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Forest Service projections of the long-term supply and demand for forest products indicate that increasing importance will be placed on the supply behavior of nonindustrial private forest owners in the South. The inventory model on which these projections are based may produce biased estimates of southern timber production, however, as a result of the failure to account for changes in management practices and shifts in the distribution of forest area by stand type. In addition, it has not been possible to assess explicitly the influence of government policies on future timber supplies.

The first component of this study is an age-class based inventory projection model that incorporates stand establishment, thinning practices and the successional tendencies of natural regeneration in the South. Model projections of southern softwood inventories differ considerably from previous estimates. Softwood grow-

ing stock on nonindustrial private forest land will decline, by the year 2000, by more than 30% from the level in 1977 when harvests anticipated by the Forest Service are combined with historical levels of softwood regeneration. Softwood inventories on forest industry lands will increase over the same period due to pine plantation establishment.

The second component is a policy analysis system which is applied to an examination of the long-term impact of reforestation cost-share payments programs. The coefficients of policy-sensitive management equations are estimated from historical data; these equations are linked with the inventory model and a model of timber markets. Projections with these models indicate that when program funding is continued at current levels softwood stumpage and product prices will increase faster than previously expected. Substantial increases in cost-share payments can result in lower prices but have little effect before the year 2010.

Nonindustrial Forests, Public Policy and Long-Term Timber Supply in the South

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NONINDUSTRIAL FORESTS, PUBLIC POLICY AND LONG-TERM TIMBER SUPPLY IN THE SOUTH

INTRODUCTION

The dual questions of the adequacy of future timber supplies in the U.S. and the role of government in forestalling shortages have been debated since colonial times. The forest policies of the federal government which arise from this debate can be divided into broad categories which reflect the pattern of ownership of the nation's commercial forest land. Policies and programs concerned with public forest land--dominated by the National Forests--have influenced timber supplies and prices primarily by regulating the harvest of existing inventories. This short-term response has depended on old-growth stands with high volumes per acre; the extent to which these forests can satisfy future demand for forest products is limited. Other, competing uses for public forest resources and policies designed to balance the flow of public timber harvests over time restrict the use of this approach. Since, in addition, public forests account for less than 30 percent of the nation's commerical forest land, forest policies aimed at increasing timber supplies in the long-term must be more broadly based

The nonindustrial category of private forest owners--those landowners who do not own processing facilities--has been a particular target of public policy for many reasons. These owners control over half of the commerical forest land and have supplied, historically, significant proportions of total timber removals. Perhaps more important is the fact that the future supply behavior of these owners is considered to be the least predictable.

While public lands forest policies have direct impacts felt, for the most part, in the West, nonindustrial private forest policies focus on the South. This region contains nearly half of all the land in this category, and produces forests which are among the most dynamic in the country. That is, they are characterized by rapid growth, short rotations, and inexpensively operable sites. Although southern forests contained only 20 percent of the nation's softwood growing stock in 1977, they contributed over 50 percent of the net annual growth of this growing stock. As old-growth inventories in the West decline in importance it is clear that future softwood timber supplies will depend on the timber management decisions made in the near term on private forests in the South.

As expectations for southern forests have grown so, too, have concerns over their abilitity to meet future demand. Over a decade ago warnings were being sounded about the lack of pine regeneration in the South and the implications for reduced softwood growth in the future. As a result, interest in policy measures which would promote better softwood management on nonindustrial forests was renewed. The incentive approach to nonindustrial private forestry problems, dating back to the Cooperative Farm Forestry Act of 1937 was again favored by the states and federal government. The choice of incentives rather than regulatory approaches has been based on an assessment of private owners as generally willing, but unable to undertake the practices necessary to produce softwood timber. The research presented here is intended to contribute to an understanding of how this policy instrument contributes to the achievement of forest policy goals.

The first question addressed (in Chapter 2) is that of the nature and extent of the problem in future southern softwood timber supplies. That is, a demonstration that there is, in fact, a reason for policy intervention. This is done by constructing an inventory projection model which includes detail on the age class and stand type structure of the inventory as well as information on the management practices of forest landowners. An important feature of this model is the ability to describe the development of southern forests in the absence of active management.

Simulations with this model show that the problem--a reduction in pine regeneration on nonindustrial forests--is likely to have more serious consequences than previously anticipated. More rapidly rising prices and declining harvests and inventories result from the failure to actively regenerate southern pine stands after harvesting.

Chapter 3 presents an analysis of the extent to which reforestation cost-sharing programs can achieve the goal of reasonable future timber prices. Using a modified version of the Timber Assessment Market Model (Adams and Haynes, 1980) public cost-share payments are evaluated in terms of their ability to influence softwood stumpage and forest product prices. To do this, the policy analysis system has, along with the market model, a model of private forest management investment behavior and a mechanism linking the management decisions with supply decisions in the stumpage market. It is in this systematic approach that this research differs from previous analyses of reforestation cost-share payments.

First, the level of private forest management is determined by market conditions and government policy. Second, an inventory projector which explicitly models this effort--or lack of it--is utilized to evaluate the cumulative impact of program expenditures. Finally, market supplies are determined by prices and inventory levels, completing the link between policy and its intended outcome. Price are variables, not assumptions in this policy analysis system. With policy targets expressed in terms of the level or rate of change of future prices, program effectiveness and efficiency can be defined in terms of the cost (expenditures) required to achieve a given policy target.

Two levels of expenditures are examined here: a continuation of current levels (approximately 13.2 milliion dollars a year in the

South) and a five-fold increase from this "baseline." The results show that cost-share programs can have a dramatic impact on future timber prices. Using changes in producer and consumer surplus as a measure of program benefits, higher levels of cost-share payments break even (discounted benefits equal increased costs) by the year 2000; by the year 2015 these programs yield an extremely favorable benefit-cost ratio.

SOUTHERN TIMBER SUPPLIES TO THE YEAR 2000: ALTERNATIVE PROJECTIONS

Abstract

The projections of southern softwood inventories used by the U.S. Forest Service in the assessment of future timber supplies employ a stand table projection model (TRAS) with no explicit representation of the distribution of forest area by management class or stand type. Estimates of growth and future growing stock based on this characterization of the inventory may be biased as a result of the failure to account for area shifts among stand types and changes in the management practices of owners. In addition, it is difficult to conduct an analysis of the impact of more intensive forestry given the diameter class structure of the model and its level of aggregation.

This paper presents an age-class based softwood inventory projection model (SPATS) for private owners in the South. Along with information on the age structure of stands this model includes a stand type dimension, providing an opportunity to examine the results of alternative levels of softwood management by each private owner group. Stand establishment, thinning practices and the successional tendencies of natural regeneration in the South are explicity modeled. Projections of softwood inventories in the South using this model differ considerably from previous estimates,

despite common initial inventories. Softwood growing stock on nonindustrial private land declines, by the year 2000, by more than 30 percent from the level in 1977 when previously projected harvests are combined with historical levels of softwood regeneration. Softwood inventories on lands owned by forest industry in the South increase over the same period as a result of pine plantation establishment. Nonindustrial owners in the South are also unable to provide, in these projections, the level of softwood growing stock removals anticipated in previous studies. Increases in softwood regeneration, if begun immediately, have little impact on the volume available for harvest prior to the year 2000.

Model validation is discussed and comparisons are made with other sources of information on southern forests and management practices.

Introduction

The importance of southern forests in national timber supply can be demonstrated by reference to statistics compiled by the U.S. Forest Service (USDA, Forest Service, 1982). In 1977, 39 percent of the nation's commercial forest land was in the South, with most of these 188 million acres (90 percent) held by private owners. Nonindustrial private (farmer and other private) owners controlled 134.1 million acres of the commercial forest land in the South--70 percent of the region's forests and nearly 28 percent of the nation's commercial forest area.

Southern forests contained approximately 20 percent of the nation's softwood growing stock inventory in 1977, but in 1976 contributed over 50 percent of the net annual growth of softwood growing stock (USDA, Forest Service, 1982). Southern forests dominate softwood growth in the nation in spite of the fact that southern pine types occupy less than half the area considered to be suitable for southern pine growth (Murphy and Knight, 1974).

Based on the softwood growth potential of southern forests and increases in growing stock inventories between 1962 and 1977, the South is expected to provide over 50 percent of domestic softwood roundwood supply by the year 2000 (USDA, Forest Service, 1982). In addition, the southern share of timber production is projected to increase steadily to the year 2030.

A contrasting view of the future of southern forests is suggested by others. This view questions the ability of southern softwood stands to sustain high levels of softwood timber production given historical management practices, particularly those on non-industrial private forests.

Over a decade ago the Southern Forest Resource Analysis Committee warned that pine regeneration in the South needed to be dramatically increased in order to assure that future supplies would be adequate to meet timber demands projected for the year 2000 and beyond (SFRAC, 1970). This conclusion was also reached by others based on subsequent assessments (White, 1974; Boyce, 1975). In the decade following the Third Forest Report (SFRAC, 1970) pine reforestation remained well below the 2 to 3 million acres a year required to meet that Report's timber production goals (see Figure 2.1).[1]

Ten years after the Third Forest Report, Boyce and Knight (1979) examined the condition of southern forests and the prospects for future softwood growth. By this time the failure to regenerate pine stands following harvests and the accumulating area of non-

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(1) In this paper the regional subdivisions used by the U.S. Forest Service will be used. The Southeast region includes Florida, Georgia, North Carolina, South Carolina and Virginia. The South-central region includes Alabama, Arkansas, Louisiana, Mississippi, Oklahoma, Tennessee and Texas.

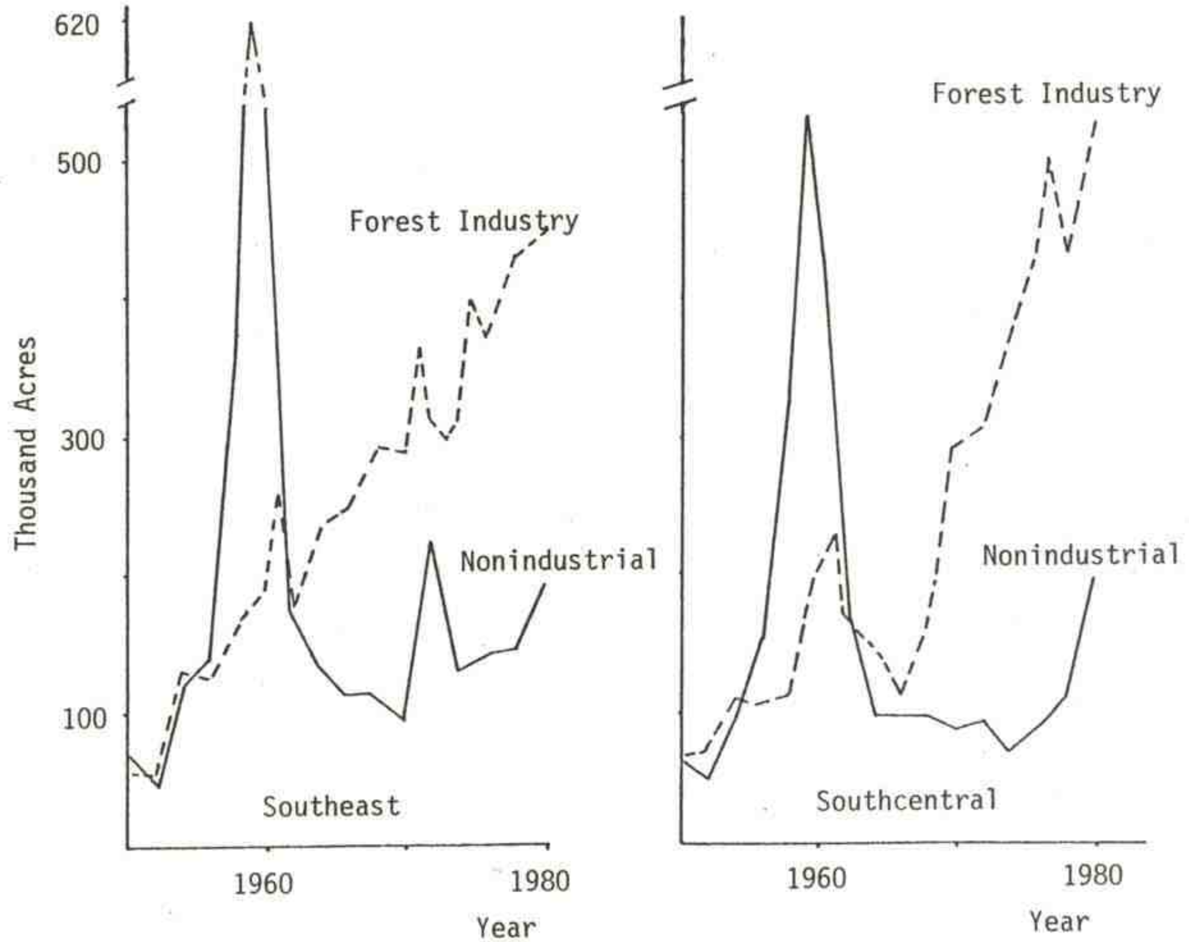

Figure 2.1 Forest planting by private owners in the South

stocked and under-stocked forest land had a clear impact. Boyce and Knight (1979) showed that the number of trees in the two inch diameter class (for softwoods) had declined noticeably in State resource inventories completed after 1974. The increases in softwood growing stock volume between 1962 and 1977 which resulted from high rates of pine regeneration prior to 1965 cannot be sustained given this reduction in softwood regeneration.

Improved stocking levels could account for some of the decrease in numbers of trees in the smaller diameter class if stands were being actively managed. This decrease, however, coupled with other information on management practices, and the continued succession of hardwoods on pine sites suggests the need to revise the outlook for softwood production in the South. Continued low levels of pine regeneration following harvest, combined with the virtual end of cropland retirement in 1965 (a major source of new pine stands) are likely to bring about declines in softwood growth and growing stock inventories (Boyce and Knight, 1979).

Boyce and Knight (1979) suggest that accumulated growing stock volumes could be liquidated in 10 to 20 years--that is, by the year 2000. This is in marked contrast to projections by the U.S. Forest Service. In spite of mounting evidence of problems in pine management in the South, Forest Service projections show that, even with increasing harvest levels, any declines in southern softwood inventories are 40 to 50 years in the future (USDA, Forest Service, 1982).

The Timber Resource Analysis System

The inventory projection system used by the Forest Service in its assessment of future timber supplies is the Timber Resource Analysis System (TRAS) (Larson and Goforth, 1974). The conflicting opinions on the prospects for southern softwood production can be traced, in part, to the nature of the TRAS model and its representation of southern forests.

