TIMBR-2: Intensive Timber Management Practices

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What are the status and trends of forest management practices in the South?

1 Key Findings

- Forest management in the South has intensified over the past two decades and this trend is expected to continue.
- Intensive planted pine technology nearly doubles growth and yield rates and offers superior investment returns compared to more traditional management composed only of site preparation and planting.
- Planted pine management intensity is expected to continue to grow as forest industry and timberland management organizations increase investment on their land.
- Hardwood forests are managed less intensively in natural stands.
- Intensive management is difficult and more expansive on smaller tracts; increasing fragmentation of forests in the South will exert downward pressure on management intensity.
- Forestry incentives programs have supported tree planting, management planning, and improvement of forest management practices, substantially increasing planted pine area, timber production returns, and environmental benefits.

2 Introduction

Timber harvests in the South have taken advantage of a substantial accumulation of forest growing stock and considerable investment in timber growing over the past four decades. As some forest owners adopt more intensive forest management, the production potential of forests changes accordingly. Planting genetically improved stock and applying fertilizer and herbicide will increase growth, yield, and long-run timber supply. This Chapter assesses the status of forest management in the South. It describes both the types and extent of silvicultural treatments in the region. It also analyzes costs and returns from intensive management practices.

3 Methods

Applied approaches included statistical data analysis, growth and yield analysis, capital budgeting analysis, and literature review. The first step in assessing the status and trends of forest management practices in the South involved analysis of forest inventory statistics. Effects of particular plantation management practices on productivity were estimated from a forest industry survey, which served as a baseline for the development of planted pine growth and yield tables. The survey's results were used to develop five planted pine management intensity classes. Management treatments included site preparation, planting of genetically improved seedlings, applications of fertilizer and herbicide, and thinning.

The TAUYIELD model was used to evaluate effects of these management treatments on growth and yield. TAUYIELD is a stand-level growth and yield model for unthinned and thinned loblolly pine plantations (Amateis and others 1995). The model estimates number of trees, average height, basal area, and volume by diameter at breast height (d.b.h.) class.

Growth and yield analysis was the first step in the evaluation of the impact of forest investment on forest conditions and productivity. Capital budgeting analysis, which discounts the cash flow of investments, was used to develop financial indicators such as net present values (NPVs), soil expectation values (SEVs), and internal rates of return (IRRs). These measures were used to determine whether intensive forest management generates attractive returns. This step was supplemented with results of surveys of forest owners. Forest industry (FI), timberland management organizations (TIMOS), and nonindustrial private forest (NIPF) owners were asked about their current and future management approaches. Results permitted inferences about likely future management intensities and their impact on forest conditions and productivity.

4 Data Sources

Reports from USDA Forest Service Forest Inventory and Analysis (FIA) units, State forestry organizations, literature, industry associations, and research cooperatives were the primary data sources for the analysis.

Two most recent rounds of FIA surveys (with the exception of KY, where only 1988 FIA survey data were available) were used to determine the status and trends of specific forest management practices that can be observed and recorded on sample plots. For all States except KY, the latest FIA survey measurement year is in the 1990s. The earlier of the FIA surveys were conducted between 1982 and 1989. Average measurement years for the latest and earlier rounds of the FIA surveys are 1993 and 1986, respectively.

Management practices represented by FIA data include clearcutting, partial cutting, thinning, timber stand improvement (TSI), site preparation, burning, planting, and natural regeneration. Because there were some differences between the Southeast region (FL, GA, NC, SC, VA) and the South Central region (AL, AR, KY, LA, MS, OK, TN, TX) and between particular States in defining management practices and data collection standards, some adjustments had to be made to develop southwide forest management practices categories.

In the Southeast, partial cutting, seed-tree cutting, and salvage cutting categories were merged into one partial cutting category that corresponds to the South-Central's partial cutting category. Similarly, in the South Central, thinning, commercial thinning, and precommercial thinning categories were merged into one thinning category that corresponds to the Southeast's thinning category.

In the Southeast prescribed burning was classified, depending on purpose, as site preparation or other prescribed burning, whereas in the South Central burning could be included in both site preparation and burning categories. This situation raises some concerns with double counting in site preparation and burning categories and the confusion of prescribed burning with wildfires. In Kentucky, burning disturbance was recorded without notation of purpose, and no thinning, timber stand improvement, or site preparation information was noted.

Finally, adjustments had to be made in developing southwide planting and natural regeneration estimates. In the Southeast, FIA recorded information about planting, afforestation, and natural regeneration. The same information was not available for the South Central. Planting and natural regeneration rates there were developed using stand origin and age variables. This approach yielded only approximate results because FIA used regression results to assign stand ages to sample plots that originally were in a mixed-age category. These problems and assumptions indicate that the results based on FIA data are only moderately accurate.

