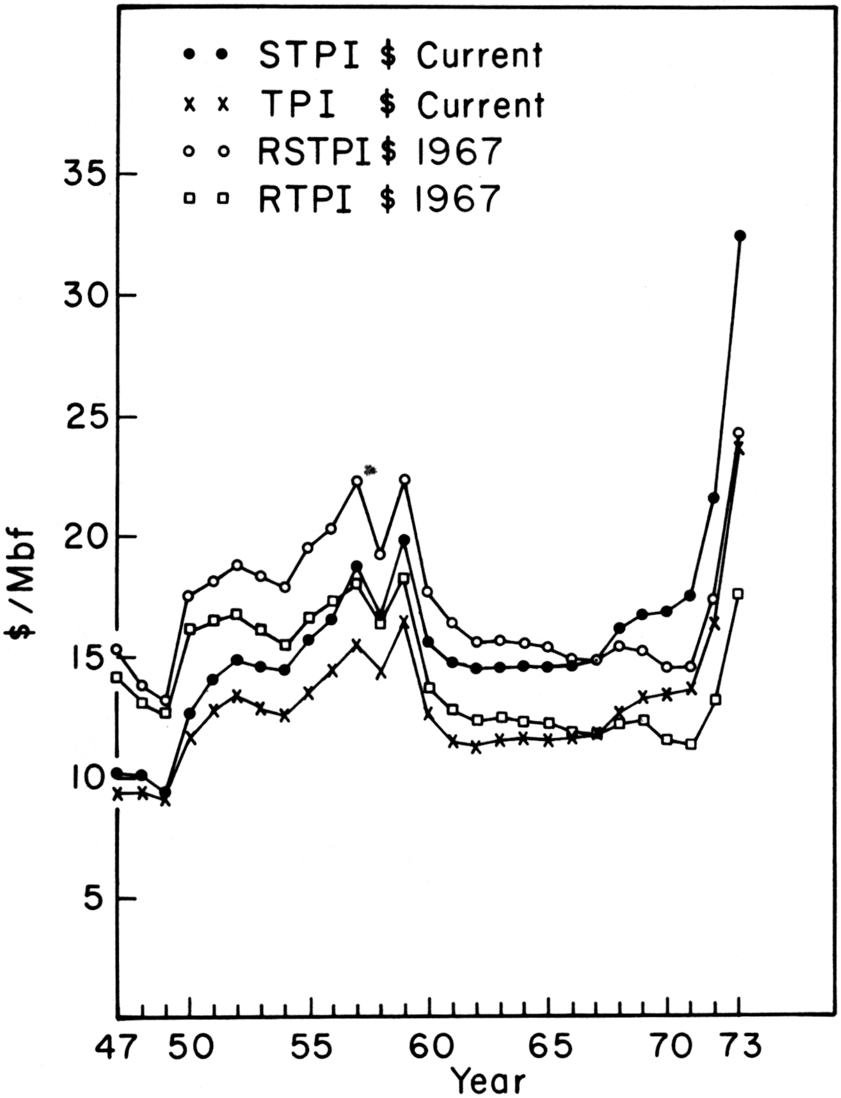

Figure 4.4 Price Indices by Year, 1947 to 1973

therefore bias the estimated significance of the effect of income towards zero.

Both nominal and a form of "real" income were used. Recall that the choice model operates over the period 1947 to 1973. Hence, income in each of those years is needed for the analysis. Since those data are not available, two alternative assumptions were made: (i) the respondent's income did not change in current dollars throughout the period and (ii) his income did not change in constant dollar amount during the period. These are both very strong permanent income assumptions, and consequently other socioeconomic indicators are useful to help measure the "permanent income." Age and education were used for this purpose. Education was coded as a categorical variable but was transformed into a continuous variable by using the midpoints of the interior intervals and 7 and 20 years for the "less than eight" and "doctorate" categories, respectively. Age was adjusted backward to the year in question by subtracting the number of years between that year and 1973 (the year of the survey) from the reported age of the respondent.

Occupation was used in the form of a farm/nonfarm dummy variable and was assumed to be constant throughout the study period.

Area refers to the acreage in woodland owned by the respondent, in one or more parcels. The definition of "woodland" does not necessarily conform to the Forest Service definition of "commercial forest land." The area held by a respondent was assumed to be constant throughout the period of analysis.

Table 4.6 gives the distribution of parcel sizes represented in the sample as well as the distribution of parcel sizes for those owners who harvested timber sometime during the study period. Generally the proportion of owners who harvested timber increases with the size of holding. The next section explores in depth the statistical determinants of the probability of harvest.

TABLE 4.6

Size Distribution of the Sample

Area Held (Acres)	Number of Respondents	Percent of Respondents[1]	% who harvested during the study period
0- 10	18	7.8	11.1
11- 25	17	7.3	U .8
26- 50	20	8.6	30.0
51-100	42	18.1	35.7
101-250	57	24.6	59.6
251-500	34	14.7	61.8
501–750	12	5.2	83.3
751-1000	12	5.2	75.0
1000+	20	8.6	100.0
Total	232	100.1	51.3

1. does not add to 100.0 due to rounding

4.3 Statistical Results

Maximum *likelihood* estimates for the model described in Chapter 3 and section 4.1, above, were obtained using a logit algorithm supported by the Social Science Computing Facility at Yale University. Chapter 3 provides some guidance regarding the expected sign of the relationship between the probability of harvest and the independent variables of the model. These expectations are summarized *in* Table 4. 1. Recall that the sign of the price variable is ambiguous because of the utility tradeoffs between income and the nontimber outputs of the land. The size of forest holding is generally expected to be positively associated with the probability of timber harvest. Income is unambiguously negatively associated with harvest probability. No prior expectation concerning the relationship between various socioeconomic indicators and probability of harvest have been developed, except that farmers could be expected to be more likely to harvest timber than nonfarmers. The empirical findings presented in this section are in accord with these expectations.

Tables 4.7,4.8, and 4.9 report the logit results for the full model estimated on the three different samples. The tables report the estimated coefficient, assymptotic t-values and the elasticity computed at the mean of the independent variables. The chi square statistic (χ^2) tests the hypothesis that all of the coefficients except the constant are zero. This statistic corresponds conceptually to the F-statistic in ordinary least squares regression.

The effect of each variable is discussed separately in the following sections. The final section analyzes the difference in timber harvest behavior between farmers and nonfarmers.

TABLE 4.7

Estimated Coefficients for 1973 Alone

C	STPI	LAREA	NINC	AGE	ED	χ^2(5 df)	R^2
-12.8	.151	.959	- .0125	.0119	.0507	47.0	.298
(-4.98)	(3.75)	(4.49)	(-.835)	(.648)	(.599)		
	3.84	.919	-.340	.557	.704		
C	STPI	LAREA	NINC	AGE	ED		
-12.5	.190	.923	-.0172	,0143	.0589	44.7	.280
(-4.96)	(3.69)	(4.41)	(-.826)	(.776)	(.693)		
	3.59	.880	-.332	.664	.814		
C	RSTPI	LAREA	RINC	AGE	ED		
- 12.9	.210	.889	-.00654	.0154	.0357	41.7	.270
(-4.80)	(3.41)	(4.32)	(-.311)	(.824)	(.438)		
	4.26	.845	-.115	.716	.492		
C	RTPI	LAREA	RINC	AGE	ED		
12.0	.232	.832	-.00169	.0187	.0355	36.7	.247
(4.58)	(2.93)	(4.17)	(-.0820)	(.992)	(.440)		
	3.54	.786	-.0297	.860	.487		