TRAS is a stand table projection model, in which the inventory of each owner is represented by the distribution of the number of trees per acre by diameter class. In the version of TRAS used in assessments of future timber supplies (see USDA, Forest Service, 1982; Adams and Haynes, 1980) the stand modeled is a composite of all stands in each ownership. The total number of softwood trees are aggregated by diameter class and divided by the total number of acres to arrive at a composite representative acre used to project softwood growth. Growth in TRAS is the result of the advancement of trees through diameter classes, after adjustments for mortality and removals. Regeneration is accounted for by specifying a rate of ingrowth into the two inch diameter class.

TRAS, while designed to project changes in timber volume in response to net growth and timber removals, is less well suited for long-term projection of the essentially even-aged, rapidly changing softwood stands in the South. The composite stand which is the basic unit for TRAS is averaged across site classes, stocking levels, stand types and age classes--representing a wide range of softwood growth potential. Growth in TRAS is dependent only on tree shifts among diameter classes (with basal area constraints) and is independent of these other factors. Perhaps even more important is the fact that over a relatively short period of time the composition of the average stand in the South can change considerably. Over half of all harvested loblolly and slash pine stands become nonpine after regeneration (Boyce, 1975); in light of this, the implicit stability of the composite acre in TRAS seems quite unreasonable.

These changes in softwood stand composition over time are even more dramatic when examined by owner group in the South. Forest industry in both southern regions has, for some time, been replacing harvested pine stands with more rapidly growing plantations (see Forest Industries Council, 1980; and Figure 2.1). TRAS projections do not account for the changes in softwood growth and growing stock which should become evident 10 to 15 years following this shift in management practices.

For nonindustrial private owners the change is equally dramatic, and opposite in nature. These owners have been planting 20 percent or less of the area harvested annually (Forest Industries Council, 1980; Boyce and Knight, 1979), on sites where natural succession favors hardwood regeneration (Murphy and Knight, 1974; Boyce and Knight , 1979). The inevitable result is marked reductions in softwood growth and growing stock, and the impact of this laissez-faire approach to pine management should become apparent within one rotation (20 to 30 years). TRAS, however, employs softwood ingrowth rates based, for the most part, on information from the period 1965-1975. Ingrowth into the two inch diameter class for softwoods during this period would not yet reflect the changes in pine regeneration decribed above. The average age of southern inventory information in TRAS, used in the projection described, is 1972 for the Southeast region, and 1973 for the Southcentral region. It is not surprising, therefore, that softwood growth on nonindustrial private ownerships in the South is projected to remain at high levels past the year 2000.

In summary, projections of southern inventories using the TRAS model may be biased as a result of the failure to account for the growth impacts of management practices and changes in stand type and stand age. The management practices of private owners in the South (regeneration practices in particular) should have a noticeable effect on softwood growth and future growing stock. TRAS, however, is not designed to reflect these changes. An inventory model with greater detail on stand age, stand type and forest management practices should provide more reliable projections of the development of southern inventories to the year 2000 and beyond.

The Southern Pine Age-Class Timber Simulator

The Southern Pine Age-class Timber Simulator (SPATS) is designed to provide estimates of the softwood inventories of private owners in the South. Projections are made by region (Southeast and Southcentral) and by owner group (forest industry and nonindustrial private). The model can be used in conjunction with the Timber Assessment Market Model (TAMM) (Adams and Haynes, 1980), replacing the TRAS inventory projector for the southern regions, or run independently with annual roundwood demand by region-owner as additional data.

SPATS characterizes the softwood inventory of each owner by the distribution of acres by age class and three stand types. Softwood stand types modeled are pine, plantation and natural origin, and oak-pine. Up to 19 five-year interval age classes are modeled for each stand type. Hardwood acres are treated as a "pool", with no explicit age class structure. Nonstocked acres are modeled for each softwood stand type.

The SPATS projection model provides more detailed information than currently available in projections of southern inventories. It remains an aggregate model, however, in that only one site class and one stocking level are recognized in each stand type. The yield tables of the model, then, are actually average volumes per acre weighted by site and stocking level.

The age class dimension of the SPATS model provides information on the development of existing stands for each owner; the stand type dimension provides information on the composition of the softwood inventory given management practices and successional tendencies.

Model Structure

In each five year period of the projection, an owner's inventory is first adjusted for net changes in the commercial forest land base. Total volume removals (from growing stock inventory) due to area reduction are computed and an estimate of the volume harvested (i.e. utilized) in the shift to another use is deducted from total growing stock removals for roundwood demand. Net area loss is removed from all stands and age classes in the ownership; net additions to an owner's forest land base are made in the softwood types only.

Roundwood demand for each owner is converted to growing stock removals using estimates of the proportion of removals from non-growing stock sources, the proportion of removals left as logging residues, and other removals from growing stock as a proportion of roundwood output. Thinnings are taken from each softwood stand type according to specified input parameters: age classes to be thinned, the proportion of eligible stands actually treated, and the proportion of the existing volume removed in thinning. These proportions are entered by age class and stand type for each period of the projection. The volume removed in thinning is deducted from the total growing stock removals demanded from each owner. The remainder is removed in final harvests distributed across softwood stand types and eligible age classes.

Leased lands in each region are given explicit treatment in SPATS. At the beginning of the simulation the distribution of leased land by stand type and age class is removed from the total acreage distribution of nonindustrial private owners in the region. From this point leased lands are treated as a separate category, essentially a third "owner" group. Thinning, harvesting and planting on leased lands is done by forest industry; data on these activities is reported with that done on fee land owned by industry. Summary statistics (growing stock inventory and total area) for leased land are reported with the total for nonindustrial private to maintain consistency with reporting practices for the data.

The treatment of regeneration in SPATS is intended to reflect both the management practices of each owner as well as natural succession tendencies for each stand type. Management intensity is modeled as the establishment of pine plantations. Three options are available for estimating the number of acres planted in each period by each owner: 1) the annual rate of planting can be entered as data; 2) annual planting for the period can be estimated using equations developed from historical data; or 3) planting in the period can be set equal to the area harvested by the owner. The reforestation equations (option 2) utilize the level of cost-share subsidies in predicting nonindustrial private planting. The development of these equations is described in greater detail in Chapter 3.

Estimates of the number of acres planted are treated as "gross"; planted acres are assigned to various outcomes according to probabilities entered as data. Alternative outcomes are successful plantations, pine stands with yields equivalent to stands of natural origin, oak-pine stands or non-stocked (plantation) stands. The probabilities are derived from published sources (e.g., Alig et al., 1980; Kurtz et al., 1980; Knight and Sheffield, 1980) and from a comparison of reported accomplishments with inventory data.

The difference between the area harvested in a period and the area planted is treated as regenerating naturally. For each owner a conditional transition probability matrix is entered as data and specifies the probability of an acre harvested in a "source" stand type regenerating to a given "destination" stand type. Sources are the three softwood stand types; destinations are the three softwood stands, hardwood stands and a non-stocked condition (by stand type). Values for the transition probability matrix were computed from resource survey data and are similar in concept to work reported by Van Loock et al. (1973). In addition to the regeneration of acres harvested, acres which are nonstocked at the beginning of the period are metered into the first age class of each stand type according to specified regeneration probabilities.

In any period the area planted by an owner group can exceed the area harvested. Any "surplus" planting is treated as stand conversion with nonstocked acres and hardwood stands as targets (sources) for conversion.

Harvested acres are assigned to alternative destinations according to the procedures just described. Acres not harvested in a period are grown into the next age class and the owner's inventory for the beginning of the next period is computed.

Yield Structure

In both structure and data the yield information in this type of inventory model is a critical aspect. Since stands are modeled as aggregates there are, unfortunately, few direct sources of information on which to rely in spite of a growing body of literature dealing with the growth and yield of southern forests (see, for example, Farrar (1979) and Alig and Parks (1983)). With this in mind, SPATS has been constructed with assumptions entered as data wherever possible. Projections based on alternative assumptions are easily accomplished with different yield tables and/or parameters.

For each region/owner, "base" and "upper bound" yield tables are entered as data. The base yields represent the existing volumes per acre, by age class, for the stand type. The summation across stand types of the base yield of each age class multiplied by the number of acres in that age class at the beginning of the simulation provides the starting inventory estimate for the owner.

The upper bound yields are the likely maximum volume yield by stand type and age given typical management practices over the life of the stand. As with the base yields these are necessarily composite yields with implicit site class and stocking level weights.

A number of sources provided information on appropriate upper bound yields. The yields attributed to natural pine stands are a composite of the yields of the two dominant southern pine species, loblolly and slash pine. In constructing the composite, the yields of stands of natural origin were weighted for species and site class. The weights were derived from area statistics reported by the U.S. Forest Service (USDA, Forest Service, 1982). Natural stand yields were taken from Schumacher and Coile (1960).

The upper bound yields for plantation stands are based on data from Smalley and Bailey (1973). Softwood yields in oak-pine stands were derived from data reported by Knight (1978).

Base yield data for each owner is computed from the distribution of acres by age and stand type, a target softwood growing stock volume, and the upper bound yields for each stand type. The softwood growing stock volumes reported by the U. S. Forest Service (USDA, Forest Service, 1982) were used as target volumes. The computation of the base yield involves shifting the upper bound yield tables for each stand type (downward) until the resulting volume is calibrated (within a tolerance) to the target volume.

Resource surveys of the states in the two regions provided the basic information on the distribution of acres by age class, stand type and owner group. Data from each state for each owner was updated or backdated to Jan. 1, 1977 and summed to the regional level.

Figure 2.2 illustrates base yield tables computed as described above compared to plots of the average volume per acre (by age class) reported in survey data. The method used to determine starting values for the yield tables satisfies the objectives of: 1) calibrating initial inventories to a desired total growing stock volume and 2) retaining the shape of the upper bound ("normal") yields. While meeting these criteria, however, the resulting yield tables do not differ to any substantial degree from empirical yield levels. As indicated by Figure 2.2, an adjustment process is necessitated if for no other reason than to correct for irregularities in empirical volumes per acre. Figures 2.3 and 2.4 illustrate the

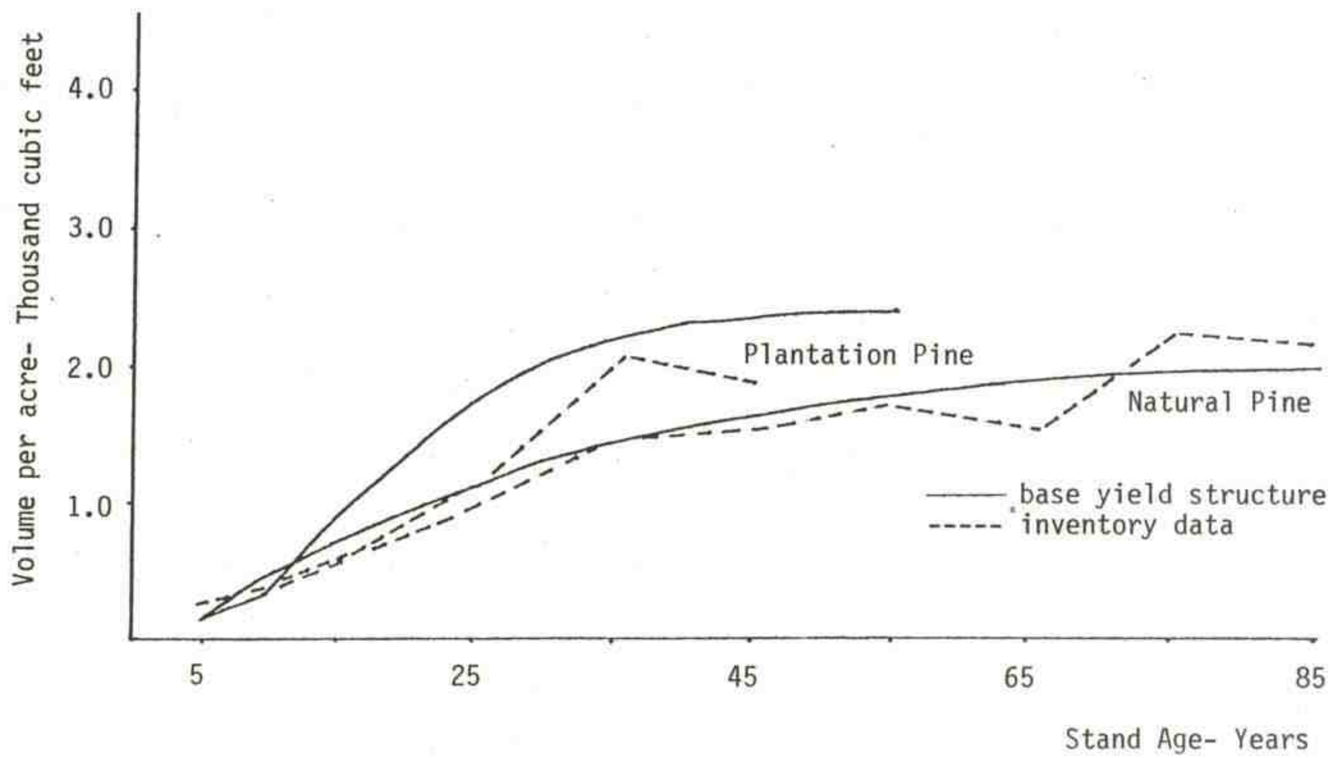

Figure 2.2 Base yield structure and average volume per acre computed from Forest Service Data, Southeast Forest Industry