Since FIA data provide no information about the use of genetically improved stock, fertilizer and herbicide application, or uneven-aged silviculture, other information sources had to be used. These data sources include industry associations, research cooperatives reports, and forest owner surveys.

In particular, the North Carolina State Forest Nutrition Cooperative (2000) provided information about fertilizer application. Forest owner surveys by the Southern Forest Resources Assessment Consortium (SOFAC) and the American Forest and Paper Association (AF&PA) provided information about management intensities on FI, TIMOS, and NIPF timberlands (Moffat and others 1998, Siry 1998, Siry and Cubbage 2001, Siry and others 2001). The surveys and literature review provided information on multiple-use intentions and outcomes, "no active management" approaches, and forestry incentives programs.

Where possible, information was provided by ownership group. FIA data provided information for public (PB), forest industry (FI, includes company and leased land), miscellaneous corporate (MC), and NIPF owner groups. SOFAC and AF&PA surveys provided information for FI, TIMOS, and NIPF owners.

5 Results

Forest management in the South has intensified over the past two decades. Practices associated with intensive forest management are used more frequently and on larger areas than ever before. These practices include clearcutting, partial cutting, TSI, planting and natural regeneration, and chemical applications. Thinning and site preparation experienced smaller increases, while burning became less common. Intensified planted pine management nearly doubles yields compared to traditional management approaches. While it is more expensive than traditional management, capital budgeting analysis indicates that intensive management generates superior returns. Compared with planted pine, hardwood forests are managed less intensively in natural stands. Their management intensity is expected to increase moderately. Attractive planted pine returns and stated future forest management intentions indicate that forest management intensity in the South will continue to grow.

5.1 Trends in Use of Specific Forest Management Practices

Table 1 and Table 2 show FIA results regarding current annual use and trends in use of forest management practices, including clearcutting, partial cutting, thinning, TSI, site preparation, burning, planting, and natural regeneration.

Clearcutting occurs on about 2 million acres annually. Upland hardwood accounts for 38 percent of harvested land, and is followed by planted pine with 22 percent. The area of clearcut planted pine is probably higher as planted pine stands with a larger hardwood component are classified as oak-pine. If this indeed is the case, then planted pine clearcut area would be similar to upland hardwood. Clearcutting is most common on NIPF land, which accounts for 57 percent of harvested area. This result is an expected result because NIPF owners hold the majority of timberland in the region. Acreage of clearcutting has grown by nearly 10 percent over the period covered by the FIA surveys or a 1.4 percent annual increase from 1986 to 1993. While clearcutting increased on PB, NIPF, and MC land, it actually decreased on FI land. The total annual clearcut area amounts to only about 1 percent of timberland area in the region. This result indicates that management is relatively extensive in the South's timberland. Partial cutting is much more widespread, occurring on about 3.3 million acres annually. It has increased by 12 percent over the period between the two FIA surveys.

Approximately 640,000 acres are thinned annually. This practice is most often used in pine plantations and on FI land, which account for 48 percent of the total thinned area. Considering the size of FI timberland area, this result indicates relatively high thinning intensity. The total thinned area increased by nearly 3 percent between the FIA surveys. The largest increases in thinning area of up to 74 percent occurred on FI and MC land. Thinning intensity decreased on PB land.

TSI operations are carried out on about 940,000 acres annually. This area has increased by about 74 percent between the FIA surveys. The largest increases also occurred on FI and MC land. Natural pine forests account for 39 percent of TSI land and planted pine forests account for 30 percent.

Nearly 1.2 million acres are site-prepared annually. About 60 percent of site preparation is for pine planting. Much of the rest is for natural regeneration of pine. FI land accounts for 54 percent of site-prepared area. While site-prepared area has been relatively stable, there were some changes among ownership groups. MC owners increased site prepared area by 56 percent, while PB and FI owners decreased their acreages of site preparation.

Burning is the only management practice that became less common. Currently, it occurs on nearly 2.3 million acres annually, primarily on FI and NIPF land. The total number of burned acres has decreased by nearly 4 percent. Burning is most frequent in natural and planted pine stands.

Annually, 1.6 million acres are planted, both for reforestation and afforestation. Planting rates have increased by 25 percent between the FIA surveys or about 3.6 percent per year. Pines dominate 75 percent of planted land. In addition, planted pines occur in oak-pine stands in which hardwoods make up over half of the stocking. Between the surveys, NIPF owners and MC owners have increased planting rates by 85 and 68 percent, respectively. Natural regeneration is practiced on nearly 1.7 million acres annually. Between FIA surveys, naturally regenerated area increased by 18 percent.