N= 213

t-values in parentheses, elasticities reported below t-values

TABLE 4.8
Estimated Coefficients for the One Harvest Sample

C	STPI	LAREA	NINC	AGE	ED	χ^2(5 df)	R^2
−7.76	.128	.281	−.0151	.0135	.0269	90.8	.0640
(−10.98)	(9.09)	(4.07)	(−1.77)	(1.86)	(.815)		
	2.03	1.42	−.308	.580	.372		
C	TPI	LAREA	NINC	AGE	ED		
8.06	.172	.255	−.0148	.0169	.0342	80.6	.0565
(−11.0)	(8.30)	(3.72)	(−1.75)	(2.32)	(1.03)		
	2.22	1.28	−.300	.722	.474		
C	RSTPI	LAREA	RINC	AGE	ED		
−7.56	.124	.169	.00952	.0212	.00454	40.45	.0272
(−9.20)	(4.61)	(2.48)	(.933)	(2.78)	(.146)		
	2.06	.847	.138	.907	.0628		
C	RTPI	LAREA	RINC	AGE	ED		
−6.33	.0663	.155	.0125	.0226	.00383	24.4	.0128
(−7.61)	(1.93)	(2.28)	(1.22)	(2.92)	(.124)		
	.899	.778	.182	.961	.0528		

N = 2881
t-values in parentheses, elasticities reported below t-values

TABLE 4.9
Estimated Coefficients Many Harvest Sample

C	STPI	LAREA	NINC	AGE	ED	χ^2(5 df)	R^2
–6.23	.0473	.647	–.0266	–.00959	.00928	80.6	.0630
(–8.81)	(3.51)	(7.28)	(–3.06)	(–1.27)	(.300)		
	.818	.622	–.519	–.440	.128		
C	TPI	LAREA	NINC	AGE	ED		
–6.38	.0636	.650	–.0269	–.00860	.120	79.28	.0618
(–8.80)	(3.29)	(7.27)	(–3.10)	(–1.14)	(.386)		
	.870	.626	–.526	–.394	.165		
C	RSTPI	LAREA	RINC	AGE	ED		
–6.68	.0686	.604	–.0214	–.00539	.00611	68.4	.0493
(–8.27)	(2.89)	(6.90)	(–2.00)	–.702	(.200)		
	1.13	.581	–.326	–.247	.0839		
C	RTPI	LAREA	RINC	AGE	ED		
–6.39	.0576	.612	–.0205	–.00425	.00631	63.72	.0439
(–7.54)	(1.81)	(6.93)	(–1.90)	(–.545)	(.208)		
	.757	.588	–.311	–.194	.0866		

N = 2032
t-values in parentheses, elasticities reported below t-values

Price. First, note that in each of the three samples the coefficients of the price variables are all positive. This is consistent with the normal relationship expected for timber supply and suggests that in the sample as a whole each respondent is operating at a point in his utility function at which the added income from additional harvest outweighs the losses in amenity values.

Second, the statistical performance of nominal price indices is superior to that of their real counterparts. Theory suggests the opposite result. There may be a lag in the perception of inflation. That is, the landowner establishes in his mind what he considers to be a "good" price for stumpage in the absence of inflationary effects. He then sells if that price is reached or exceeded, irrespective of the real price at the time of the sale. Chapter 5 discusses the details of stumpage market operations and returns to the problem of the formation of expectations.

Third, the sawtimber price index is statistically the best of the four indices. Sawtimber removals were from 65 percent to 77 percent of all statewide removals during the study period (see Appendix 2). In the New Hampshire ownership survey, which is the basis for these results, 68 percent of the owners harvested only sawlogs and only 4 percent cut only pulpwood (Kingsley and Birch, Table 18, p. 43). As a consequence, the sawtimber price index probably more closely reflects the price of the products most commonly sold than does the composite timber price index.

Finally, the effect of price is highest in the 1973 sample and lowest in the many harvest sample. If price affects the probability of harvest, the one harvest sample understates the effect of the price coefficient. The true price coefficient should therefore lie in the range of the 1973 and the one harvest sample.

The difference in performance of the nominal and real price indices is smaller for the 1973 and many harvest sample than it is for the one harvest sample. Prior to 1967 the nominal prices were less than their real counterparts. Hence, this result may be due to a better fit by the nominal prices to the harvest behavior observed in the early years.

Area. The results confirm the hypothesis that larger ownerships are more likely to be harvested than smaller ownerships. Preliminary analysis indicated that the logrithmic specification of the area variable was superior to the linear one so In(AREA) was retained throughout these results.

Section 4.2 above, notes that because of sample selection methodology, owners of smaller parcels are underrepresented in the sample. That is, larger owners are represented in the sample in greater proportion than they exist in the universe of New Hampshire forest land owners. Including the area variable compensates for this bias, but in the partial models tested the price coefficient changed only about 7 percent when AREA was included in the analysis. Consequently, using the alternative method of correcting for unequal sample frequencies - weighting each observation in inverse proportion to the area represented - only creates unequal variances and thereby reduces the efficiency of the estimated coefficients.

Finally, using the AREA as an explanatory variable is subject to an interesting identification problem: does the area effect enter the problem from the supply side as hypothesized here or through the demand side? If logging is more attractive on larger tracts, then it is possible that part of the effect measured in this analysis results from the demand side rather than from any pare of the landowner choice process. Under this hypothesis, larger holdings would command a higher stumpage price. Then area proxies for the price faced by the landowner while the price variable measures the aggregate trends.

The effect of area on the probability of harvest is highest in the 1973 sample and lowest in the one harvest sample. In all cases, the variance of the AREA coefficient increases when real price indices are used instead of the nominal price indices.

Income, Age, and Education. Given the available data, a strong permanent income assumption was required to measure income at the time of harvest. Age and education can be considered proxies which improve the measurement of permanent income. Consequently, those variables are considered here along with income itself.

Recall that income was measured categorically for 1973 only, so assumptions were needed both to develop a continuous measure and to estimate income in the years prior to the survey. Real income refers to the assumption that the respondent's real income remained unchanged throughout the period 1947-1973, and nominal income refers to the assumption that his nominal income was constant throughout the study period.

Income enters the model with the expected negative sign in all cases except for real income in the one harvest sample. In all samples the statistical performance of the nominal income variable is superior to that of the real income variable. This result lends some credence to the "lag in the perception of inflation" hypothesis advanced above. The effect of income is comparable in all three samples.

Age is significantly correlated with the probability of harvest in the one harvest sample but not in the other twO samples. In the 1973 and one harvest samples, the age coefficient has a positive sign, indicating that older owners are more likely to harvest timber than are younger ones. This result may simply be due to age replacing income, but the interviews with the Pilot Woodland Management Program cooperators reported in Chapter 5 below suggest another hypothesis. Investment in timber growing stOck marks the early years of a landowner's life. This growing stOck provides amenity values as well as a hedge against financial hardship. As the landowner grows older, his financial planning horizon shortens, and therefore the expected value of the timber assets as a hedge against uncertainty diminishes. He then is more likely to liquidate his growing stock irrespective of his nontimber income.

Education - number of years of formal school attendance - is not strongly correlated with the propensity to harvest timber. In part this may be due to collinearity between income and education in the sample. Again, this result suggests that education is needed to measure permanent income with the data used in this study.

Farm versus Nonfarm Ownership. Chapter 1 showed that farm ownership of private nonindustrial forest lands is declining. Consequently, it is of some interest to explore the differences in the determinants of timber harvest behavior between farmers and nonfarmers. Because farming is a business enterprise, one might expect farmers to reveal a greater sensitivity to price than nonfarmers.

Table 4.10 reports the results of analyzing the farm and nonfarm subsamples separately. First, observe that both groups display a strong price response, but the elasticity for farmers is nearly twice that for nonfarmers. Second, the other variables used in this analysis (forested area held, income and age) are not significantly related to farmer harvest decisions.