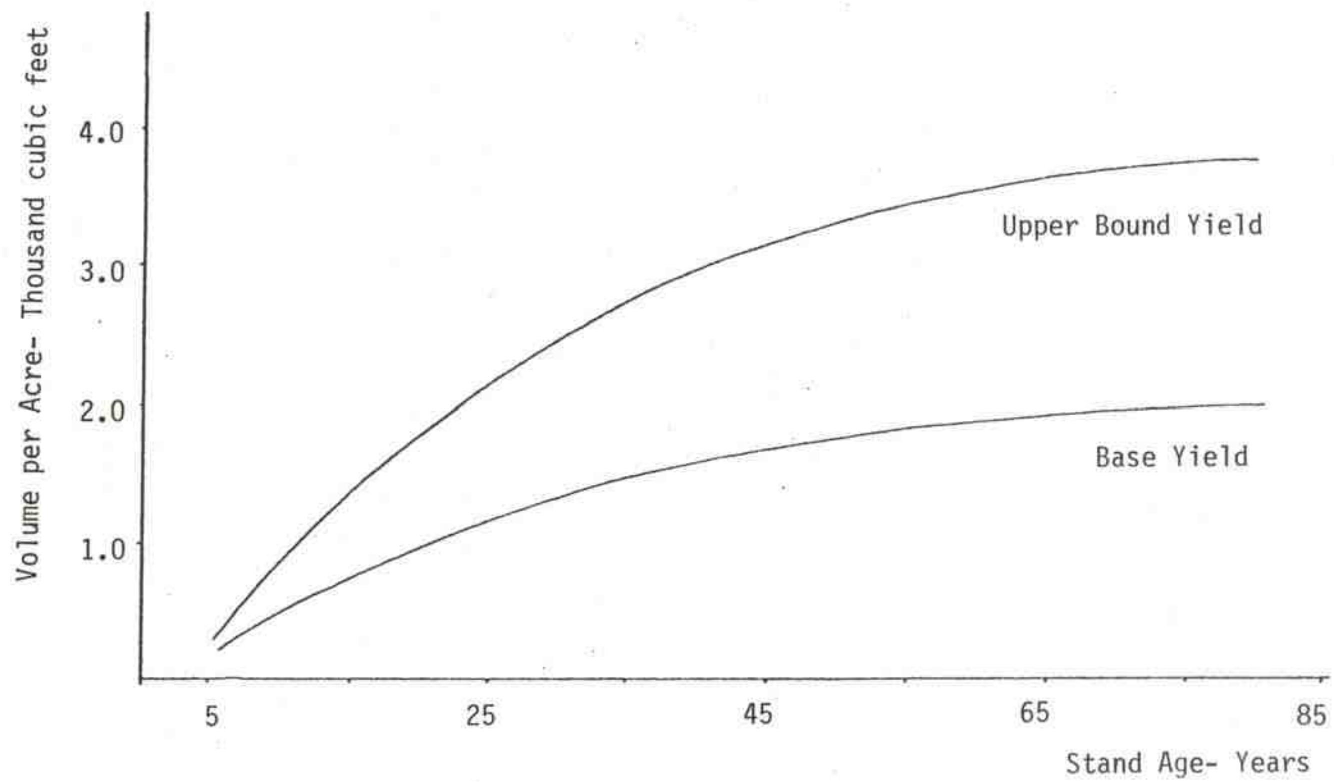

Figure 2.3 **Base and upper bound yield structure for pine stands of natural origin,** Southeast Forest Industry

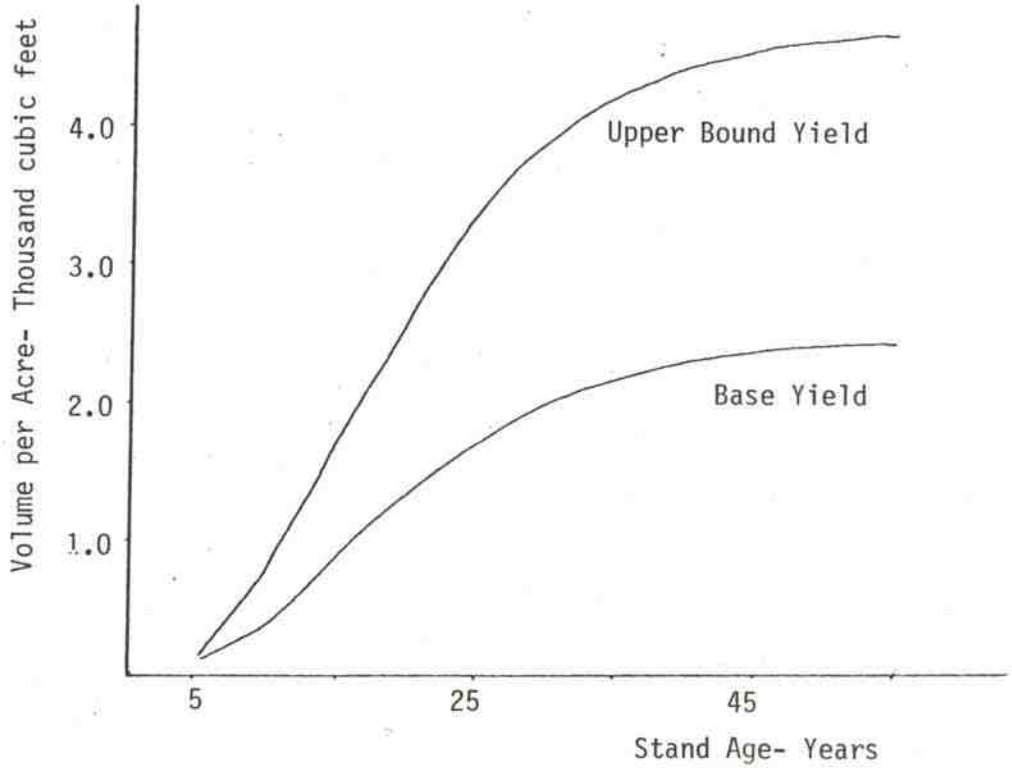

Figure 2.4 **Base and upper bound yield structure for pine stands of plantation origin,** Southeast Forest Industry

relationship between base and upper bound yields for plantation and natural origin pine stand types.

Management practices other than the establishment of plantations are not explicitly treated in terms of yield changes in SPATS. Thinning is modeled to reflect its contribution to total removals from growing stock, but its effect on yields is masked by the aggregation of stands. The volume available and actually taken in thinnings is derived from the yield tables constructed in each period (see below), but the acres thinned are not distinguished from those not thinned. Specifically, they do not shift to different yield tables with adjusted volumes per acre.

While thinning volumes are important, the proportion of eligible stands actually thinned is relatively small. Knight and Sheffield (1980) estimate that approximately one third of the pine plantation thinning opportunities in the Southeast region in the 1970's were undertaken. Given these thinning rates the impact on the average volume per acre (in all stands) in age classes just past thinning will be slight.

In addition, distribution of final harvests across all eligible age classes does not require, under most circumstances, that an entire age class be harvested. Harvesting in the youngest age class eligible for final harvest does not necessarily occur on acres thinned in the previous period. Only some of the acres in this age class are assumed to have been thinned, and not all are harvested.

Except in the case of extremely high thinning rates (i.e. approaching 100 percent of opportunities taken) the management regime in SPATS does not impose unreasonable expectations.

Approach to Normality

The base yield tables which provide the initial inventory values for each owner are the average volumes per acre which resulted from historical management practices, and do not necessarily represent the volumes likely to be realized in each age class in the future. In order to account for improvements in stocking levels, changes in management practices and the natural development of existing stands, a revised yield table is computed for each owner in each period of the projection. This adjustment is motivated in part by the observation that stands will tend to fully utilize available growing conditions, i.e. approach, over time, "normal" or fully stocked yields for a given site.

The heavy lines in Figure 2.5 illustrate the segmented structure of the yield table constructed in each period (period three in this figure). For each stand type, acres regenerated during the simulation are assigned volumes on the upper bound yield table (segment I). It is important to keep in mind that this represents "normal" yields averaged across site classes and stocking levels. While in a sense this implies the achievement of region-wide normal

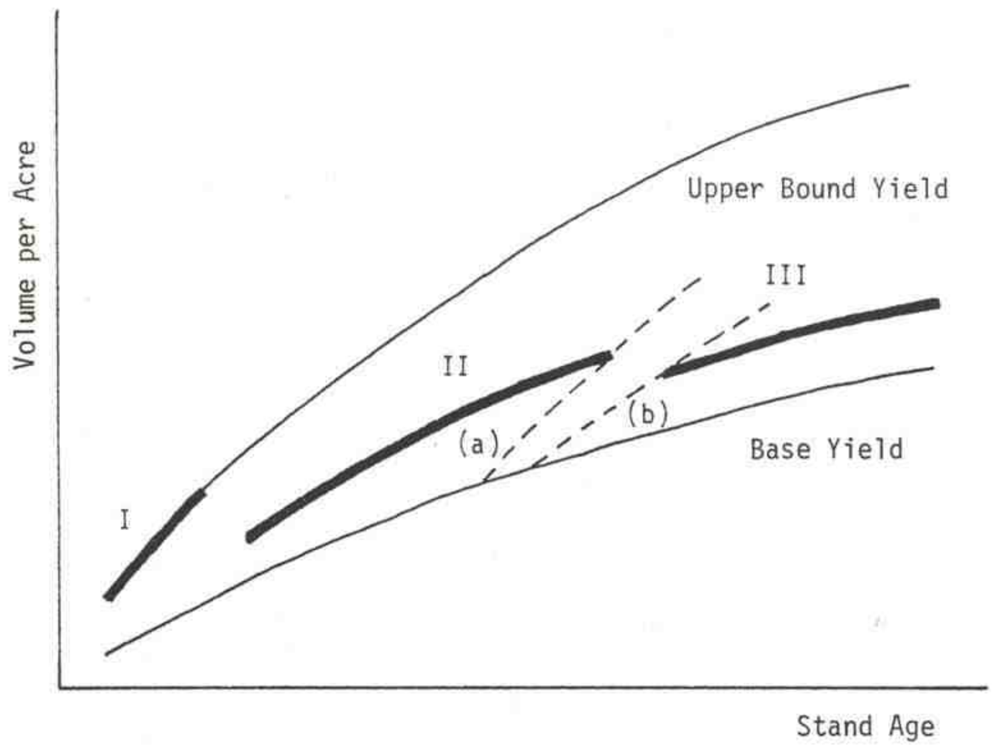

Figure 2.5 Illustration of the construction of periodic yield tables and the approach to normality

yields, the upper bound can be adjusted to reflect a more realistic yield level. This sort of adjustment is incorporated in the yield data used in these projections.

Segment II indicates the yields of stands which were up to 45 years old at the start of the projection. The yields of these stands have shifted upward from the base at a rate determined by the approach to normality data entered for each period for each owner.

Stands which were over 45 years old at the beginning of the simulation are also assumed to be moving toward normal yields, but at a slower rate than the younger stands. Segment III indicates the yields of acres in these age classes for a given stand type. The parameter which adjusts the yield table shifts for older stands is also specified as data.

Throughout the projection, then, in each period the yield table for each stand type is shifting vertically, with regenerated stands given yields on the bound towards which initial stand yields are shifting. The result is that the volume per acre assigned to each initial stand in the model traces out a path between the base and upper bound yields. Dashed line (a) in Figure 2.5 shows this "approach to normality" for one age class in the younger group; line (b) shows the development of an age class in the older group.

Just as there is little directly applicable yield data, there is little empirical information on the rate of this approach to normality in southern stands. This necessitates the use of reasonable assumptions (which can be subjected to sensitivity analysis) pending better information. In the projections reported here the yields of younger stands are shifted upward by an amount which is approximately ten percent of the base yield, in the first period. The increase in yields is the same in subsequent periods, resulting in a decreasing rate of increase as the simulation proceeds. Older stands are given slightly less than half the increase given to younger stands.

Projection and Validation

The SPATS model was designed to portray private softwood inventories in the South, and to simulate their development under alternative levels of harvest and varying intensities of forest management. Although one intended use of SPATS is in place of the TRAS model in projections of timber and forest product markets (see Chapter 3), the substantial differences between the models preclude validation by way of commparison. The SPATS results can be supported however, by drawing on other assessments of the likely development of southern inventories (e.g. those of Boyce and Knight, 1979) and by systematically altering parameters to produce TRAS-like results. In addition, the results from the first simulation period in the SPATS model (1977-1981) can be compared with published sources of information on southern forests.

The objective here is to produce a "baseline" inventory projection with data comparable to that used by the U.S. Forest Service (in TRAS) in their long-term Timber Analysis (USDA, Forest Service, 1982). Data for the two models is similar in all respects but the characterization of the inventory and the explicit inclusion in SPATS of information on management practices. As described above, the initial inventories for projection with the SPATS model are calibrated to the growing stock volume used in the TRAS projections. These are the volumes reported by the Forest Service (USDA, Forest Service, 1982), but it is important to keep in mind that these volumes are themselves derived from estimates produced by the TRAS model.(2) The SPATS projection uses forest survey data on the distribution of area by stand type and age class, and published (TRAS-based) information for estimates of total (initial) growing stock volume. Figure 2.2 demonstrates that this calibration process does not significantly alter the level of the initial yield tables.

The annual removals from growing stock, by owner group, used in the SPATS projections described here are also the same as those used in the TRAS projection reported in the Forest Service Analysis. These are fixed harvest volumes--that is, they are not, in these SPATS projections, responsive to changes in inventory levels or

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(2) Individual state forest surveys are adjusted to the common reporting date (Jan. 1, 1977, in this case) with the TRAS model.

prices. SPATS projections in conjunction with the Timber Assessment Market Model (Adams and Haynes, 1980) in which changes in growing stock inventories and prices influence timber harvests are reported in Chapter 3.

In spite of the common starting point for the projections of the two models, estimates of growing stock volumes differ substantially for all owners by the year 1990. Table 2.1 shows the projections of softwood growing stock for both models to the year 2000. Assuming that current rates of plantation establishment are continued, by the year 2000 growing stock inventories on nonindustrial private forests will be roughly one half the level previously projected. Softwood inventories on forest industry lands are projected to be higher than those estimated by TRAS, reflecting the results of more intensive management.

These results, while dramatic, are consistent with expectations of southern softwood production which take into account the regeneration practices of private owners. Boyce and Knight (1979), in fact, anticipated a similar outcome in concluding that by 1995 "... significant declines in growing stock inventory can be expected." The timber production goals of the Third Forest report (SFRAC, 1970) have clearly not been met, and the SPATS projection in Table 2.1 illustrates the consequence.

The considerable difference in the projections of the two inventory models--even with a common starting point--is largely the

Table 2.1 Comparison of projections of softwood growing stock inventory to the year 2000 using TRAS and SPATS, by region and owner group.

(million cubic feet)

Year	Forest Industry TRAS	Forest Industry SPATS[1]	Other Private TRAS	Other Private SPATS[1]
		Southeast Region		
1977	8803.7	8805.5	33701.7	33625.3
1980	9012.1	10039.8	35754.4	33193.4
1990	9830.9	13381.7	41562.4	29988.7
2000	10213.0	17777.1	44227.1	23364.5
		Southcentral Region		
1977	14559.4	14530.4	28116.6	28202.9
1980	14730.5	13761.2	29245.2	26433.2
1990	15854.1	14509.8	32893.9	20155.1
2000	15718.3	19546.2	34525.2	17155.3

[1]Projections are for 1977, 1982, 1993, and 2002

Management assumptions: forest industry plants the area harvested; cost-share payments are at recent levels (approximately $6.6 million to each region) for other private.

result of differences in estimates of annual growth. Growth estimates for both models are shown in Table 2.2. As explained earlier, the rates of growth in the TRAS model--for both industry and nonindustrial private owners--do not account for the changes which have been taking place in the forests of both owners. An artificial stability is imposed on the southern forests.