Nearly 1.6 million acres of planted pine were fertilized in 1999 (North Carolina State Forest Nutrition Cooperative 2000). The increase from 1990 is nearly 800 percent. Nearly 10 million acres were fertilized in the South since 1969. This area is estimated to exceed the sum of forest fertilization in the rest of the world taken together. While the exact distribution of fertilized land among forest owner groups is not available, the Forest Nutrition Cooperative data indicate that fertilization is primarily the domain of FI and TIMOS. Fertilization will likely become even more popular in the future as new, more intensive silvicultural systems are introduced. Assuming that we have about 34 million acres of planted pine that will be fertilized at least twice during the rotation, fertilized area could at least double from today's levels.

Data on herbicide application were not available, but some inferences can be made about the area on which it is practiced. Results of forest owner surveys, discussed in the following sections, indicate that herbicide is applied together with fertilizer in higher management regimes. These results, coupled with planted pine area estimates and the assumption of a 25 year rotation length, indicate that herbicide might be applied on about 1.5 million acres annually.

Overall, rapid increases in harvest rates, planting and natural regeneration, TSI, and chemical applications indicate increasingly intensive management of southern forests. Intensive forest management is practiced primarily in pine plantations, which account for most planting, site preparation, fertilizer application, and thinning.

Naturally regenerated forest types are managed less intensively than pine plantations. Thinning, TSI, and burning are most common in natural pine, followed by oak-pine. Between the FIA surveys, oak-pine stands experienced substantial increases in clearcutting (40 percent), partial cutting (48 percent), TSI (102 percent), site preparation (118 percent), and burning (29 percent). These increases may result to some extent from classifying planted pine stands with a larger hardwood component as oak-pine. Hardwood forests are managed primarily in natural stands. They account for most forestland that is harvested and naturally regenerated, which is conditioned on their extensive cover in the region. FIA results indicate that areas of clearcutting, partial cutting, TSI, planting, and natural regeneration increased moderately, while thinning, site preparation, and burning became less popular between the surveys.

FI and MC holdings are managed most intensively, and intensity of management has increased markedly. Management intensity of NIPF land is also increasing, but to a lesser extent. Management intensity on PB land, the smallest ownership category in the South, appears to be changing as well. Clearcutting, TSI, planting, and burning have increased. Partial cutting, thinning, site preparation, and natural regeneration have decreased.

Changes in stand structure (even-aged, two-aged, and uneven-aged) management are difficult to determine due to the lack of data. About 34 million acres of planted stands are in planted pine or oak-pine forest types. These stands are managed in even-aged systems. With few exceptions, the remaining stands were regenerated naturally. Depending on natural growth conditions, types of cutting, and other disturbances, they may represent any of three age structures. Implementation of uneven-age management systems is quite complex, and many uneven-aged forests probably were not established intentionally. Some FI firms practice two-aged and uneven-aged silviculture in hardwood forests.

5.2 Effects of Various Forest Management Intensities on Productivity

Five management intensity classes (MICs) were developed to estimate potential pine growth and yield on FI land (Siry 1998, Siry and others 2001). MICs range from traditional planted pine management, consisting only of site preparation and planting, to more intensive approaches involving planting of genetically improved growing stock, fertilizer application, and herbicide application to control competing vegetation. MICs assumptions for unthinned and thinned stands are summarized in Table 3 and Table 4.

Genetically improved stock was assumed to increase volume by 14 percent at the culmination of mean annual increment (Siry 1998, Siry and others 2001). This increase corresponds to a 5-ft site index (SI) increase on medium sites (SI 60). The impact of 200 pounds of nitrogen and 25 pounds of phosphorus fertilizer was modeled by increasing yield by 400 ft^3 during the 5-year period after treatment. The impact of competing vegetation control on yield was modeled by increasing SI by 5 ft for MIC 4 and 7 ft for MIC 5.

In thinned stands, the impact of genetically improved growing stock and competing vegetation control was modeled in the same way as in unthinned stands. Fertilizer application was assumed to take place at the time of thinning. Thinning had to remove at least 450 ft^3/ac of wood volume, which roughly corresponds to about 600 ft^3/ac of gross volume (wood and bark). This volume was assumed to be the minimum for economically feasible thinning. Furthermore, thinning could not reduce the basal area of residual stands below 80 ft^2/ac, ensuring that sufficient growing stock remained. For multiple thinnings, a 5-year time lag between thinning was specified to capture the full response from fertilizer. These thinning assumptions reflect management objectives to provide intermediate cash flows and increase production of higher quality sawtimber. Single thinning was assumed to prevail in the Southeast. In the South Central region, multiple thinnings occurred in most cases.