TABLE 4.10

Comparison of Farm and Nonfarm Ownerships, One Harvest Sample

	C	STPI	LAREA	NINC	AGE	X^2	L
Farm	-6.59	.242	-.162	.0133	.0lOl	23.04	43.219
	(2.229)	(4.126)	-.3916	(.2925)	(.00359)		
		3.74	(-.156)	.292	.004		
Nonfarm	-7.37	.121	.287	-.0147	.0147	73.43	368.27
	(-12.17)	(8.094)	(4.012)	(- 1.781)	(1.874)		
		1.92	.279	-.296	.632		

Sample Size

Farm = 264

Nonfarm = 2617

t-values in parentheses, elasticities reported below t-values

L = Value of log likelihood function

Compared to the sample of private nonindustrial owners as a whole, nonfarmers show somewhat different responses to the independent variables. Sensitivity to price and to the size of holding is slightly less for nonfarmers than for the full sample. Nonfarmers are slightly more responsive to income and to age than is the sample as a whole. (Compare Table 4.8 with Table 4. 10 to see these differences.)

The overall differences in the relationship between the independent variables and the probability of harvest between the twO groups can be tested statistically. The test is based on the difference between the value of the log likelihood function for the full sample and the sum of the log likelihood function values for the two subsamples. Twice this difference has a chi square distribution (Theil, 1971, pp. 396-397) under the null hypothesis that there is no difference between the two groups. This test is analogous to the so-called Chow test in ordinary least squares regression. This test indicates that the model's coefficients collectively differ between farmers and nonfarmers (chi square = 8.13, 1 degree of freedom). This classification has practical importance as well as statistical significance. The predicted probability of timber harvest at the mean of the independent variables is .0339 for farmers and .0270 for nonfarmers, a difference of 25.6 percent.

4.4 *Summary o/Statistical Results*

The theoretical model of choice was tested empirically on data from a sample of private nonindustrial forest owners in New Hampshire. The posited model of choice requires information on timber harvest decisions over time, but the survey used in this study determines only the year of last harvest. Consequently, three alternative choice sets were developed to correspond to three different assumptions about the number of harvests possible during the study period.

The statistical results are generally consistent between the three different choice sets. When the estimated coefficients are statistically significant, their signs are the same in each of the three cases. The magnitude of certain coefficients differs between the samples. For example, price elasticity ranges from .818 in the many harvest sample to 2.03 in the one harvest sample and 3.84 in the 1973 sample.

The empirical results agree with the expectations developed from the theoretical model. Stumpage prices strongly influence the probability of timber harvest. Owners of larger holdings are more likely to harvest timber than are owners of smaller holdings. The probability of timber harvest is negatively correlated with the income of the owner.

The statistical fit of nominal prices and income is superior to that of their real counterparts. This result suggests that there is a significant lag in the perception of inflation by this class of owners. The next chapter examines the process of selling price formation to try to explain this lag.

In this analysis response to price and the effect of nonprice variables distinguish farmers from nonfarmers. Perhaps because of their use of land to produce income, timber harvest by farmers is nearly twice as responsive to price as is harvest by nonfarmers. Owner and ownership characteristics tested in this study do not seem to influence the probability of harvest by farmers, although these characteristics are related to harvest decisions by nonfarmers.

Chapter 5

TIMBER SUPPLY ANALYSIS AND THE PILOT WOODLAND MANAGEMENT PROGRAM COOPERATORS

Founded in 1955, the Pilot Woodland Management Program (PWMP) provided detailed timber management information to 50 individuals who owned forest land in New Hampshire.[1] The records from this program were studied and the cooperators interviewed provide some additional insight into how timber supply decisions are made. This chapter reports the results of that effort.

To provide the context for these results, Section 5.1 below describes the PWMP, its original objectives and its available records. Appendix 3 contains additional information on the program and the survey instrument used in the cooperator interviews. The central source for the program records had been destroyed so much of the information on the program had to be assembled from a wide variety of sources. What records could be found are now held by the Henry S. Graves Memorial Library at the Yale University School of Forestry and Environmental Studies, and are available for other researchers interested in following the program, its cooperators, and their lands.

The purpose of examining these records was threefold. First, the interviews verified in an anecdotal way the basic timber supply model presented in Chapter 3. Does that model capture the essence of the objectives and constraints operating on this class of owners? Section 5.2 below uses the PWMP data to answer this question.

Second, Chapter 4 showed that the propensity to harvest timber strongly related to stumpage prices. However, previous studies of private nonindustrial owners have found only poor knowledge of timber prices. If the forest owners do not know prices, by what mechanism do higher prices lead to a greater cut? Section 5.3 focuses on this question.

Finally, in Chapter 3 the relationship between land and timber prices was derived from the model of owner behavior. In principle this relationship can be exploited to estimate the technical tradeoffs between timber and nontimber outputs of the forest, given data on land prices and timber values. Section 5.3 discusses why estimating this relationship with the PWMP data was not possible. That section also describes the data and techniques which would be appropriate for estimating the multiple use constraint.

5. 1 *The Pilot Woodland Management Program*

The Pilot Woodland Management Program was launched in 1955 and the last field work was completed in 1961. The purpose of the PWMP was to obtain good information on the labor and capital requirements of, the economic returns from and the motivations for small scale forest operations, but the data from the program has never been fully analyzed.

The PWMP grew our of the New England Dairy Farm Management Program at Harvard *V*niversity which was directed by Professor John D. Black and financed by the Charles H. Hood Dairy Foundation. As part ofthe economic analysis ofdairy farms, the contribution of forestry operations to farm income was determined. That research lead to a second set of studies, also supported financially by the Charles H. Hood Dairy Foundation, concerned with the economics of farms in the agricultural fringe areas of New England (see Barraclough and Gould, 1955). The study farms had significant income from forestry in addition to that from agriculture. These two research projects highlighted the usefulness of input-output data for farm operating units to aid the evaluation ofpublic rural development and tax policies. These studies also showed there was little good information of this type concerning the economic operation of private nonindustrial woodlands. Dr. Ernest M. Gould, Jr. of the Harvard Forest and Kenneth E. Barraclough, then Extension Forester in New Hampshire, designed the PWMP to fill this need.

The PWMP was jointly sponsored by the *V.S.* Forest Service Northeastern Forest Experiment Station, *V.S.* Forest Service Eastern Region, the Boston Federal Reserve Bank, the New Hampshire Agricultural Experiment Station, the New Hampshire Forestry and Recreation Commission, the New Hampshire Cooperative Extension Service, Harvard Forest, and the Sears Roebuck Foundation. A committee representing the various cooperating agencies was responsible for the overall guidance of the project, and included in 1955:

K.E. Barraclough, Chairman, New Hampshire Cooperative Extension Service

W. H. Messick, New Hampshire Forestry and Recreation Commission
E.M. Gould, Jr., Harvard Forest
H.I. Baldwin, Fox Research Forest
O. P. Wallace, Forestry Department, University of New Hampshire
C. A. Bickford, Northeastern Forest Experiment Station
R.D. Jones, Eastern Region, U.S. Forest Service
V. S. Jensen, Northeastern Forest Experiment Station
R. W. Eisenmenger, Federal Reserve Bank of Boston
A.L. Jones, Sears Roebuck Foundation.

The technical work of the project was carried out under the direction of E.M. Gould, Jr. with the cooperation of the New Hampshire County Foresters. The Sears Roebuck Foundation provided funds to offset the cooperators' record keeping costs.