Growth projections to 2010 for both models are shown in Figure 2.6 and 2.7. The TRAS projections show growth on nonindustrial private forests remaining at high levels for the entire period. The trajectory labeled SPATS (1) shows growth over time given a continuation of current levels of management (regeneration to pine). SPATS (2) is a growth projection predicated on intensified pine regeneration on nonindustrial forests begun in 1982. This effort involves planting all or nearly all the stands harvested in each period. In both of these projections nonindustrial private inventories in both regions are unable to supply the quantity of growing stock removals requested after 1995. That is, even if intensive regeneration efforts are begun immediately, they cannot alter the inability of nonindustrial forests to meet the timber productions levels--demand--anticipated in the Forest Service's Analysis. The nonindustrial forests available for harvest in the South over the next 25 years are those already established--and these forests are the consequence of management practices which have not promoted softwood growth.

An additional comparison of the growth projections of the two

Table 2.2 Comparison of initial estimates of net annual growth using TRAS and SPATS, by either region and owner group

(million cubic feet)

Region	TRAS[1]	SPATS[2]	% difference
Southeast			
Industry	606.49	784.30	+29.3
Nonindustrial	2111.21	1572.91	-25.5
Southcentral			
Industry	894.15	728.29	-18.5
Nonindustrial	1967.18	1229.07	-37.5

[1] Growth for 1976

[2] Annual average for the first simulation period (1977-1981)

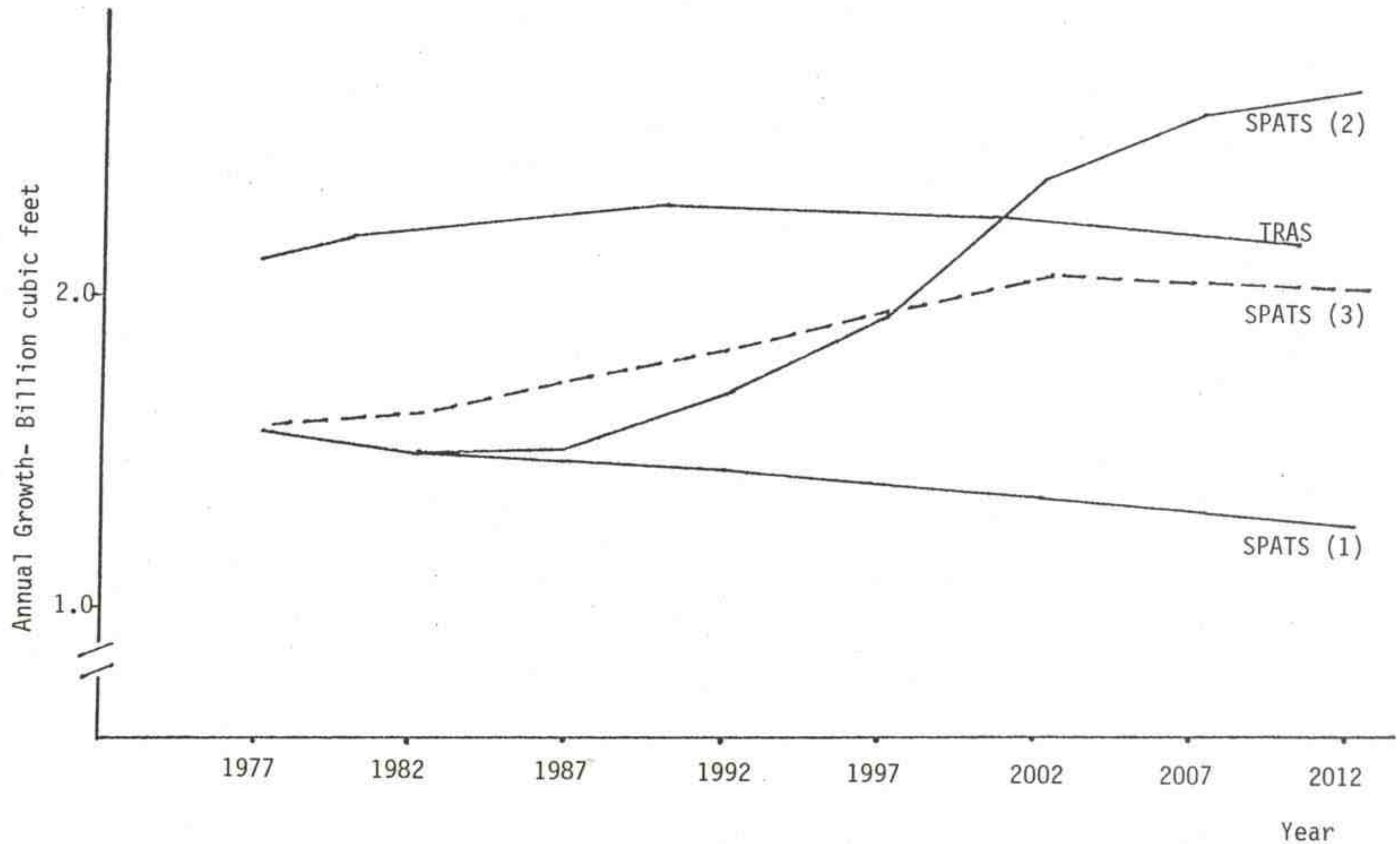

Figure 2.6 Comparison of projections of net annual growth using TRAS and the SPATS model under alternative assumptions, Southeast Nonindustrial Private

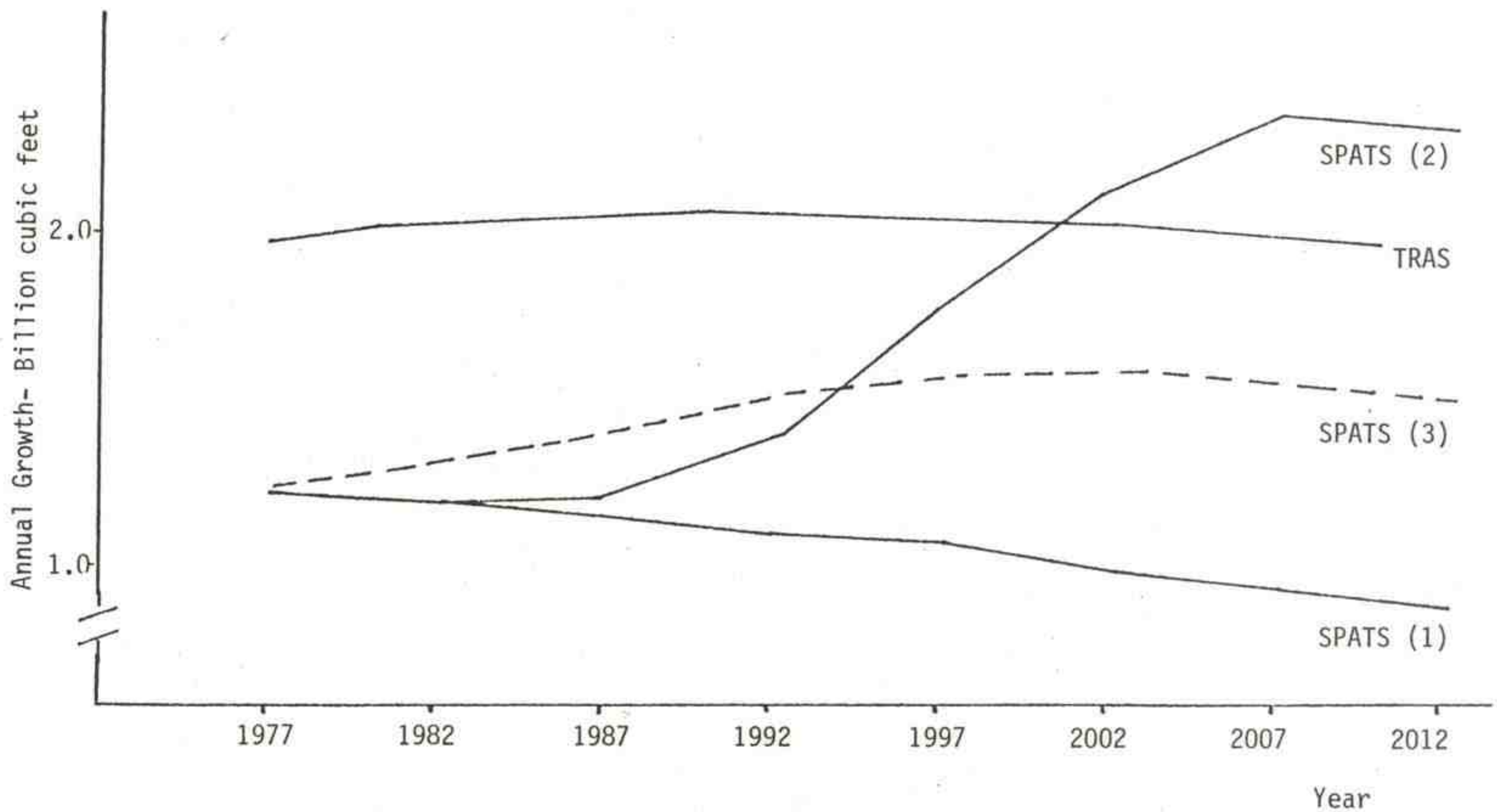

Figure 2.7 Comparison of projection of net annual growth using TRAS and the SPATS Model under alternative assumtions, Southcentral Nonindustrial Private

models is also possible. The lines labeled SPATS (3) in Figures 2.6 and 1.7 show growth projections for nonindustrial owners which result when the natural regeneration transition matrix is modified to regenerate all nonplanted stands to the source stand type. This is, in fact, what the TRAS model assumes. As one would expect, annual growth increases (from the initial SPATS estimate) rather than decreasing. In 15 years the divergence between the base growth trajectory (SPATS (1)) and this modified one is substantial. Growth estimates are 20-25 percent lower in the base run (1). The implication here is clear. If it were possible to begin projections of both models in 1965--the point at which rates of pine regeneration declined sharply (Boyce and Knight, 1979)--by 1977 growth estimates of the two models could differ by as much as is indicated in Table 2.2, due primarily to the TRAS assumption of regeneration to the invariant composite stand distribution.

Further information for validation of results from SPATS is provided by an examination of estimates of the area harvested and planted by each owner. Table 2.3 presents the SPATS estimates of area harvested along with estimates from other sources. Estimates for the Southcentral region differ by ten percent or less from the area reported by the Forest Industries Council (FIC, 1980). In the Southeast region multiple estimates are available, and the projection from SPATS is within reasonable bounds.

Table 2.3 Estimates of acres harvested in the South, by region and owner group

(thousand acres)

REGION/OWNER	SPATS[1]	FIC[2]	HK[3]	SRR[4]
Southcentral				
Industry	517.00	496.7		
Nonindustrial	933.10	1034.2		
Southeast				
Industry	312.84	459.0	435.0	388.8
Nonindustrial	857.51	1179.0	800.0	867.8

1 Annual average for the first period (1977-1981)

2 Forest Industries Council (1980) Forest Productivity Report

3 H. Knight, personal communication

4 State resource reports, summed to the region

Estimates of the area planted in the first period are also reasonable when compared to the most recent reported accomplishments. In Table 2.4 the annual rate of planting for the first period in SPATS is compared with published data for each owner. In this SPATS projection forest industry is assumed to plant all stands harvested (consistent with recent practice--see FIC, 1980). Nonindustrial private planting is estimated using the reforestation equations. The independent variables used to predict planting by these owners are an index of planting costs and the level of public cost-share expenditures. In the base run reported in Table 2.4 (also Table 2.1) and SPATS (1) in Figures 2.6 and 2.7) these payments remain at current levels, approximately 6.6 million dollars a year in each region. In the projection SPATS (2), payments are increased in both regions by a factor of five. For more detailed policy simulations using the SPATS model see Chapter 3.

A final measure of the SPATS projection is provided by Table 2.5. Under a continuation of current management practices, the transition of forest land from pine types to pine-hardwood and hardwood types should continue at a rate comparable to that of the recent past. Table 2.5 presents data on the area in pine types (plantation and natural pine stands) at the beginning of the projection (Jan. 1, 1977) and at the beginning of the second period. The total change (loss) in area in pine types for the South as a whole--2.56 million acres--is comparable to the loss over a five

Table 2.4 Estimates of acres planted in the South, by region and owner group

(thousand acres)

REGION/OWNER	SPATS[1]	ACTUAL[2] 1980	ACTUAL[2] 1981
Southeast			
Industry	312.84	447.88	372.00
Nonindustrial	196.32	192.66	206.85
Southcentral			
Industry	516.98	522.58	319.52
Nonindustrial	171.21	199.24	180.57

1 Average annual rate for the first period (1977-1981). Area planted equals the area harvested by industry; other private planting estimated using management equations.

2 Source: USDA, Forest Service. Forest and Shelterbelt Planting Report

Table 2.5 Area in pine types in the South and estimates of periodic change, by region and owner group

(thousand acres)

	SPATS			
Region	1977	1982	Change	Previous[1]
Southeast				
Industry	8708.85	9207.50	+ 498.65	
Nonindustrial	23506.69	21799.53	-1707.16	
TOTAL	32215.54	31007.03	-1208.51	
Southcentral				
Industry	9313.16	9734.72	+ 421.56	
Nonindustrial	16944.97	15163.56	-1781.41	
TOTAL	26258.13	24898.28	-1359.85	
SOUTH	58473.67	55905.31	-2568.36	-3241

[1] Estimate of area loss in pine types over a five-year period leading up to 1977 using survey data from 1970 and 1977.

year period just prior to to the start of the projection, 3.24 million acres. This table suggests that SPATS may, in fact, underestimate the shift out of pine types in the South.

Conclusions

The SPATS inventory projection model offers improvements over current projections of southern softwood inventories because it provides a more dynamic characterization of the forests of the region. Stand age and stand composition (stand type) are modeled explicitly and direct account is taken of the management practices of owners.

This model is, however, only a first effort at improving inventory projections in the South. Refinements in all areas of the model are required to provide greater detail and precision in projections of the development of southern softwood inventories over time. Information on site classes and stocking levels is desirable, as is a more detailed treatment of alternative management regimes. Improved estimates of model parameters such as regeneration transition probabilities and changes in yields over time are also needed. To some exten the structure of SPATS is the result of constraints imposed by the uneveness of available data. Greater scope and depth of information on the age class structure of southern forests will improve this and future models like it.