Examples of planted pine yields by MICs and thinning regimes on medium sites are presented on Figure 1, Figure 2, and Figure 3. Yields in unthinned stands vary at age 25 from about 2,700 ft^3/ac for MIC 1 to nearly 4,600 ft^3/ac for MIC 5. The difference of about 1900 ft^3/ac indicates that MIC 5 has the potential to produce almost 70 percent more volume that MIC 1. In unthinned stands, the largest increase in yield comes from controlling competing vegetation. That treatment increases yields by 600 ft^3/ac for MIC 4 and 750 ft^3/ac for MIC 5 at age 25. Genetic improvement increases yield by nearly 420 ft^3/ac at age 25. Finally, as explicitly assumed, fertilization increased yield by 400 ft^3/ac.

Yields in thinned stands vary at age 25 from about 1,900 ft^3/ac for MIC 1 to 2,600 ft^3/ac for MIC 5. Thinning removals for a single treatment range from nearly 500 ft^3/ac to 800 ft^3/ac. Thinnings produce primarily pulpwood, with the exception of MIC 5, where 35 percent of wood volume produced by the second thinning is sawtimber. Total yield (thinnings plus yield at age 25) ranges from about 2,400 ft^3/ac for MIC 1 to nearly 3,900 ft^3/ac for MIC 5. The difference of about 1,500 ft^3/ac indicates that MIC 5 has the potential to produce 65 percent more volume that MIC 1 in thinned stands. More intensively managed stands were thinned earlier. The most pronounced yield increases resulted from competing vegetation control and fertilizer application. Fertilizing permitted earlier second thinning or increased volume in the thinning.

Thinning reduced total volume production throughout the rotations, because accelerated basal area growth of residual stands did not compensated for the loss of productive capacity removed in the thinning. The volume reduction ranged from 7 to 15 percent or from 230 ft^3/ac to nearly 700 ft^3/ac when compared with unthinned stands in the MICs at age 25. Thinning also shifted the diameter distribution to the right, implying that thinned stands grow less timber, but that its quality and value are higher. While the share of sawtimber in total volume in unthinned stands ranges from 32 to 48 percent at age 25, in thinned stands it ranges from 45 to 76 percent.

Table 5 compares unthinned planted pine yields by MIC on medium sites with empirical yields used by the Subregional Timber Supply (SRTS) model (Abt and others 2000) and the 1993 RPA, and yields recorded in the 1997 FIA survey of Georgia. SRTS yields rely exclusively on empirical values developed directly from FIA data, while RPA yields rely on FIA data as well as on yield curves developed during past RPA assessments. This analysis of the planted southern pine growth and yield indicates that projected plantations yields are much higher than historical FIA data. Increases range from 15 percent (for MIC 1) to 94 percent (for MIC 5) above current SRTS empirical data for average sites at age 25. Projected yields are also greater than those used in the last RPA modeling efforts. Furthermore, projected yields, with the exception of the youngest age class, are consistently higher than yields from the most recent FIA Georgia survey.

In summary, intensified management of planted pine provides substantial opportunities for increasing timber growth, yield, and quality. Fertilizer increases yield by 400 ft^3/ac per treatment; genetic improvement increases yield by nearly 420 ft^3/ac; and competing vegetation control increases yield by up to 750 ft^3/ac. These treatments applied together have the potential to exceed traditional yields (MIC 1) by 70 percent and SRTS-FIA and the last RPA yields by nearly 100 percent.

Information about effects of various management intensities on natural forests productivity is limited. FIA based empirical yields developed for the SRTS model indicate that average annual growth rates for natural pine across all sites can be as high as 86 ft^3/ac, followed by oak-pine (54), upland hardwood (47), and bottomland hardwood (44) (Abt and others 2001, Siry and others 1999). These results also indicate that FI natural pine yields can be nearly 20 percent higher than NIPF yields. The estimated average annual growth rates in natural stands are lower than those of planted pine stands, which range from approximately 109 ft^3/ac (MIC 1) to 183 ft^3/ac (MIC 5).

In comparison with pine management, hardwood management in the South has been neglected. The range of active management approaches varies, but managed stands rarely achieve growth rates that are much higher than those in unmanaged natural stands (Robison and others 1998). Research results indicate that treatments including herbicide application, fertilization, enrichment planting, and thinning have the potential to substantially increase hardwood stand productivity (NC State Hardwood Research Cooperative 2001, Groninger and other 1998, Lockaby and others 1997, Meadows and Goelz 1999a, 1999b).