Detailed forest management information was provided to 50 private nonindustrial forest owners in New Hampshire. This information included a map of the cooperator's land and growing stock (divided into seedling and sapling, poletimber, and sawtimber stands) on a scale of 660 feet to the inch. Volume estimates were provided by cruises with either 3 point sample plots per stand or 45 plots per property, whichever was greater. Eight permanent one-fifth acre growth plots were also installed on each property. In addition, an aerial photo was provided.

The field information was assembled during the summer of 1955 and 1956. On the basis of the field information, several alternative management plans for each property were drawn up by E.M. Gould, Jr. Each plan described the forest treatments required to implement the plan required by the labor inputs and the direct and indirect economic returns which could be expected from the alternate levels of management. In general, five alternative management plans were prepared for each cooperator:

i. Liquidation of all merchantable stands
ii. Liquidation of sawtimber stands only
iii. Selective harvest in sawtimber stands
iv. Selective harvest in sawtimber stands and improvement cuts in poletimber stands
v. Timber stand improvement on all stands

The alternatives were explained to each cooperator by Dr. Gould, Clifton LaBree (then Assistant County Forester in Hillsborough County), and usually the county forester for the county where the property was located. The discussions covered not only the basic data and the alternative plans, but also how the costs and returns might be altered by market conditions different from those assumed in preparing the plans. These conversations were tape-recorded, and twenty-five of these recordings were located and reviewed as part of this research.

The cooperators were asked to keep detailed records on the labor, capital, and equipment inputs required for their forest management activities, and on the products sold and the revenues realized from those sales. In 1961 the growth plots were remeasured by Forest Service personnel and statistics on growth, mortality, and removals were assembled for each property.

Five cooperators were selected from each of the ten counties in New Hampshire. The literature on the PWMP is unclear on the method of selecting cooperators, but according to one report (Breck, 1957) potential participants were stratified according to size and type of ownership before the selections were made. Potential participants were identified primarily by previous contacts with the county foresters; consequently the cooperators generally had a higher interest in forest management than the population of New Hampshire woodland owners as a whole. Another account of the PWMP comments, "While the owners as a group are not typical in all respects, they and their properties illustrate forest problems frequently found in northern New England." (Anon., 1958, p. 6). Hence the data from these owners *represent* private nonindustrial forestry in the region, but are not necessarily *representative* of the population in a statistical sense. Holdings ranged in size from 38 to 955 acres, averaging 256 acres. Both merchantable timber and growing stock were above the state average on these properties. The occupational mix in 1955 of the cooperators was:

Nonresidents	12
Fulltime farmers	19
Parttime farmers	5
Lumbermen	2
Residents with nonland income	12

The two "lumbermen" operated sawmills, and therefore do not belong to the class of private nonindustrial owners treated in this study.

Appendix 3 contains additional information on the PWMP and describes the data which are available on the cooperators.

5.2 Is the Timber Supply Model Valid?

Just as the proof of the pudding is in the eating, the validity of a model rests principally on its statistical performance in describing "real world" behavior. In this sense, Chapter 4 has verified the timber supply model, but one might also examine directly the applicability of the model to private nonindustrial forest owners.

This issue can be divided into two parts. First, is the model appropriate? That is, are the assumed objective and constraints important features of the forest owner's decision process? Second, is the model adequate? Are there other important constraints which the model neglects? These two questions are addressed below.

Review of the PWMP records and interviews with the cooperators seem to indicate clearly that the model is appropriate. In the first place, nearly every cooperator derived utility from forest ownership values with which timber production competes. For example, most respondents were reluctant even to consider clearcuts (question 11) because of the perceived resulting damage to nontimber values which they felt were important. (Throughout this discussion, "most" means more than two-thirds of the respondents, "many" means between one-third and two-thirds, and "few," "some" or "several" mean less than one-third.) Frequently the nature of this reluctance was not clear. Nor could probing identify whether it derived mostly from aesthetic, recreational, or philosophical concerns.

The major exceptions came from one of two sources. First, a few respondents mentioned that heavy cutting might stimulate wildlife values. Second, some of those interviewed expressed a willingness to cut all the merchantable timber if they planned to sell the land and move away. In this case, however, both timber and nontimber values are sacrificed for other objectives.

In the second place, timber was perceived as a source of income by most of the respondents. In many cases, timber harvest was providing annual income either directly by stumpage or log sales, or indirectly through fuelwood cutting which offset expenditures on oil. In some cases, income was derived from timber only infrequently, perhaps every five to eight years. Even most of those who did not harvest timber realized that their growing stock was a potential source of Income.

In sum, the forest owners interviewed gain utility from their woodlands both from the income they can provide and from a wide range of nOntimber outputs. These nontimber outputs were perceived to conflict with the use of the forest for producing timber income. Timber is always cur with the belief that some nontimber values are being sacrificed at least temporarily. Therefore the model posited in Chapter 3 seems to be appropriate.

Is the model adequate? A number of factors outside the model emerged from the interviews as determinants of timber harvest behavior. Many respondents cited labor constraints on their timber output. For one reason or another these individuals preferred to do the woodswork themselves but did not have enough time to do more of it. Reasons for wanting to do their own woodswork ranged from the desire of several farmers to employ labor and equipment in the winter when it would otherwise lay idle to a simple distrust of loggers.

Secondly, many respondents viewed the timber standing on their land as an investment. That is, in time of financial need the income from the timber would be available. This attitude towards timberlands implied a lower cut than would have otherwise been made. An interesting note is that a few respondents expressed similar concerns for saving but these concerns led them to maintain a certain level of timber harvest even if their regular expenses such as property taxes declined. Instead of reducing the cut, these respondents saved the income from timber harvest. An economist might attribute these different behaviors in meeting the same investment objective to different perceptions of the risks and returns available in savings accounts and woodlots.

Finally, a few of the respondents cut timber for reasons only tangentially related to income production. For example, one of the cooperators cut a large amount of timber annually in conjunction with timber stand improvement of his sugarbush. He claimed he would continue to do so even if there were no market for the material removed simply because of the additional value this activity provided to his maple operation. As another example, several repondents mention something akin to "harvest for the good of the forest." While this statement could be viewed as a self-serving explanation for heavy exploitation, it seems more Yankee frugality combined with a sincere sense of responsibility for stewardship of the land. Some respondents understood the value of the axe for improving a stand, and others simply had a conception of "good forest management" which included cutting certain stands or trees.

Overall, the model of timber harvest behavior hypothesized in Chapter 3 neglects factors which affect the propensity of private nonindustrial forest owners to harvest timber. This is hardly surprising. Which variable should next be introduced to the analysis?

A prime candidate is some consideration of the problem's dynamic aspects. In addition to trading income from timber production against amenity values lost, many owners also trade current income against future income. Modelling this process requires knowledge of individual preferences for present versus future income. A model of timber inventory development is also needed. These relationships would permit analysis of interesting and important problems, such as the effect of capital cost and availability on future timber supply or the substitution between timber and other capital assets such as savings accounts or securities.

5.3 How Does Price Regulate Cut?

The results presented in Chapter 4 above clearly demonstrate that higher stumpage prices bring forth a larger cut. Yet previous research on private nonindustrial ownership behavior has concluded that this class of owners is largely unaware of prevailing timber prices. If owners do not know the current price, then how does price act to regulate the amount of timber which they cut?

Most of the PWMP cooperators interviewed did not have an accurate perception of current stumpage prices in their county. Either they confessed ignorance on the subject, or their estimates were more than 20% different from those reported in the 1978 New Hampshire *Forest Market Report*. Of course individual prices vary more than countywide averages, so some deviance between their response and the *Forest Market Report* data would be expected. In any case, many of the respondents knew where they could obtain an estimate of current stumpage prices. The New Hampshire County

Forester, the *Forest Market Report*, consulting foresters, and primary wood processing facilities were all mentioned as possible sources of price information. Most of those respondents said they would check with one of these sources prior to selling stumpage.