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PUBLIC POLICY AND LONG-TERM TIMBER SUPPLY IN THE SOUTH

Abstract

Forest Service projections of the long-term supply and demand for forest products in the U.S. indicate that increasing importance will be placed on the supply behavior of private forest owners (see USDA, Forest Service, 1982). Southern forests are expected, in these projections, to expand their share of national softwood timber supply, with the bulk of the increase coming from nonindustrial private forests. There is, however, considerable uncertainty surrounding the willingness and ability of these owners to meet the anticipated demand.

The provision of direct payments through sharing the cost of reforestation is a favored policy instrument of those who advocate a role for the government in promoting timber production on nonindustrial private forests. Evaluations of this policy have been, to date, limited to consideration of the performance of particular programs (in establishing pine plantations) and have not addressed the question of the overall efficacy of the policy. The present study considers that question.

Simulation models are used to describe the short and long-term components of private timber supply behavior. An inventory model with policy-sensitive management equations is linked to a model of

markets with short-term stumpage supply relations. This policy analysis system provides an opportunity to evaluate the impact of reforestation cost-share payments programs on future timber supplies and prices.

Projections with these models indicate that, given current levels of management (pine regeneration) by nonindustrial owners, softwood stumpage prices will rise faster than previously expected to the year 2000, and that forest industry will provide a greater share of the southern softwood timber harvest. Substantial increases in cost-share payments can reverse this decline in nonindustrial inventory and harvest, but will have little effect before the year 2010. In the long-term the South's role in domestic softwood timber markets can be maintained only through increases in management on nonindustrial private forests. Cost-share payments programs are one means of accomplishing this, but only at funding levels considerably higher than those of the recent past.

Introduction

Previous projections of long-term supply and demand for forest products in the U.S. have indicated that the supply behavior of private forest owners will become increasingly important (USDA, Forest Service, 1982). These projections suggest that future domestic supplies of softwood fiber will depend in large part on southern forests and the nonindustrial private owners who control the majority of that region's timber inventory and commercial forest land base. There is mounting evidence, however, indicating that nonindustrial private owners are unwilling to make the softwood regeneration investments required in order to meet these expectations (see Fecso et al., 1982). Projections of southern softwood inventories which take these management practices into account predict considerably reduced inventories and harvest from nonindustrial private forests (see Chapter 2).

In the early 1970's the Federal and state governments began to take a more active role in trying to bring about higher levels of timber management on nonindustrial private forests. One form this increased policy activity took was a renewed emphasis on programs which share the cost of reforestation and other timber management practices. The largest of these cost-share programs is the federally-funded Forestry Incentives Program (FIP) (PL 93-86). Nearly

90 million dollars has been spent through this program since its inception in 1973, much of this on reforestation in the South.

Programs involving public expenditures are inevitably the subject of debate and criticism and forestry programs are no exception. This study does not hope to resolve the philosophical differences between supporters and opponents of cost-share programs; rather it is intended to provide a better understanding of the likely impact of these expenditures. In order to evaluate the role policy can play in assuring future timber supplies from private forests it is necessary to construct a framework for analysis which links policy instruments, timber inventories and forest products markets. The policy analysis system devleoped for this purpose consists of: 1) a model of private reforestation in which cost-share expenditures are an explicit component; 2) a model of southern softwood inventories which reflects both changes in management practices and natural regeneration tendencies in the absence of management; and 3) a model of softwood stumpage and product markets. With this system the cumulative and aggregate effect of alernative levels of cost-share expenditures can be examined.

Government Policy and Nonindustrial Forests

Congress created the Forestry Incentives Program (FIP) in 1973 out of concern over the quality of management on the nation's private, nonindustrial forests. Since these owners control the majority of the commercial forest land in the U.S. it is clear that their actions will significantly affect future timber supplies. The FIP authorizes direct payments of up to 75 percent of the cost of forest management practices for the purpose of assuring "plentiful supplies" at "reasonable prices" (PL 93-86, sec.4). Over the life of this program the practice of tree planting in the South has received the majority of available funds.

In addition to the federally-funded FIP some states have also enacted programs similar in practice and objectives. Virginia's Reforestation of Timberlands program was enacted in 1972. Programs were also started more recently in North Carolina and Mississippi, and have been considered in other states as well (Meeks, 1982). While these efforts are not the sole policy instrument directed at nonindustrial forests, direct cost-share payments are a major policy tool intended to stimulate greater fiber production by these owners.

Previous studies of cost-share expenditures for forestry practices have tended to concentrate on program rather than policy evaluation. Program accomplishments in the FIP have been examined by Risbrudt and Ellefson (1983), Mills and Cain (1979) and Mills (1976). James and Schallau (1961) reviewed forestry practice accomplishments under the Agricultural Conservation Program (ACP). Kurtz _et al_. (1980) and Alig _et al_. (1980) investigated retention rates for plantation established under the ACP and the Conservation Reserve Soil Bank (CRP) programs.

Landowner response to actual or proposed programs has been been considered by (among others) Hickman and Gehlhausen (1981), Mullaney and Robinson (1980), Taylor and Wilkersen (1977), Beazley and Holland (1973) and Webster and Stoltenberg (1959). Fecso et al. (1982) in their survey of harvested southern pinelands raised the question of previous or prospective participation in incentives programs. However, none of these studies was designed to evaluate the extent to which the policy of providing cost-share payments can achieve the objective of affecting future timber supplies and prices.

Foster (1982) estimated the public benefits from increased stumpage supply in the South, concluding that the rate of return (to the public) from pine regeneration is likely to be quite high. This study, however, only partially addresses the question of stumpage market interactions, and does not consider how incentive programs influence reforestation decisions. Flick and Horton (1981) conducted a similar benefit-cost analysis of Virginia's Reforestation of Timberlands programs, also concluding that program benefits exceed costs.

Adams and Haynes (1980) and Adams et al. (1982) report a projection of the Timber Assessment Market Model (TAMM) under the assumption of intensified forest management by private owners.

While most of the management opportunities identified were in the South, and most involved planting trees, that analysis is not useful for answering the question of interest here for two reasons. First, the effect of government policy on reforestation decisions is not addressed. Second, while investment opportunities are determined by economically rational behavior (and perfect price expectations), the rate at which these investments are undertaken is arbitrarily determined.

This study does not consider the question of program design or the likely returns (to landowners or the public) from implementing particular practices, but estimates aggregate policy impacts in a model of total private reforestation. The cumulative effect of this policy intervention is evaluated using a modified version of TAMM (Adams and Haynes, 1980) to determine the supply and price effects of cost-share expenditures in stumpage and product markets.

A Model of Reforestation Behavior

Whether as stand re-establishment following harvest, conversion of low-value stands, or afforestation of idle land, planting southern pine is involved in nearly all the economic opportunities for increasing timber supplies in the South (USDA, Forest Service, 1982). To meet the objectives of the present study, a model of reforestation behavior must explain the total number of acres planted by nonindustrial private forest owners. An econometric analysis of time series data is used to develop the desired behavioral relationship.

When considering a model of plantation establishment it is tempting to look to the literature on investment analysis for a theoretical framework. DeSteiguer (1982) develops a model of private capital expenditures on reforestation which is patterned after a model of investments in financial assets. Tikkanen (1982, 1983) uses both investment theory and utility maximization to explain forest management by private owners in Finland. It is difficult, however, to apply the assumptions on which most investment models are built to the diverse group which owns the nonindustrial forests of the South. While planting trees does have many of the characteristics of an investment, a number of studies have shown that the management practices of these owners are motivated by broader concerns than return on investment in fiber production (see Fecso et al., 1982; Royer et al., nd; Kurtz and Bradway, 1981; Mullaney and Robinson, 1980).

The approach taken here is similar to that used by Tikkanen (1983), but adapts a theoretical framework found in the agricultural literature. Crop supply models have been quite commonly formulated in terms of producer response to a variety of influences, including market information and government policy intervention (Houck et al., 1976; Walker and Penn, 1975; Houck and Ryan, 1971, French and Mathews, 1971). A variant of these acreage supply models is advanced for the case of forest landowners who are faced with the opportunity to establish a stand of trees. The decision to actively reforest can be explained, it is argued, by economic, policy and (perhaps) other variables. The general model is

$$A = f(G,M,Z) \qquad (1)$$

where the dependent variable, A, is the total number of acres planted, G represents government policy, M represents market influences (such as prices and costs), and Z represents all other determinants of management response and random effects. Among the other determinants of response are nonquantifiable factors, such as a land ethic or the desire to leave a productive forest to one's heirs. Factors which can, in theory, be quantified but for which there is little or no data would also be included in this category.

Explanations of nonindustrial owners' decisions to, or (more accurately) not to, reforest their harvested and unproductive land to pine are quite numerous. Sedjo and Ostermeier (1978) summarize the problems facing these owners when they consider forest management expenditures: multiple management goals, a lack of technical information, inhibitive taxes, low profitability, illiquidity and long payback periods, diseconomies due to small scale operations, and environmental constraints. Dutrow and Kaiser (1982) in an analysis of forestry investment opportunities in the Southeast suggest that the need for large initial committments of capital, long payback periods, and the lack of technical information are important constraints on nonindustrial timber management.

A survey of southern management practices and reforestation decisions (Fecso et al., 1982) provides useful insights for specification of the reforestation model. Growing timber or other wood products for sale was given as an important reason for owning half the acres included in that survey. However, the feeling that the timber had matured was more important in the decision to harvest timber than was the offer of a "good" price. The availability of cost-sharing funds was important on over half of the clear-cut acres which were reforested by owners surveyed. The anticipation of future profits was important on a slightly higher percentage of the acres in the survey, but the feeling that the land "should be kept in timber production" dominated all reasons given for actively reforesting harvested lands.

The decision not to reforest harvested land was, in this survey, a consequence of other uses for harvest revenues, the feeling that reforestation costs were too high, and the notion that the site would naturally regenerate to pine. Increased availability of cost-sharing funds, along with reduced tax liabilities were cited as factors which would be likely to stimulate reforestation after harvesting.

Some of the factors cited as important in the decision to reforest in the Fecso et al. (1982) survey must be relegated to the category of "other influences" for econometric purposes because they are either nonquantifiable or the data needed in order to include them is not available. The feeling that land should be kept in timber production, and the extent of landowner knowledge of silviculture present problems in quantification. Information on actual or anticipated tax liabilities (property, inheritance and income taxes) is generally not available in a form useful for inclusion as an explanatory variable in this sort of model. Nevertheless, costs, prices and government policy can be incorporated in a model of reforestation behavior.

In many agricultural response models market influences are specified, in part, through price or price expectation variables . In the case of forestry planting decisions, the appropriate prices are those to be realized 25 or more years in the future--unlike the annual or short-term perennial decisions of agricultural producers. It seems reasonable to hypothesize, however, that forest landowners form expectations of the level or direction of future prices based on observations of the past. Using this premise, a number of variables were constructed using stumpage prices. The expectational processes investigated ranged from simple adjustments using prices from the recent past, to more complex formulations using recent price levels and rates of change computed over a longer historical period.

The pertinent costs for this model are those incurred in establishing a stand of trees. These include any necessary site preparation costs, seedling costs, and the cost of planting (either by hand or machine). Actual costs for annual reforestation accomplishments are not available, but it is possible to construct an index of total planting costs based on surveys begun in 1952 (see Moak et al., 1979; Yoho et al., 1969; Worrell, 1953). The index constructed is an aggregate, composite cost index, developed by weighting the components of total cost described above. The weights vary through time to reflect changes in the extent of site preparation necessary (increasing with time), and the general shift, over time, from hand to machine planting. The resulting index increases more rapidly than the all commodity Producer Price Index (PPI) over the sample period (1950-1979), but the rate of increase slows after 1976. This pattern is consistent with findings of Moak et al. (1979).

Over the past thirty years, subsidies for forest management practices have been provided through a variety of programs. The Agricultural Conservation Program (ACP) was begun in 1936 and continues today. The Conservation Reserve Soil Bank Program (CRP) lasted less than ten years (1956-1964), but had a significant impact on pine regeneration in the South (see Figure 2.1). Both the ACP and CRP programs had soil and water conservation as primary goals;

the planting efforts of these programs have been concentrated on former agricultural land. The more recent FIP and state programs emphasize timber production and assist in planting (primarily) cut-over and poorly stocked forest land. With the exception of facing different plantation establishment costs, however these programs may be essentially comparable in terms of their effect on nonindustrial reforestation behavior. That is, in the model proposed, the policy of providing cost-share payments is treated as being more important than the particular program through which funds are (have been) spent.

Both direct and indirect effects are hypothesized for these expenditures. This treatment of the influence of government policy on reforestation decisions is similar to explanations of the formation of expectations. The direct effects of cost-share payments are measured in terms of the plantations established by the direct public and induced private expenditures. In any year the number of acres planted as a result of this direct effect bears a relationship to the level of expenditures which depends on the cost-share rate (the proportion of total costs provided by the government).

Secondary or indirect effects are the influence payments have on those who do not participate in a program (in a given year), but who are in a position to consider planting trees. These effects may be positive or negative. Negative effects occur if, for example, an owner's willingness to bear the total cost of reforestation is diminished by observing the payments received by others. Cost-share expenditures may influence expectations of future prices as well. Observation of new (cost-shared) plantations may result in expectations of future prices being revised downward.

Also included in the category of negative effects should be the argument that cost-share expenditures merely represent a "windfall" to those who would have planted trees anyway. As a result, it is suggested, forest landowners delay planting until cost-share funds are available. Many critics of these programs emphasize these "substitution" and "queueing" effects. Their premise is that the net change in investments is small and (or) that the timing of planting is controlled by the funds made available. DeSteiguer (1982) attempts to investigate this question, although his results are inconclusive.

Positive secondary effects could come about as a result of: 1) cost-shared reforestation accomplishments advertising programs to those who might otherwise not have known about them; or 2) cost-sharing programs instilling confidence in the merits of forest management investments (as a result of the government's participation) in those who remain willing to bear all costs. McKillop (1975) suggests the possibility of positive influences of this sort.

Positive and negative secondary effects are by no means mutually exclusive. Secondary effects may reinforce or offset the direct effects of payments. What is of interest here is the over-all effect of cost-share payments on total nonindustrial private planting.