Here the nonrandom nature of the sample may be influencing the results. As Section 5.1 above points out, the cooperators who were selected have a greater interest in, and therefore a greater knowledge about forestry than do New Hampshire private nonindustrial forest owners as a whole. One may reasonably presume that the majority of owners would not have so complete a view of the possible sources of price information.

Nearly all of the cooperators interviewed had been approached to sell stumpage. Then one could hypothesize that high prices lead to more activity by timber buyers and thereby a greater frequency of timber sales. Unfortunately most respondents could not recall the date of their last request to sell stumpage, so it was not possible to relate the frequency of requests to the price prevailing at the time.

One can imagine the market operating as follows: stumpage buyers make irregular requests to buy stumpage, but the frequency of the requests may increase as stumpage prices are driven up by exogenous forces (increased housing demand, for example). The owner mayor may not ask the price offered. If he asks the price, he will sell if that price is high enough, that is, if the price exceeds what he considers to be a "good" price. The notion of what constitutes a "good" price is influenced by past prices offered or knowledge of current prices from the sources mentioned, or both. A consequence of the process by which the "good" price is determined is imperfect reaction to inflation, which would explain the superior statistical performance of the nominal price indices over their real counterparts discussed in Chapter 4.

From the seHer's point of view, the sawtimber stumpage market is sequential rather than simultaneous. That is, a series of offers are spaced out in time rather than in some predetermined auction. Of course, stumpage sales by auction do occur, but the predominate pattern seems to be independent offers by different buyers occurring at different times (and possibly for different products). The sequential offer process is still a market although its behavior differs from the classic simultaneous market economists are wont to conceptualize.

To the sample interviewed in the course of this study, the market for sawtimber stumpage seemed to be competitive. The respondents generally had more opportunities to sell stumpage than they cared to exercise. Most felt that sawtimber stumpage prices were "fair." On the other hand, in counties with pulpwood markets, many of the respondents complained that stumpage prices were too low. Generally only a single buyer was mentioned, and one can reasonably conclude that pulpwood prices are lower than those which would result from a competitive market because of the monopsonistic power of that buyer.

From the point of view of public policy, concern for the sawtimber stumpage market should be focused primarily on insuring that owners have access to current price information. For the sample of owners interviewed in this study, this access already seems to be available. This result may be partly a result of bias in the sample. The pulpwood market presents a more complicated problem. Marketing cooperatives are traditionally recommended as a solution. However, because timber income is only a small fraction of total owner income, and because pulpwood stumpage income is only a small fraction of timber income, the economic incentive for joining and contributing to such a cooperative is weak at best.

5.4 Land Prices, Nontimber Forest Outputs and the Multiple Use Constraint

Chapter 3 extends the model of land owner behavior to derive equations which simultaneously determine timber supply and forest land demand. From the latter equation one can find the slope of the multiple use constraint associated with different observed levels of timber and nontimber output. Hence, given data on price and timber values on a sample of forest tracts, one can estimate the multiple use function. The estimate could be derived either by assuming a functional form (e.g. Section 3.3 above) or by solving a one-dimensional differential equation. The estimate could then be used in conjunction with the data presented in Chapter 4 to estimate the timber supply model.

A straightforward method for assembling the requisite information involves four steps; (i) selecting a sample of parcels, (ii) determining market price through transaction or other evidence, (iii) cruising the timber on the plots and, (iv) interviewing the owner to determine timber harvest behavior. This effort was beyond the scope of this research.

Instead, the PWMP records include a substantial and accurate but dated timber inventory for each parcel. Since timber growth was estimated for each plot, a history of removals is needed to update the inventory to reflect the current volume of standing timber. An estimate of current land price is also required. These data were sought in interviews with the PWMP cooperators.

This strategy erred on both counts. Of the cooperators interviewed, only those who were in the forest products industry had any reasonably accurate record of removals. Estimates of land values were vague. Most of the respondents had been approached to sell land but few had ever discussed prices with the prospective buyers. Although land prices can be used to estimate the multiple use constraint, one must collect direct information on land prices and timber values to implement the model.

An interesting note is that most respondents did not feel that timber management activities influence land prices to any considerable degree. On one hand, some thought most of the merchantable timber could be removed and the land price would remain unaffeaed, provided that a few years had passed since the logging so some brush could grow up to cover the stumps and skid roads. Of course, urban buyers of forest land may not share this view. On the other hand, the cost of timber culture activities such as pruning or precommercial thinning could not generally be justified in terms of incremental value of the land.

The latter finding suggests an interesting failure in timber and land markets. A basic assumption in the capital theory model of forest investment is that future markets clear at the assumed price. Theoretically, then, an owner can Start a stand and then sell it prior to maturity for the discounted value of the timber. If land prices do not reflect the value of the partially grown timber, then such a market does not exist. An owner cannot cash out the investment in timber production prior to the termination of the rotation. This may occur beyond his effective planning horizon such as his own lifetime. Offering a parity price for immature timber on the stump, as Gould (1976) proposes, to be held by a public or private agent until mature; would be an appropriate public policy to counteract this specific type of market failure.

Chapter 6

CONCLUSIONS

What has this study revealed about timber supply from private nonindustrial forests? The forest area held by this diverse class of owners has remained roughly constant since 1952, equalling about three fifths of the total commercial forest land in the United States, but this aggregate area has experienced sizable shifts in the types of owners. Farm ownership of forest land has declined substantially. Moreover, the per acre contribution of the remaining farm woodland to farm income has significantly diminished. At the same time, increases in "miscellaneous" private ownership of forest land have offset losses in farm ownership. Owners in business and professional occupations comprise the major element of the latter ownership trend.

Since colonial days, timber management on private nonindustrial forest lands has been thought of as a problem requiring some sort of public intervention. The foundation of this contention is twofold. First, timber shortages will occur in the future. Second, timber management on private nonindustrial lands is poor and, if improved, the timber output from these lands would overcome the perceived timber shortage.

Neither premise is supported by this study. In the first place, the data are not adequate to evaluate nationally the effectiveness of timber management of these lands. In the second place, the forest products economy in this nation is undergoing a transition from an old growth resource to a second growth one. Economic forces tend to level the long term upward trend in stumpage prices once this transition is complete. What is seen as evidence of impending timber shortages may be more properly viewed as the dynamics of this transition. The traditional view of the private nonindustrial ownership problem focuses on the timber outputs from those lands and ignores the public goods (outdoor recreation, wildlife habitat, pleasing landscapes, and so on) produced by those forests.

Timber from private nonindustrial forests forms an important component of the national timber budget. In 1970, about one half of all roundwood products came from these lands. The Forest Service projects that the timber output from private nonindustrial forests will almost double by 2000. These projections are based on unsatisfactory models of supply behavior by private nonindustrial owners. Improved estimates depend on quantifying the effect of price and ownership characteristics on timber harvest from these forests. The analytical work of this essay focuses on this problem.

Multiple objectives in forest ownership characterize private nonindustrial owners. Typically these owners derive recreational and aesthetic benefits from their lands which may conflict with timber harvest. This study developed a formal microeconomic model to estimate the effect of price and ownership characteristics on timber harvest. This model incorporates both timber and nontimber objectives of the owners and outputs from the forest.

Statistical estimates of the model's parameters were based on a sample of private nonindustrial forest owners in New Hampshire surveyed by the U.S. Forest Service. The measure of timber supply derived from those data is dichotomous, indicating only whether or not a respondent harvested timber in a certain year but not the quantity of timber removed. A maximum likelihood logit estimator was adopted ro model this dichotomous dependent variable. This statistical procedure results in equations relating the probability of harvest to owner and ownership characteristics and stumpage price. Interviews with a second set of New Hampshire private nonindustrial owners, cooperators in the Pilot Woodland Management Program which operated during the late 1950's and early 1960's, permitted examination of the model in a more detailed, nonstatistical way.

The results from these analyses warrant five main conclusions. Concomitant to each are suggestions for public policy. The remainder of this *Bulletin* presents these conclusions and recommendations.

Timber Supply From Private Nonindustrial Forest Results From Economic Rationality

Owners of private nonindustrial forest lands make rational timber harvest decisions within the framework of their own constraints and objectives. To some, this statement is a truism; to others, it is a conclusion.

The objectives of the owners include both income for consumption and nontimber benefits derived from land ownership. Furthering these objectives through the management of forest land is constrained by the technical tradeoffs between timber and nontimber forest outputs. A model based on this premise is corroborated both by its statistical fit to the actual behavior of a random sample of private nonindustrial forest land owners in New Hampshire and by its coincidence with the objectives and constraints of a second independent sample of forest landowners.

The fit of the model to observed behavior could be improved. First, one should characterize the dynamic aspects of the problems: timber inventory change, investment in timber production and other capital assets, and the preferences for present versus future consumption. The extended model would be useful in exploring decisions concerning investment in timber management which were beyond the scope of this study. Second, the empirical fit of the model developed in this research could be improved if the tradeoffs between timber and nontimber forest outputs could be measured and incorporated into the statistical analysis. Data and methods for estimating the multiple use constraint are described. This additional analysis would also illuminate an issue of central importance to timber management on private lands: does the land market capture the value of timber production investments, or are they illiquid until near the end of the rotation? Chapter 5 describes the policy implications of this type of market failure.

Price is a Major Determinant of the Propensity to Harvest Timber

Price strongly influences the probability that a private nonindustrial forest owner will harvest timber. Uncertainties surrounding the statistical estimator used in this analysis preclude setting an exact value for the supply elasticity. It is likely that the elasticity of the probability of harvest with respect to nominal sawtimber prices lies in the range of 2.0 to 3.9.

The response to price is nonlinear in the model estimated. Consequently, price elasticity will depend on the value of the other independent variables. In the theoretical model, it is possible that higher prices could lead to reductions in timber harvest. This would occur if the utility of the reduction in harvest is greater than the utility of the added income made possible by additional harvest at a higher price.

This finding has two important implications for policy. First, price is apparently an inducement for timber harvest on private nonindustrial lands. In other words, timber will be supplied from these lands as long as prices are high enough. If altering the timber supply from these lands is deemed socially desirable, public policy can use this price responsiveness to help motivate timber stand improvement. To intervene in the long run supply situation, policy should focus on regenerating the harvested stands with an adequate stocking of desirable species. Although the regeneration problem is outside the scope of this research, its extent and solutions apparently vary considerably between regions. A regionally focused policy could be expected to be more effective than a uniform national one.

Second, Forest Service projections appear to underestimate the effect of price on timber supply from this class of owners. The Forest Service assumes an elasticity of the percentage of inventory harvested with respect to price equal to 0.5, but this research finds a value from four to eight times that estimate evaluated at the mean of the sample. Timber supply estimates should consider the differential price response of owners holding different size parcels.

Owners of Small Holdings are Less Likely to Harvest Timber

Both theoretical and empirical results support this conclusion. A shift in the distribution of parcel sizes to smaller holdings will, all else equal, lead to less timber supplied. The public goods produced by private nonindustrial forests may also be affected by trends in tract size. If maintaining timber supply from these lands is socially desirable, then one possible point of policy intervention lies in the prevention of parcelization or in the stabilization or improvement of the existing tract size distribution.

Farmers are Different From Nonfarmers

Farmers are more likely to harvest timber than are nonfarmers. In addition, their response to timber price is significantly greater than that observed for nonfarmers. Existing trends away from farm ownership of forest land towards nonfarm ownership will, all else equal, reduce the timber supply from the class of private nonindustrial forest lands. At the same time, the contribution of forestry to farm income appears to be declining. Overall, the importance of farmers to timber supply has declined relative to that of nonfarmers.

In the context of the model of land owner behavior, this implies that nontimber land values are in ascendancy as the objective of forest land ownership. Then the focus of concern for improving private land management should shift from timber management to forest management. Production of nontimber forest outputs should be emphasized, and close attention should be paid to the public good aspects of those products. Government forest management assistance to private landowners is justified only if the social value of the public goods produced exceeds the program costs.

More Affluent Owners are Less Likely to Harvest Timber

According to both theoretical and the empirical results, income is negatively related to the propensity to harvest timber. Higher rural incomes will lead, all else equal, to reduced timber supply from private nonindustrial lands. Reductions in the costs of holding land (e.g. property taxes), in effect, increase landowner income. For either small decreases in these costs or for large decreases in the short run, reducing land holding costs will reduce timber supply. In the long run, large decreases in land holding costs will increase timber supply. If the objective of forestry property tax classification is to increase timber supply, then the program should incorporate mandatory timber management and harvest provisions.

Increased timber supply is not the only legitimate public policy objective for private nonindustrial lands. Pursuing that objective depends on the judgment that the value of the additional timber exceeds the value of the nontimber outputs which must be foregone to obtain the additional timber supply. Consequently, one cannot advocate increased timber supply from these lands without some knowledge of the tradeoff between timber and nontimber outputs. The nontimber outputs from private nonindustrial lands, particularly those public goods such as wildlife, aesthetically pleasing views, and some forms of outdoor recreation, may be more valuable than the potential timber supply from those lands. Programs to reduce land holding costs could be focused on the production of these public goods by, for example, tying property tax classification to access for hunting or fishing.

Historically, private nonindustrial forests have made significant contributions to the national timber budget. The future is likely to see continued reliance on timber supplied from these lands. Timber supply decisions by the owners of these forests seem to derive from a comparison of the income from timber production to the loss of nontimber land values concomitant to timber harvest.

In sum, the postulated model of landowners' behavior with respect to short term timber supply seems co accord with observed behavior. The statistical estimates of the model's coefficients conform to the theoretical expectations. Price affects the propensity to harvest timber. Higher incomes are associated with lower levels of timber production. Smaller parcel sizes lead co a lower probability of timber harvest. Farmers are more likely to harvest timber than are non-farmers, and farmers are more responsive co price.

Stumpage price is endogenous co the timber market but the other variables are not. In the United States, trends are cowards higher rural incomes, smaller parcel sizes and less farm forest land owner-ship. Consequently, all else equal, timber supply from private lands will decline unless prices rise to compensate for the trends in these other variables. In shoft, the supply curve is shifting inward so increased prices will be necessary just to keep Output constant.

Interpreted another way, the problem of timber supply from private nonindustrial forests cannot be divorced from larger questions of rural land policy. Raising rural incomes is a traditional objective of public policy. The activities of farmers respond, in parr, to agricul-tural policy and price support systems. Conversion of farms to nonfarm ownership and the parcelization of rural lands are land use issues which transcend the problem of timber production. Perhaps placing the issue of timber supply from private nonindustrial forests in this larger context of rural land policy would achieve greater success.

ENDNOTES

Chapter 2

1. The data in Figures 1.1 to 1.3 are derived from various *V.S.* Bureau of the Census materials, including the Census of Agriculture. "Farm forest land" differs in this source and in Forest Service publications despite the fact that the twO agencies share the same definition of "farm." The Bureau of the Census asks the respondents to record the acreage of forest on their farms; hence, land used as pasture but having trees might be excluded from the report. Similarly, land either less than 10 percent stocked or capable of less than 20 ft^3/year growth may be included as forests in the Census publications but is not recorded in Forest Service statistics. Although the Census and Forest Service definitions of "commercial forest land" differ, the data in Figures 1.1 to 1.3 are nominally consistent since they are derived from Census publications.