As indicated above, the model to be estimated from equation (1) includes price expectations, planting costs and the level of cost-share expenditures as explanatory variables. The effort to incorporate price information in the reforestation model was not successful, however. None of the specifications of the price variable added explanatory power to the model and often had unexpected signs as well as low significance. Tests for multicollinearity indicated that this was not likely to be the cause of the poor performance of the price variables in this version of the model.

This result with prices may be due, in part, to the long period over which any price expectations must be formed. Expectations of future prices would, as a consequence, be effectively independent of current or past prices. It may also be true that stumpage prices are, in general, of little importance in reforestation decisions on nonindustrial lands in the South. This finding is consistent with other observations of southern forestry (see, for example, Ernest, 1982) and with DeSteigeur's (1982) results. Morzuch et al. (1980) also found that, in the case of wheat acreage supply response, policy intervention effectively destroyed the role of price in producers' decisions. Since, over the past thirty years, government has been constantly involved in sharing the cost of private planting, it is not surprising that stumpage prices are not a significant component of the reforestation decision.

A revised model was estimated and includes the cost of plantation establishment and the level of cost-share expenditures. To capture the secondary as well as the direct effects of policy, a distributed lag in government payments was introduced. The specification is

$$A_t = b_0 + b_1 COST_t + \sum_{i=0}^{n} \lambda_i GOVP_{t-i} + u_t \qquad (2)$$

where COST is the index of per acre planting costs, GOVP is cost-share expenditures and u is a random error term. The sign of the coefficient b_1 in equation (2) is presumed *a priori* to be negative. Higher costs should result in lower levels of planting. The appropriate length (n) of the distributed lag in GOVP is unknown, but the sum of the lag coefficients $\sum_{i=0}^{n} \lambda_i$ should be positive. The structure of the lag coefficients is also not known *a priori*, but current values of cost-share expenditures should be weighted more heavily than earlier ones. The direct effects of expenditures should be greater than the indirect effects. To the extent that positive secondary effects occur, lag weights may rise (from the current period) before declining as these effects weaken and/or negative effects occur.

The econometric literature provides many examples of distributed lag models, and a number of different specifications were examined, including polynomial functions of various degrees and lag lengths. Results from more complex models were compared with results from direct estimation of the lag coefficients. While the latter method risks introducing multicollinearity, it has the advantage of not imposing any a priori constraint on the lag structure.

The model in equation (2) was estimated for each of the two southern regions (Southeast and Southcentral) using data from 1950-1979. The dependent variable was taken from published reports of forest management accomplishments (USDA, Forest Service, annual series). Reforestation cost-share payments were collected from published data for all programs (federal and state) and deflated by cost indices appropriate for each program. Expenditures in programs which concentrated their efforts on planting abandoned cropland (ACP and CRP) were deflated by an index of open field planting costs. Expenditures in the FIP and state programs were deflated by an index which reflects the higher cost of planting land requiring site preparation. The derivation of these indices is comparable to that used in constructing the cost index variable, discussed earlier.

Estimation results for the models are shown in Table 3.1. Explanatory power is high, coefficients have expected signs and (with the exception of COST in the Southeast region) standard errors are very small relative to coefficients. Specification of the model with a distributed lag suggests the possibility of introducing

Table 3.1 Coefficient estimates for the nonindustrial private reforestation equations

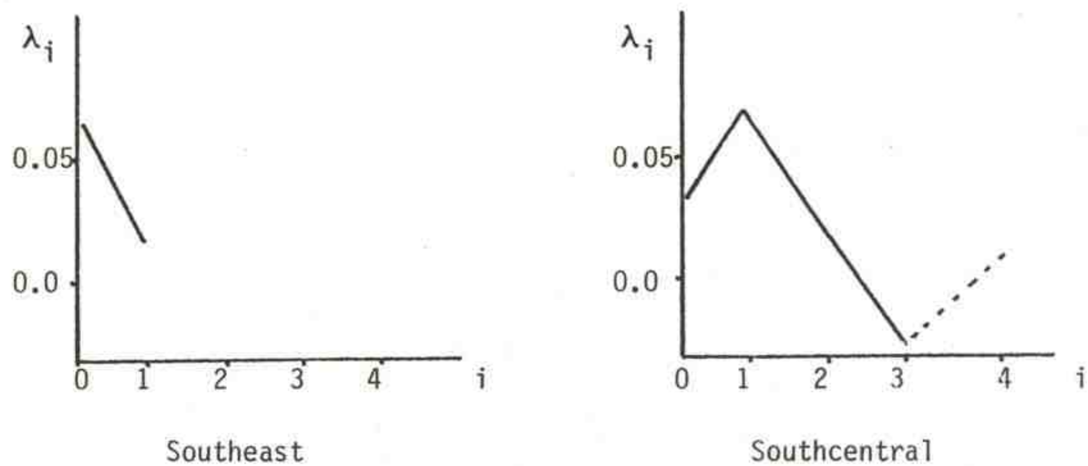
	Coefficient estimates (standard error)					
Region	Intercept	COST	GOVP	R^2	dw	L
Southcentral	93.732 (16.566)	-37.408 (7.726)	.097841 (.00933)	.946	1.977	5
Southeast	65.640 (19.629)	-14.497 (10.949)	.085583 (.00617)	.897	1.846	2

Dependent variable: acres planted (thousand acres)
sample period: 1950-1979
COST: per acre planting cost index (1967 = 1.0)
GOVP: deflated cost-share subsidy payments (thousand dollars)
dw: Durbin-Watson statistic
L:number of lags on GOVP (inludes current year)

serial correlation. An examination of the Durbin-Watson statistic, however, suggests that this is not a problem.

Figure 3.1 illustrates the structure of the lag coefficients for the subsidy payment variable in both regions. For the Southeast region two lags (the current and previous year) were adequate to capture the effect of government payments and the lag coefficients were estimated directly. In the Southcentral region, values of the policy variable over five years were useful in explaining total nonindustrial private planting. In this region a polynomial distributed lag in GOVP was employed to estimate the lag coefficients. Minimum standard error of the regression was the criterion used in determining the appropriate lag length.

The importance of government policy in determining nonindustrial private planting in the South can be seen in the strength of these results. The aggregate policy coefficient (Table 3.1) indicates the total number of acres planted as a result of each dollar spent through subsidy programs. (The dependent variable is thousands of acres, and the policy variable is thousands of deflated dollars.) The inverse of this policy coefficient yields the public expenditure (in 1967 dollars) per acre planted by nonindustrial private owners. This value-- \$11.69 for the Southeast region and \$10.51 for the Southcentral region-- can be compared with direct public expenditures on reforestation, shown in Table 3.2.



Lag Coefficients
(standard error)

Region	G(0)	G(1)	G(2)	G(3)	G(4)	$\sum G(i)$
Southeast	.062018 (.00929)	.023566 (.00923)	-	-	-	.085584 (.00617)
Southcentral	.034880 (.01133)	.07070 (.01293)	.01683 (.00584)	-.03430 (.01298)	.00973 (.01149)	.097841 (.00933)

Figure 3.1 Structure of the lag coefficient for the cost-share payments policy variable in the nonindustrial private reforestation equations

Table 3.2 Average public expenditures per acre for cost-shared nonindustrial private reforestation in the South

Year	FIP: current dollars[1]	FIP: constant dollars[2]	All Programs[3]: Southeast (constant dollars)	All Programs[3]: Southcentral (constant dollars)
1974	39.0	20.85	23.98	19.96
1975[4] 1976[4]	48.0	20.69	24.42	32.37
1977	47.0	17.55	13.46	21.12
1978	51.0	17.67	20.56	20.40
1979	54.0	17.42	20.70	19.35
sample[5]	47.8	18.84	17.92	17.01

1 Average federal cost for reforestation (Risbrudt and Ellefson, 1983).

2 Constant 1967 dollars, deflated by the index of planting costs.

3 Expenditures in all programs deflated by the indices of planting costs, divided by the total number of acres planted with subsidies.

4 Data for 1975 and 1976 are combined due to the impoundment of FIP funds in 1975 and the change in the federal fiscal year in 1976.

5 Sample is 1974-1979 for FIP; 1970-1979 for all programs combined.

The difference between the average direct expenditures per acre and the inverse of the policy coefficient indicates positive indirect effects from the policy of providing cost-share payments. This conclusion must be drawn with some caution, however, as the model exhibits instability when subsets of the sample are used. This implies that the assumption of a behavioral response which is stable through time (or, what is roughly equivalent, across programs) is not sustained by the data. The power of this test is diminshed, though, by insufficient observations on the effects of more recent programs. In addition, uncertainty and instability are not inappropriate characterizations of cost-share payments policies throughout most of the past decade. The use of the full data set (1950-1979) to estimate the response to policy appeals to the idea that there is, in fact, a stable response when policy is stable.

The ability of the model to explain planting behavior in years outside the period used for estimation is illustrated in Table 3.3. While the model is estimated with annual data, it is used in an inventory projection system with a five year period as the basis for simulations (see Chapter 2 and the following section). Values for the explanatory variables used to produce the estimates shown in Table 3.3 are the period averages, thus the proper comparison is with the average actual planting shown in the last column. The reasonably good fit (differences of 5 percent or less) bears out the contention that the models reported in Table 3.1 are useful for

Table 3.3 Estimates of reforestation by private owners and actual accomplishments, by region and owner group

(thousand acres)

REGION	OWNER	ESTIMATED[1]	Actual[2] 1980	Actual[2] 1981	Actual[2] Average[3]
Southeast					
	Industry	417.30	447.88	372.00	394.24
	Nonindustrial	176.77	192.66	206.85	167.83
Southcentral					
	Industry	455.21	522.58	319.52	454.62
	Nonindustrial	144.50	199.24	180.57	139.24
South					
	Industry	872.51	970.46	691.52	849.86
	Nonindustrial	321.27	391.90	387.42	307.07

1 Annual average for the first projection period (1977-1981) based on the reforestation equations. Development of the model for forest industry is reported elsewhere.

2 Source: USDA, Forest Service, Forest and Shelterbelt Planting Report

3 Average for 1977-1981

simulating the effects of cost-share policy in the future. As with any simulation based on relationships derived from historical data, however, the assumption that these relationships remain stable is made here. An anlysis of the sensitivity of the overall policy analysis to the magnitude of the coefficient on the policy variable will be conducted as a further test of the model.

The Inventory Model

An age-class based inventory projector was developed for private owners in the South to provide the link between the reforestation model and the markets where the policy of reforestation cost-share payments has its final impact. Previous projections of southern softwood inventories and their response to alternative harvests and management practices have depended on the Timber Resource Analysis System (TRAS) model (Larson and Goforth, 1974). For a number of reasons, however, this model is inappropriate for the present study.

The TRAS model characterizes the inventory of each owner by the distribution of the number of trees per acre by diameter class. In the version of TRAS used in recent Timber Assessments (see USDA, Forest Service, 1982; Adams and Haynes, 1980) a single composite softwood stand is specified for each owner in each region of the South. At this level of aggregation TRAS in unable to account for the growth and growing stock shifts from softwood to hardwood stands, or shifts between softwood stands with different growth rates. Under these circumstances, projections over long time periods with TRAS may considerably under- or over-estimate growing stock levels. The composite acre representation employed in TRAS also presents the problem of converting area-based accomplishments (the estimates from the reforestation model) into changes in average ingrowth and radial growth rates.

The Southern Pine Age-class Timber Simulator (SPATS) model was designed to project the development of southern softwood inventories under alternate assumptions regarding the rate of pine regeneration. Each owner's inventory is characterized by the distribution of acres by age class and stand type. Four stand types are modeled: natural pine, plantation pine, oak-pine and hardwood. Nineteen five-year age classes are specified for each softwood stand type. Hardwood acres are modeled as a "pool", with no explicit age class structure.

Pine plantation establishment can be computed using the reforestation equations, or set to a pre-determined level. Natural regeneration transition probabilities are specified for each softwood stand type; these parameters indicate the probability of alternative regeneration outcomes given the stand type prior to harvesting. If the area to be planted in a period exceeds the area harvested in that period, nonstocked and hardwood acres are converted to pine plantations.

The SPATS inventory model provides a more detailed and more dynamic characterization of southern softwood inventories than is possible with the TRAS model. The SPATS model is structured to project the development of private softwood inventories under alternative management practices-- in particular the establishment of pine plantations. Further detail on the SPATS model, including comparisons with TRAS is provided in Chapter 2.

The Market Model: TAMM

The Timber Assessment Market Model (TAMM) is a spatial model of softwood lumber, plywood and stumpage markets (Adams and Haynes, 1980). Six demand regions (one southern) and nine supply regions (two southern) are represented using sets of supply and demand equations. Equilibrium solutions for each region, for stumpage and product markets are found for each year of the model simulation. For further detail on TAMM see Adams and Haynes (1980).

TAMM was designed to facilitiate forest policy analysis and, with minor modifications, is able to provide a powerful structure for evaluating the impact of alternative levels of reforestation subsidies. In addition to replacing the TRAS inventory projector with the SPATS model in the southern regions, two other changes were made in TAMM.

Revised inventory projections indicated that under certain conditions (continued low levels of pine regeneration) owners in the South could exhaust the merchantable portion of their softwood growing stock inventory. In order to avoid the situation where the market model requested, in its equilibrium solution, more harvest volume than the inventory model could supply, a stumpage supply constraint was introduced. For each five year period of the projection, for each owner, the inventory model supplies to the market model an estimate of the maximum merchantable volume available in any year. This is computed using the merchantable volume available at the start of the period, adjusted for ingrowth into merchantable age classes. For those years when an estimate of the market solution indicates that this limit will be exceeded, the owner's stumpage supply is taken to be a perfectly inelastic function at the constraint level (zero price response).

The second change also involves a constraint, in this case on imports of lumber from Canada. Initial projections showed that Canadian supply to the U.S. would reach unreasonable levels as domestic lumber production fell. In the projections reported here, imports of lumber from Canada are not allowed to exceed 17.5 million board feet per year. In both the baseline case and in the simulation of higher levels of cost-share payments this constraint is binding by the year 1995. Nevertheless, Canadian producers capture over 40 percent of the new supply of softwood lumber after 1990 in both simulations.

<u>**Policy Simulations**</u>

Two projections were made with TAMM using the SPATS inventory model for the southern regions and the reforestation behavior equations for nonindustrial owners. In the "baseline" simulation, cost-share payments (in all programs) are assumed to remain constant (in current dollars) at 6.6 million dollars in each region. This is approximately equal to current levels. In the alternative "high payments" simulation, cost-share payments increase to 33.0 million dollars a year in each region beginning in 1982 and are held constant at that level. In both simulations, planting by forest industry was set equal to the area harvested in each period. Data compiled by the Forest Industries Council (1980) confirms that this is, in fact, current practice.