2. Comparing the data from these twO sources suffers two shortcomings. First, as noted in the text, the Barraclough survey included only ownerships larger than 10 acres in size. The 1973 data cited shows that 56.9 percent of the owners held less than 10 acres of land, but only 3.8 percent of the area was held in parcels of less than 10 acres in size. In 1953 for the nation as a whole, only 18 percent of the land was held in tracts of less than 10 acres in size (U.S. Forest Service, 1958, p. 309). In 1953 the average parcel size in New England was 65.9 acres *(V.S.* Forest Service, 1958, Table 171, p. 302), but had declined to 36.3 acres in 1973. Since the Barraclough survey ignored (intentionally) the owners of less than 10 acres of woodlands, there is a risk of bias in comparing the two sets of figures as has been done in Table 1.2. However, since both the average size of holding has declined since 1948 and the fraction of the owners holding fewer than 10 acres has increased, the errors associated with the comparison in Table 1.2 are less than they would be if the tract size distribution had remained constant.

   Second, no detailed ownership survey has been completed for Maine, so the 1973 data do not include data for this state whereas the 1948 do. The farm-nonfarm breakdown can be made comparable, and this was done in Table 1.2. The disaggregation within the nonfarm class cannot be reconciled, so here one must tacitly assume that the distribution of owners in Maine is identical to that in the other four states. Because of the prevalence of large common and undivided ownerships in Maine, this assumption may be violated, and the disaggregate comparisons for the percentage of area held might then be misleading.

3. Take p = stumpage price
$v(t)$ = volume at time t
t^* = optimal rotation age
v_t = derivative of v with respect to t

Now the point of maximum mean annual increment (called culmination of mean annual increment) occurs when v/t is maximal. Elementary calculus shows this to occur when $v_t = v/t$, or in forestry terms, when the current annual increment equals the mean annual increment. Call this value t^*_m.

Maximization of present net worth is the financial objective of selecting the optimal rotation. The problem, using continuous discounting, is

$$\max PNW = pv(t)e^{-it} + PNW\, e^{-it},$$

where i is the discount rate. Rearranging and solving gives the conditions for the optimum as $v/v_t = i/(1-e^{-it})$. Call this value t^*_p. Because of the shape of v (i.e. v_t/v decreases with time), t^*_p is always less than or equal to t^*_m. In fact t^*_p limits in t^*_m as i approaches zero.

Using Douglas-fir cubic foot yields (McCardle, Meyer and Bruce, 1961) and an interest rate of 10 percent, t^*_p equals about 50 years. Culmination occurs at about 110 years. At 50 years an average site stand carries about 6.6 thousand cubic feet per acre, whereas a 110 year old stand carries over twice that amount, about 14 thousand cubic feet per acre. Conversely, the annual growth in the 50 year old stand is about 170 cubic feet per acre whereas that in the 110 year old stand is about 65 cubic feet.

4. The Forestry Industry Council's productivity study is divided into two parts: (i) identification of forest lands where additional silvicultural treatment might be desirable, and (ii) analysis of the costs, additional yields and eventual returns from applying more

intensive management. All of the cost, yield and future price data used in this study are derived from local State Committees on Forest Productivity.

The state committees are responsible for specifying the alternative silvicultural treatments and the possible yields from those treatments. For example, in Alabama the principal treatment was to place all suitable lands under pine plantation management with a 30 year rotation. Other types of less intense management, relying on natural regeneration for example, might have higher returns than the assumed pine plantation, but this does not affect the acreage yielding a return greater than or equal to some specified figure. Inflation of 4 percent annually was assumed, and taxes were calculated at the old (pre-1978) capital gains tax rate for corporations of 30 percent. Expensible items were accounted assuming a 30 percent marginal tax bracket (Allen, personal communication). National Forest Products Association (1980) contains a more complete description of the program.

Chapter 3

1. The second order condition for a maximum requires that the derivative of (3.14) with respect to t is negative. Taking the derivative and rearranging gives:

   $$g_t u_{ry} p + u_{rr} g_t^2 + u_r g_{tt} + u_{yy} p^2 + u_{ry} g_t p$$

   which is seen to be negative given the assumed signs of the derivatives of u and g.

2. If g_{tt} is positive then the optimal harvest policy will be a corner solution (i.e. either $t = 0$ or $r = 0$) if the curvature of the utility function is less than that of the multiple use constraint.

Chapter 5

1. The Pilot Woodland Management Program is documented in: Anon. (1958), Anon. (1955), Sloan (1961), LaBree (1957a, b), Barraclough (1957), Breck (1957), Bruns (1965) and Gould (1957).

Appendix 1

THE OWNERSHIP SURVEY

In conjunction with their responsibility for timber resources inventory, the U.S. Forest Service Northeastern Forest Experiment Station has surveyed the owners of commercial timberland in several of the northeastern states. The survey for New Hampshire (Kingsley and Birch, 1977) is the source of the data on timber harvest behavior and owner and ownership characteristics used in Chapter 4. This appendix discusses some of the pertinent details of that survey.

The people sampled in the survey are the owners of the U.S. Forest Service permanent timber survey plots. The probability of selection is proportional to the area held, so the sample is biased rowards larger owners. One of the consequences of this sampling plan is that small holdings are underrepresented in the sample in relation to their frequency in the universe of New Hampshire owners as a whole. The standard errors of any estimates based on the sample will be larger for the smaller owners.

Table A1.1 presents some pertinent data on this survey. Of 562 owners, 367 responded to the mailed questionnaire. The high response rate is probably due to extensive follow-up work by Forest Service personnel and the prestige of the Forest Service. No difference between respondents and nonrespondents was found in terms of average size of parcel or place of residence (Kingsley and Birch, personal communication).

A subset of the survey information was provided in machine-readable form by Neal Kingsley of the Northeastern Forest Experiment Station.

TABLE A1.1

Selected Data from New Hampshire Ownership Survey

Data Points in New Hampshire	562
Acreage/Plot	7957
Number of Responses	367
% Response Rate	65.3
Number of Owners (thousands)	85.6
Average Size (acres)	28.7
Number of Owners with Less than 10 A (thousands)	55.9
% Land in Holdings Less than 10 A	6.5
Average Size of Plot Greater than 10 A in Size (acres)	77.4

Source: Kingsley and Birch (1977)

Appendix 2

STUMPAGE PRICE INDICES

The desiderata for estimation of the effect of price on the propensity to harvest timber are the real price offered and accepted at the time of the transaction and the prices previously refused. These data are nOt available for the respondents to the New Hampshire ownership survey so proxy prices were constructed. Since the species or products sold by the respondent are not known, price indices which reflect a mix of species and products were used. This appendix describes how these price indices were constructed and discusses the limitations of their accuracy and applicability.

The price data used in this study were derived from the New Hampshire *Forest Market Reports*. These reports are published annually by the Cooperative Extension Service in New Hampshire. A range of prices is given for sawtimber, pulpwood and a variety of other forest products (e.g. posts, piling, excelsior). For the years following 1959 the sawtimber data are presented by county; for earlier years only statewide averages are given. Pulpwood prices are broken Out by "northern" New Hampshire, which includes Coos, Grafton and Carroll Counties, and "southern" New Hampshire, which includes the remaining seven counties.

The data are obtained by the county foresters who contact loggers, mill operators and other primacy forest product buyers in Januaty of each year. The prices used in this study refer to theJanuacy following the year in question. Hence, the prices used may accurately reflect neither a year long average nor the price prevailing at the time of the timber sale. Prior to 1960 the simple arithmetic mean of these figures was reported for the statewide average, so a consistent time series for the state as a whole can be constructed by averaging the post-1960 figures.