Table 3.4 shows projections of softwood acres harvested and planted under these assumptions. In the baseline case, nonindustrial owners continue to plant fewer than 20 percent of the softwood acres harvested-- a rate generally consistent with recent historical observations (Boyce and Knight, 1979 and Fecso <u>et al</u>., 1982). When cost-share expenditures in the South are increased to 66.0 million dollars a year, nonindustrial private planting is projected to be roughly equal to the area harvested annually. While this does not treat the considerable "backlog" area suitable for reforestation or stand conversion, it is clearly a major change in pine regeneration

Table 3.4 Projections of acres harvested and planted by nonindustrial private owners in the South under alternative levels of cost-share payments[1]

	1982	1992	2002	2012
SOUTHCENTRAL				
Baseline[2]				
Harvested	830.43	926.19	623.83	451.66
Planted	161.70	142.89	124.26	105.62
High Payments[2]				
Harvested	830.83	941.15	434.66	724.41
Planted	927.28	864.58	804.59	746.79
SOUTHEAST				
Baseline[2]				
Harvested	838.61	906.77	860.31	735.61
Planted	189.79	177.01	164.66	152.60
High Payments[2]				
Harvested	838.61	911.13	860.25	709.25
Planted	876.90	824.75	775.29	728.07

[1] Annual Average for a five year period beginning in the year indicated

[2] See text for a description of assumptions.

in the South (Southern Forest Resource Analysis Committee, 1970; Forest Industries Council, 1980).

Tables 3.5 and 3.6 show the impact of the two levels of cost-share expenditures on removals, growth and growing stock inventories. In the baseline case (Table 3.5) nonindustrial private softwood inventories decline rapidly after 1990 as a result of reduced pine regeneration. While this is in striking contrast to previous "baseline" projections made by the Forest Service (USDA, Forest Service, 1982) it is the logical result of the continuation of current management practices (Boyce and Knight, 1979). Removals by industrial owners (along with growth) increase by more than 60 percent in this simulation, but are insufficient to compensate for the reduced contribution from other private owners. By 2012 total private softwood inventories in the South are less than 70 percent of the volume reported for 1976 (USDA, Forest Service, 1982).

This decline in private timber harvest and softwood growing stock inventories is reversed when planting by nonindustrial owners is increased to equal the area harvested (Table 3.6). In this projection, growth and removals on nonindustrial forests are better balanced, with the result that by 2012 private softwood inventories regain the level reported for 1976. The period of decline, even in this simulation, is the consequence of reduced softwood regeneration between 1965 and 1980.

Table 3.5 Projections of softwood harvest, net growth and growing stock inventories in the South (BASELINE)[1]

(million cubic feet)

REGION	1992		2002		2012	
	FI	OP	FI	OP	FI	OP
SOUTHCENTRAL						
Harvest[2]	1237.3	1432.2	1664.7	1092.4	2089.5	853.9
Growth[2]	1557.3	1087.9	1896.9	1009.6	1874.8	842.4
Inventory	13039.9	22626.7	17796.2	17124.0	17952.5	16390.5
SOUTHEAST						
Harvest[2]	1006.6	1602.6	1243.3	1758.3	1590.7	1508.4
Growth[2]	1277.6	1349.7	1381.9	1336.2	1408.5	1103.9
Inventory	10502.8	31352.6	12665.1	27066.6	12658.3	20524.9
SOUTH						
	All Private		All Private		All Private	
Harvest[2]	5278.7		5758.7		6042.5	
Growth[2]	5272.5		5624.6		5229.6	
Inventory	77502.0		74651.9		67526.2	

1 See text for an explanation of the assumptions. FI = Industry; OP = Nonindustrial

2 Removals and growth are average (annual) over a five year period.

Table 3.6 Projections of softwood harvest, net growth and growing stock inventories in the South (HIGH PAYMENTS)[1]

(million cubic feet)

REGION	1992		2002		2012	
	FI	OP	FI	OP	FI	OP
SOUTHCENTRAL						
Harvest[2]	1231.4	1453.0	1652.0	983.6	1638.6	1987.6
Growth[2]	1555.7	1447.8	1893.8	2195.1	1818.6	2356.9
Inventory	13044.9	23237.1	17786.4	22814.2	19744.7	30025.9
SOUTHEAST						
Harvest[2]	999.9	1609.5	1230.6	1928.8	1224.5	1989.6
Growth[2]	1275.7	1650.4	1379.3	2374.8	1330.2	2405.3
Inventory	10506.2	31811.3	12728.3	31749.4	13294.5	34396.4
SOUTH						
	All Private		All Private		All Private	
Harvest[2]	5293.8		5795.0		6840.3	
Growth[2]	5929.6		7843.0		7911.0	
Inventory	78599.5		85078.3		97461.5	

1 See text for an explanation of the assumptions. FI = Industry; OP = Nonidustrial

2 Removals and growth are average (annual) over a five year period.

Table 3.7 compares these projections in terms of shares of removals, growth and growing stock by owner group. The results from a baseline simulation using the TRAS model for the southern regions are shown for contrast. Both the level and the distribution of private harvest are considerably different as a result of the higher level of cost-share expenditures. A continuation of current management practices would place more of the burden of softwood supply in the South on industrial owners.

The growth and inventory effects of higher levels of reforestation cost-share payments are not surprising. Increased pine reforestation yields higher softwood growth and higher levels of growing stock. As noted at the outset, however, the primary objective of the FIP is to influence supplies and prices. Table 3.8 shows projections of softwood product price indices, production and consumption for the baseline and high payments simulations. Table 3.9 shows the product and stumpage price impacts of the increase in cost-share payments to 66.0 million dollars a year from the baseline amount of 13.2 million dollars. Figure 3.2 illustrates the changes in stumpage prices in each region which result from this five-fold increase in expenditures.

As Adams et al. (1982) observed, intensified management can have little impact on supplies and prices prior to the year 2000. Supplies available to this point are dependent on stands already established. From the year 2000 and beyond the reduction in stumpage and product prices is increasingly dramatic as the new planta-

Table 3.7 Projected shares of total private harvest, net growth and growing stock inventory in the South under alternative levels of cost-share payments

(percent)

REGION	1992		2002		2012	
SOUTH	FI	OP	FI	OP	FI	OP
Baseline						
Harvest	42.5	57.5	50.5	49.5	60.9	39.1
Growth	53.8	46.2	58.3	41.7	62.8	37.2
Inventory	30.4	69.6	40.8	59.2	45.3	54.7
High Payments						
Harvest	42.1	57.9	49.7	50.3	41.9	58.1
Growth	47.8	52.2	41.7	58.3	39.8	60.2
Inventory	30.0	70.0	35.9	64.1	33.9	66.1
TRAS[1]						
Harvest	35.2	64.8	33.6	66.4	33.2	66.8
Growth	27.2	72.8	28.9	71.1	30.0	70.0
Inventory	22.8	77.2	20.5	79.5	18.7	81.3

1 Baseline projection using the TRAS model for southern owners. Years are 1990, 2000 and 2010.

Table 3.8 **Historical values and projections of lumber and plywood producer prices indices (deflated), consumption and production under alternative levels of cost-share payments in the South**

ITEM	1976	1990	2000	2010	2015
Baseline					
Producer price index (1967 = 100.0)					
Lumber	135.6	197.5	244.6	304.7	338.9
Plywood	135.3	191.1	210.1	238.5	261.9
Production					
Lumber (MMBF)	30066	22936	20562	20757	20536
Plywood (MMSF)	18440	21823	22889	24222	24062
Consumption					
Lumber (MMBF)	36432	36580	35639	35834	35561
Plywood (MMSF)	17734	20932	21895	23231	23018
High Payments					
Producer price index (1967 = 100.0)					
Lumber	135.6	197.4	240.9	272.2	288.1
Plywood	135.3	191.5	207.9	214.7	230.4
Production					
Lumber (MMBF)	30066	22967	20802	23286	23985
Plywood (MMSF)	18440	21800	22998	25620	25965
Consumption					
Lumber (MMBF)	36432	36599	35879	38363	39010
Plywood (MMSF)	17734	20909	22007	24629	24921

Table 3.9 Projected stumpage and product price effects of an increase in reforestation cost-share payments in the South

	PERCENT CHANGE FROM BASELINE LEVEL[1]				
	1995	2000	2005	2010	2015
STUMPAGE					
Southeast	-1.9	-1.0	-5.0	-27.2	-36.8
Southcentral	0.0	+2.8	-2.6	-29.8	-44.8
PRODUCTS[2]					
Lumber	-0.8	-1.5	-0.7	-10.7	-15.0
Plywood	0.6	-1.0	+2.1	-10.0	-12.0

[1] See text for description of assumptions

[2] Computed from producer price indices

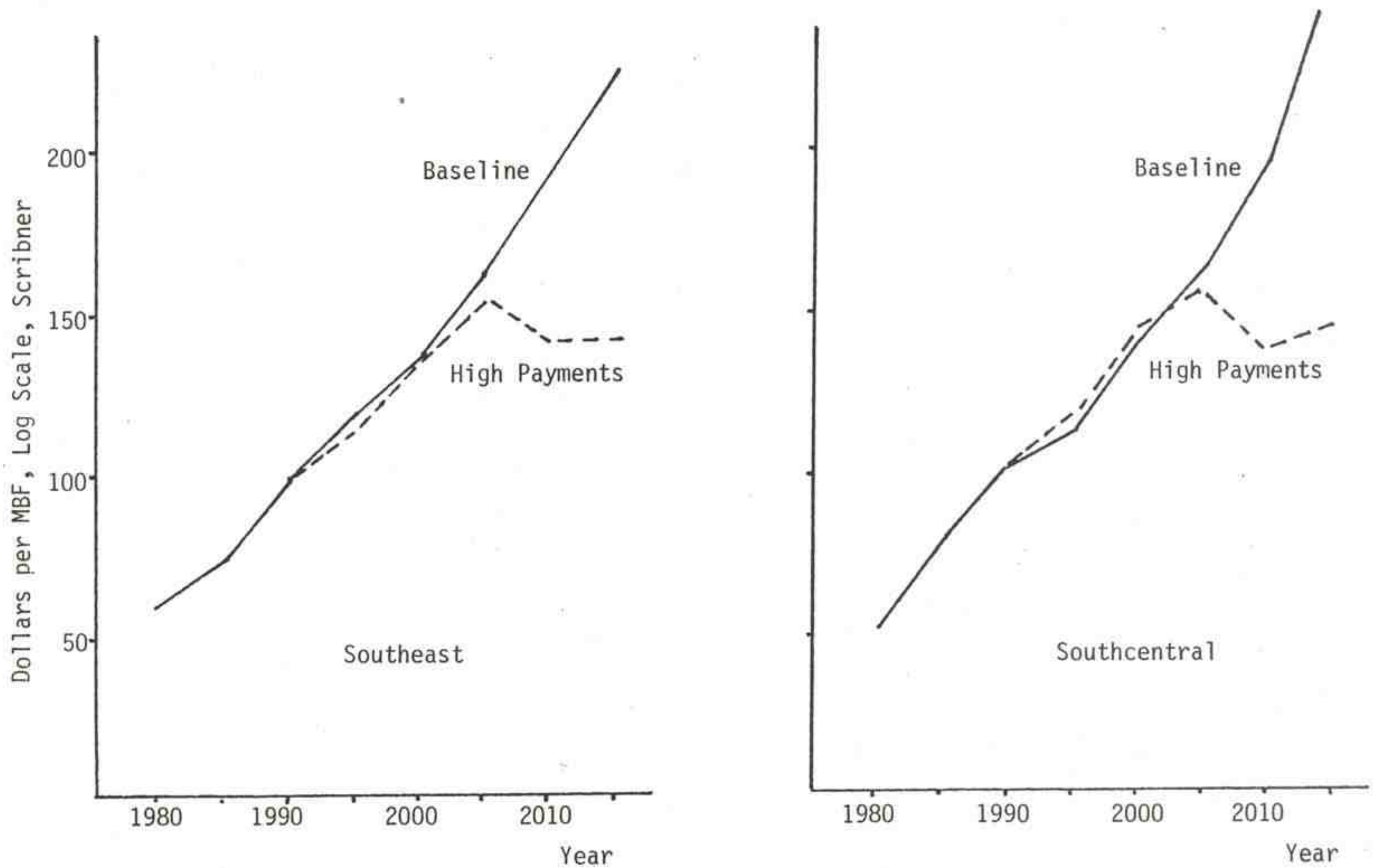


Figure 3.2 **Projections of stumpage prices to the year 2015 under alternative levels of cost-share payments Southeast and Southcentral regions**

tions mature and are harvested. By the year 2015, lumber consumption (in all demand regions) is nearly 10 percent higher, while the index of lumber prices is 15 percent lower than if payments remain at current levels. Price reductions are even greater in stumpage markets where by the year 2015 prices in the southern regions are 37 percent to 45 percent lower than under a continuation of current management practices and policy intervention.

A further measure of the benefits of this publicly supported increase in pine regeneration is provided by examining the change in consumer and producer surplus which results from the change in expenditures. While consumer surplus as a measure of changes in welfare has theoretical flaws, it is nevertheless an appealing and often used index of social gains or losses (see Just et al., 1982).

Consumer surplus is defined as the area under the demand curve and above the (equilibrium) price line. Changes in consumer surplus can be used, with some caution, as a measure of the income adjustment required to compensate consumers for a given change in prices (Willig, 1972). Producer surplus is the area above the supply curve and below the price line i.e., short-term quasi-rents. Changes in producer surplus are the corresponding measure of changes in producer benefits. Changes in the sum of these two measures are indicative of the net social benefits resulting from a policy decision.

An additional complication arises from the fact that the costs of the change in policy occur in a steady stream (from 1982 to

2015), while the benefit of price reductions--and subsequent changes in surplus measures--do not begin to any significant extent until after the year 2000. While benefits and costs can be compared easily through discounting, this introduces the problem of the choice of an interest rate. The computations are presented using two interest rates (4 percent and 10 percent) to demonstrate the sensitivity of the outcome to this parameter. As all prices in TAMM are in constant (1967) dollars, these should be interpreted as "real" interest rates.