All of the analysis reported here covers the period 1947 to 1973. Although the *Forest Market Reports* series was initiated earlier, the data for the years prior to 1947 were unsuitable for a variety of reasons. The ownership survey was taken in 1973; consequently, prices after that date are of no use to the analysis of harvest decisions. However, the price indices were computed up to the latest prices available, 1976. O. P. A. price setting for the forest produces industry ended in 1947. During the early 1970's, prices on certain forest products were controlled, although stumpage prices were not directly regulated. Otherwise the prices were not directly administered by any governmental agency and were determined by market forces.

In this analysis, only sawtimber and pulpwood are included in the price indices. In 1972, these products comprised 91.7 percent of the removals on a cubic foot basis (Kingsley, 1976b). Sawtimber prices are in units of dollars per thousand board feet (International ¼ inch rule, although the Blodgett rule is the statutory scale in New Hampshire). Pulpwood prices were converted from units of dollars per cord to equivalent prices in dollars per thousand board feet by multiplying by a factor of 2.0640 (85 ft^3/standard cord x 5.7 board feet per ft^3 ÷ 1000 = .4845 Mbf/cd = 2.0640 cd/Mbf). The resulting price indices are in units of $/Mbf. For sawtimber, the *Forest Market Report* gives a range of prices for several levels of quality. For the results reported here, medium or average quality was assumed and the midpoint of the price range was taken.

The price indices equal a weighted average of prices. The weights are the percentage contribution of a particular species or product to total removals on a volume basis. For pulpwood, the weight equals the pulpwood removals as a percentage of total removals for each species. The weight for all of the sawtimber species together equals one minus the weight for pulpwood.

Unfortunately, data on removals by county by year were not available to construct the weights for the price indices. During the period of concern, the Forest Service completed three forest inventories in New Hampshire. The relevant results from these surveys are presented in Table A2.1. Removals for each year were estimated by linear interpolation of these data. The removals are assumed to be equal in all counties, except in counties where no prices were reported for a species (e.g. spruce in the southern counties). In these cases, the removals for that species were assumed to be zero and were therefore eliminated from the calculation of the weights.

In Table A2.1 note that some assumptions were necessary to derive the removals of some species and that in 1948 two different sets of removal figures were constructed. The implications of these different assumptions are discussed below. Also note in Table A2.1 that the seven sawtimber species included in the price indices comprise from 90 percent to 95 percent of all the sawtimber cut, and that pulpwood removals range from one quarter to one third of all removals. Examples of sawtimber species not considered in this analysis are cherry, ash, beech, white oak and aspen.

TABLE A2.1
Estimated Removals by Species in 1972, 1959 and 1948
(Mbf, Int. ¼-inch scale)

Species	1972[1]	1959[2]	1948/1[3]*	1948/2[3]**
White Pine	69535	118000	107400	141500
Hemlock	20190	21400	39300	51800
Spruce/Fir	14209	25500	44500	58600
Red Oak	23281	11300	10300	5200
Birch	15695	41460	52400	26600
Hard Maple	2889	17500	26000	13180
Soft Maple	3863	3522	12400	6300
Total, All Species	166000	253700	32200	
Coverage fraction	.902	.942	.902	.942
Pulpwood Removals as a fraction of all Growing Stock Removals	.3398	.3036	.2337	

Source: 1. Kingsley (1976b)
2. Ferguson and Jensen (1963)
3. Larson, *et. at.* (1954)
* cut by species allocated in proportion to sawtimber volume by species
** cut by species allocated between hardwoods and softwoods according to hardwood and softwood sawtimber removals then between species in proportion to sawtimber volume by species

Four price indices were computed for each county for each year: a sawtimber price index and a joint sawtimber/pulpwood price index in both constant and current dollar forms. The constant dollar indices were constructed from the current dollar ones by dividing by the consumer price index (CPI) and multiplying by 100, the 1967 base of the CPI. The CPI was used because timber prices enter the choice model through the owner's income. The CPI is the best measure of the buying power of that income.

The twO assumptions give nearly identical price indices. The correlation coefficients between the two series (n = 10 counties X 27 years = 270) for the four indices are:

STPI	TPI	RSTPI	RTPI
.9996	.9995	.9983	.9987

The peaks and troughs of the twO price series occur in the same years.

The high correlation between the price series is not surprising, considering the pattern of correlation among the prices which are used to construct the indices. If the prices were perfectly positively correlated, then any choice of weights would give the same relative price indices. The correlation among the various prices within a county is high and positive in all cases. By Occam's razor, the first assumption concerning 1948 removals was used throughout this study. Figure 4.4 in the main text shows the price indices over time resulting from this assumption.

Appendix 3

THE PILOT WOODLAND MANAGEMENT PROGRAM

Section 5. 1 discusses the history and rationale of the Pilot Woodland Management Program and the methods used in selecting its cooperators. This appendix describes the information from the program that was used in the analysis reported by Chapter 5.

Five types of data were available from the PWMP.

i. The basic PWMP file, which included the property and stand maps, estimates of volume by species and size categories, an air photograph and alternative management plans with labor input requirement, and gross returns for various levels of management.

ii. The extended PWMP file, which included records of the stands cut, products sold, time and money spent in forest management, equipment used, wages paid, type of operation, and the returns realized.

iii. Tape recordings of the interviews in 1955 and 1956 with the PWMP cooperators in which the data in the basic file were discussed (e.g. to check the estimates of acreage held with the owners' personal estimates) and the alternative management plans were described. These discussions frequently reveal considerable information about the cooperators' forest landownership objectives.

iv. Records from the five year remeasurement of the growth plots which was completed in 1961. The summary data for each cooperator is available and Bruns (1965) has analyzed the data as a whole.

v. Reinterviews with the PWMP cooperators, their heirs, or the current owners of the land.

Table A3. 1 summarizes the availability of the PWMP data. Of the 50 basic files, 39 were found in more or less complete condition. Originally three copies of each basic file were made: one for the cooperator, one for the county forester in the cooperator's county, and one for a central file on the PWMP. Because the central records for the program were destroyed, the county foresters had to be canvassed and visited to assemble copies of the basic files. Frequently, interesting additional information about the cooperator or his lands was revealed in these discussions. For example, one cooperator apologized to the county forester for a particularly heavy cut, saying "My preference would be to let this stand grow, but to tell the truth, running two homes is quite a financial burden and I could use the money." Another of the cooperators owns the largest horse chestnut in New Hampshire.

TABLE A3.1
Summary Data on PWMP Records Available

Item	Number Available
Basic files	39
Tape Recordings of Interview	25
Extended files	0
Status of Property	
Part or All held by PWMP cooperator or family	24
Sold	8
Unknown	18
Current Owner Identified	26
Interviews with Current Owner	10

The twenty five remaining tape recordings of the original interviews with the cooperators were reviewed and summarized as part of this research. Each is from one to two hours long and provides some insight into the owner's intentions for forest management. In some cases the reinterviews could compare these intentions with the forest management activities actually carried out.

Only fragments of the extended files could be found. In some cases cutting records can be assembled from other sources (e.g. the cooperator or the county forester), but these records are incomplete. None of the input or output data that the PWMP was originally designed to collect were found.

The current status of each property originally owned by one of the PWMP cooperators was determined through interviews with the county foresters and their staffs. Some of the parcels had been sold outright, subdivided into house lots, donated to charitable organizations, or taken for public works projects.

Beyond interviews with the county foresters, methods to identify the current owner (title search, for example) were outside the scope of this research. The current owners of 26 of the properties were tentatively identified through this process. Several attempts were made to telephone each, and interviews were eventually completed with 10 owners.

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