Table 3.10 presents computations of the change in the sum of consumer and producer surplus resulting from the change to a higher level of reforestation cost-share payments. Values are in millions of dollars discounted to 1982 using either a 4 percent or 10 percent interest rate. The change in expenditures required to bring about this change in "welfare" is put in comparable terms by deflating with the planting cost index and discounting to 1982. Table 3.10 shows that using either interest rate the benefits which accrue by 2015 will far exceed the costs, measuring both in terms of present value.

In addition to the calculation of the relationship between benefits and costs as shown in Table 3.10, a "break-even" computation can be made as well. Figure 3.3 illustrates that the cumulative benefits of increased cost-share payments exceed cumulative program costs by the year 2000 when both are deflated and discounted

Table 3.10 Cumulative, discounted change in producer and consumer surplus as a result of increased reforestation cost-share payments in the South[1]

(million dollars)

Interest Rate	1995	2000	2005	2010	2015	Costs[2]	B/C[3]
4 %	73.3	267.3	549.2	2242.7	4870.6	228.7	16.9
10 %	35.2	112.0	204.0	616.3	1073.1	163.2	6.6

1 All regions, lumber and plywood markets, discounted to 1982.

2 Change in expenditures, 1982-2015, deflated and discounted to 1982.

3 Ratio of cumulative benefits and costs to 2015.

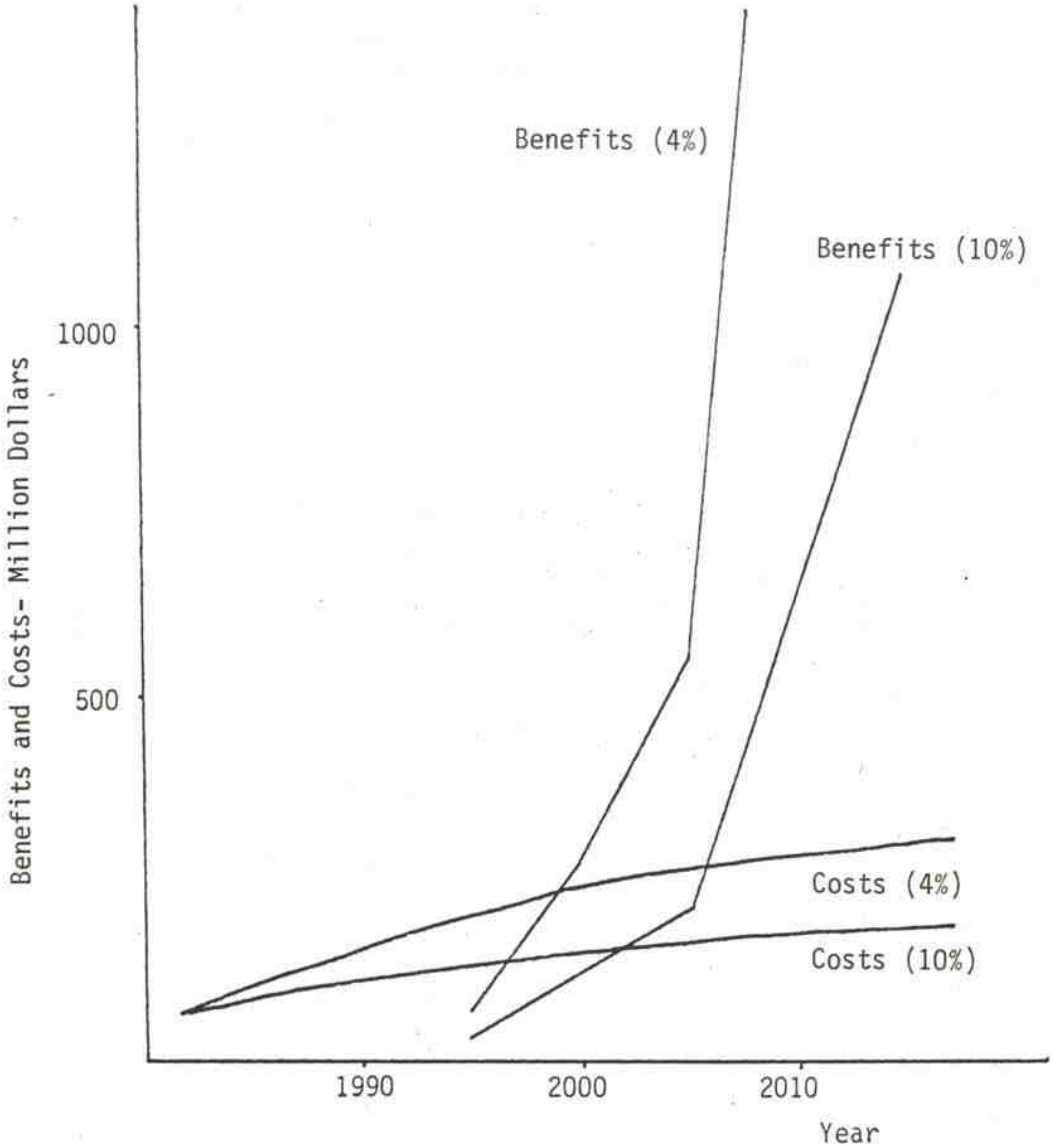


Figure 3.3 Cumulative benefits and costs of increased cost-share payments using alternative (real) interest rates

to 1982 at a 4 percent interest rate. When a 10 percent real interest rate is used, benefits exceed costs by the year 2005.

The extent to which the measure of benefits exceeds costs depends on the magnitude of the policy coefficient in the reforestation equations. The benefits shown in Table 3.10 are based on the coefficients estimated using data from 1950-1979 and reported in Table 3.1. Since, as noted earlier, there may be some reason to question the extent of the positive indirect effects included in these coefficients, a further simulation was conducted to test the sensitivity of the policy evaluation to this parameter.

A revised value for the policy coefficient was derived from the data in Table 3.2. The sample average of constant dollar expenditures per acre in the FIP program ($18.84) was inverted to provide an estimate of the acres planted per dollar of program expenditures. The resulting value (.053079) is a 40 percent to 50 percent reduction in the magnitude of the response to the policy variable. This can be taken as a parameter value which "meters" expenditures--that is, converts them to planting accomplishments with no consideration of indirect effects.

Table 3.11 summarizes estimates of benefits using both the original and the revised coefficients in the reforestation equations, and the two interest rates. Also included in this table is an alternative computation of costs, in which total (deflated) expenditures are used rather than the change in expenditures from

Table 3.11 Summary of public benefits and costs of increased reforestation cost-share payments under alternative assumptions

Ref. No.	Interest Rate	Benefits[1/] (million dollars)	Costs[2/] (million dollars)	Benefits/Costs
1	4%	4870	288.7	16.8
	10%	1073	163.2	6.6
2	4%	4870	360.9	13.5
	10%	1073	204.1	5.3
3	4%	2049	288.7	7.1
	10%	419	163.2	2.6
4	4%	2049	360.9	5.7
	10%	419	204.1	2.1

[1] Benefits are the cumulative, discounted change in the sum of consumer and producer surplus. Numbers 1 and 2 show the benefits estimated using the policy coefficients based on the full data set (1950-1979). Numbers 3 and 4 are the benefits estimated when the policy coefficient is reduced to the level which "meters" in expenditures (see text).

[2] Costs are the cumulative expenditures discounted to 1982. Numbers 1 and 3 use the change in expenditures (from the baseline level). Numbers 2 and 4 use the total expenditures required to achieve the benefits reported.

the baseline level. While this alternative cost calculation is not theoretically consistent with the computation of benefits, it is included to provide further evidence of the desirability of public reforestation cost-share payments. If planting levels reported in the baseline projection are assumed to occur in the absence of any payments, then it is, in fact, appropriate to use total expenditures to calculate public costs in the simulation of higher levels of payments. Even under this unfavorable assumption, however, and using a real interest rate of 10 percent, the social benefits of cost-share expenditures by the year 2015 are more than double program costs.

Conclusions

Reforestation cost-share programs have been established by the federal and state governments with the objective of stimulating higher levels of timber production on nonindustrial private forests. Until now it has not been possible to determine the extent to which these programs could achieve the goal of increased timber supplies and more "reasonable" prices. A policy analysis system was developed to provide a framework for examining the policy of sharing the cost of forest management practices.

Reforestation cost-share programs have been criticized by some as unnecessary since pine plantation investments are projected to provide a high rate of return. An examination of nonindustrial private reforestation behavior indicates that in spite of potentially high returns, few owners choose to undertake the opportunity to reforest their harvested or understocked land to southern pine. Numerous factors may account for this, but whatever the reasons behind private forest management decisions, an analysis of behavior over the period 1950-1979 incidates that nonindustrial owners have responded to programs which provide direct payments to defray reforestation expenses.

A simulation of future softwood stumpage and product markets under the assumption that nonindustrial private forest management in the South remains at the relatively low levels observed over the recent past indicates that both stumpage and product prices will rise even faster than previously expected. Low levels of pine regeneration in the South dating from 1965 will lead to a decline in softwood inventories and harvest by 1990. Increased management and harvests by forest industry are unable to offset reductions in supply from the region's dominant owner group.

Increased pine regeneration on nonindustrial forests, if begun by 1985 can reverse these declines by the year 2000. Significant increases in harvests and consequent reductions in prices (from the baseline) will not occur until 2010 and beyond. While other changes in public and private programs may bring about changes in nonindustrial private reforestation, the present study shows that reforestation cost-share payment programs can have the desired result:

increased softwood timber supplies and lower future prices. Forest landowners are the direct beneficiaries of these programs, but an analysis of public costs and benefits shows the policy of sharing the cost of reforestation investments to be highly desirable from the public's perspective. Consumers and producers of forest products receive benefits which, when discounted to the present, far exceed the present value of program costs.

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SUMMARY

There are, broadly, two contributions which result from the research presented here. The first is contained in an age-class based inventory model designed to permit a more detailed analysis of the softwood timber production potential of southern forests. Simulations with this model which are based on a continuation of current regeneration practices show that present expectations for nonindustrial private timber production in the South--i.e. those contained in the Timber Analysis of the Forest Service (USDA, Forest Service, 1982)--are unlikely to be realized.

When rates of pine harvest in the South are combined with low rates of pine regeneration by the region's dominant landowner, future softwood inventories decline dramatically. Perhaps even more important than the long-term (30 to 50 year) consequences indicated by the model are the implications of the inevitable reduction in timber harvests which will come about before the year 2000. These reductions are the result of reduced pine regeneration since 1965. Over this shorter time period, little can be done to augment softwood fiber production on nonindustrial private forests; as a result, expectations of total market supplies and owner group shares must be adjusted.

The second contribution is the development of an empirical link between government policy and the level of private forest management. This policy-induced management effort is linked, in addition, to changes in softwood inventories through the inventory model described above. With the addition of the Timber Assessment Market Model (Adams and Haynes, 1980), a comprehensive analysis of the long-term impact of a significant component of forest policy is possible.

The present study will not, by any means, put an end to the debate over the appropriate policy instruments for stimulating timber production on nonindustrial private forests. What has been made clear, however, is the link between a given level of funding and accomplishments expressed in terms of the policy objective: increased timber supplies and reduced prices. This study shows that given the historical response to cost-share programs, at higher funding levels these programs can have a considerable effect on future timber markets.

Some additional comments are also in order. Program funds can be both raised and expended in a variety of ways. While federal funds have come through the standard appropriations process, some states have relied upon dedicated tax revenue (e.g. Virginia) or voluntary contributions from the forest products industry (e.g. Texas) for some of the funds necessary to operate their programs. For some critics of cost-share programs, the source of funds is as much at issue as the level of funding; whether one approach is preferred to another is not readily apparent. It is generally agreed, however, that stable funding--at whatever level--is necessary.

Variety and potential flexibility in the administration of cost-share programs suggests, too, the possibility of increasing program effectiveness for any given level of funding. Cost-share rates can, for example, be lowered in order to disburse available funds to more participants. The effect of a range of cost-share rates on participation is unclear, but certainly worth investigating. A comparison of programs or administrative procedures was not part of the present study, but studies of this sort have, in the past, yielded useful results. See, for example, Mills (1976), Risbrudt and Ellefson (1983) and Murphy (1976).

The likely success of cost-share programs at higher funding levels, as shown here, does not fully define the means by which a policy of stimulating greater timber supplies on nonindustrial forests can be pursued. Forest practices regulations have been used by some states in order to require the behavior that incentives programs such as the Forestry Incentives Program attempt to induce. While the regulatory approach has been characterized as unpalatable and counter-productive in the forestry context (see Dana and Fairfax, 1980 for a review of responses to forestry regulations), it may be easier to pass such laws than to raise cost-share program funding to the levels examined here.

It is possible to cast aside these results on the importance of government policy and to advance the faith that markets and (or) technology will adjust satisfactorily in the absence of government action. The argument that private parties will come forward to capture pine investment opportunities is rather weak given historical evidence. The possibility of dramatic changes in this behavior cannot be entirely ruled out, however. Recent changes in tax laws may make some difference in the level of reforestation in the South, but if, as many suggest, available capital is the effective constraint on nonindustrial private planting, these provisions can be expected to have only a modest impact.

The activity of institutional investors in purchasing southern forest land may, too, make some difference. These represent a clear case of private investors recognizing the earning potential of southern pinelands and making committments of capital. It isn't clear, however, that much besides ownership is changing as a result. The amount of capital required to both purchase land and make investments in fiber production on a significant scale is well beyond reasonable expectations for this market.

The technology of fiber utilization may adapt if (as) markets fail to anticipate fiber demands. In fact, when total fiber production (hardwood as well as softwood) on nonindustrial private forests is examined, there is considerably less reason for alarm. As the value of softwood fiber increases, through scaricity, industry will, in all likelihood, begin utilizing more hardwood fiber wherever possible. The time horizon for this adjustment may not be quite as long as that required for investments to produce softwood fiber, but may have some undesirable dislocations associated with it.

Finally, on the positive side, there are (or may be) public benefits from programs such as those providing cost-share payments which are not measured in this type of analysis. Under certain circumstances the employment resulting from planting program expenditures may be considered a net benefit. While it is important not to confuse distinct policy objectives (in this case an incomes or employment policy with a resource policy), multiple objectives may be satisfied by a single program. If, as may be the case in parts of the South, those employed in planting trees would be otherwise unemployed (either cyclically or chronically) an additional net benefit to cost-share programs can be claimed.

It is also interesting to note that the present problems of pine regeneration in the South coincide with a period of farm crop surpluses and government programs designed to remove land from agricultural production. The Soil Bank Program, whose beneficial impact on southern softwood inventories has been mentioned had, as its primary purpose, soil and water conservation. There is reason to expect then, that cost-share programs with similar multiple objectives can have a comparable impact.

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