The area of hardwood plantations is very small. It is estimated that there are about 200,000 acres of hardwood plantations in the South (Dvorak and others 1998). FI owns about 60,000 acres of hardwood plantation (Goetzl[1]). In addition, the industry established about 12,000 acres of hardwood plantations with short rotation intensive silviculture (SRIS). These plantations are managed on up to 12-year rotations. Management treatments include intensive site preparation, plantation of genetically advanced seedlings, complete competing vegetation control, and high-intensity fertilization. Genetic improvement increases yields by up to 25 percent per rotation.

Hardwood plantation establishment in many cases has been difficult and expensive. Earlier plantations had growth rates similar to natural hardwood stands, with the exception of cottonwood plantations along the Mississippi River (Robison and others 1998). Progress in genetic improvement, propagation, and silviculture appears critical for hardwood plantations to increase the production of high-quality and uniform wood. Hybrid poplar plantations in the South already can grow substantially more timber than natural hardwood stands (Alig and others 2000).

5.3 Quality of Forest Investments

Intensive management can greatly increase pine growth and yield, but the use will depend on financial returns. Six management cost categories were included in the analysis based on a forest industry survey (Siry and others 2001). On average, it is assumed that site preparation costs $140/ac. Seedlings and planting cost $70/ac, and the use of genetically improved seedlings raises this cost to $75/ac. Fertilization costs $50/ac per treatment. Tax and administration expenses are $8/ac annually. Assumed costs of herbicide application for MIC 4 are $50/ac. The costs of the two herbicide treatments in MIC 5 are: (1) weed control treatment at year 0 for $35/ac; and (2) woody plant control treatment at year 3 for $50/ac. There are only three revenue categories, two timber and one nontimber. Thinnings primarily produce pulpwood and the final harvest produces pulpwood and sawtimber, which generate $25/cord and $350/MBF, respectively. Hunting leases are assumed to generate $3/ac annually.

Basic financial measures commonly used in forestry - NPVs, SEVs, and IRRs for unthinned and thinned scenarios - are presented in Table 6. These financial measures were calculated using a 6 percent real discount rate. In addition, a 1-percent annual timber price appreciation was factored in. Financial results were developed for rotations determined by SEV criterion.

In unthinned scenarios, NPVs vary from $440/ac for MIC 1 to $990/ac for MIC 5. Similar relationships apply to SEVs, which vary from $532/ac for MIC 1 to $1,249/ac for MIC 5. Real

[1] Goetzl, A. March 23, 1998. AF&PA southern forest management intensity survey. Data summary and survey results. Unpublished report. On file with: American Forest and Pulpwood Association, Washington, DC.

IRRs for the MICs vary from nearly 10 to 12 percent. These criteria indicate that intensified forest management generates positive and apparently attractive financial returns.

In thinned scenarios, NPVs vary from $411/ac for MIC 1 to $1,082 for MIC 5. Similarly, SEVs vary from $504/ac for MIC 1 to $1,411 for MIC 5. Real IRRs among the MICs vary from nearly 10 to 13 percent.

A comparison of the performance of unthinned and thinned scenarios indicates that IRRs for thinned scenarios are the same as or higher than IRRs for unthinned scenarios. IRRs reach the highest level of 13 percent in the MIC 5 thinned scenario. However, NPVs and SEVs for scenarios with one thinning are lower than for unthinned scenarios. Only multiple thinning scenarios for MIC 3 to MIC 5 generate higher returns than corresponding unthinned scenarios. Among all thinned and unthinned scenarios and management intensity classes, MIC 5, the most intensive multiple thinning scenario generates the highest financial returns.

Natural hardwood stands can be managed with profit as well. Typically, such management relies on an even-aged system, clreacutting, and sorting harvested logs for the highest value market (Robison and others 1998). Naturally regenerated even-aged hardwood stands were shown to generate positive rates of return comparable with planted pine (Thompson 1992). Hardwood afforestation also generates positive returns. Cottonwood afforestation projects in the Mississippi Valley were profitable under most conditions (Stantruf and Portwood 1999). Even-aged management appears well suited to intensive hardwood pulpwood production. Two and multi-aged silviculture also have promise, but there are not practiced on a large scale, and conditions for uneven-aged silviculture generally are not favorable (Robison and others 1998).

To obtain more information about current and future forest management intensities, results of current surveys of FI, TIMOS, and NIPF land in the South were compared (Moffat and others 1998, Siry 1998, Siry and Cubbage 2001, Siry and others 2001). The surveys provide information about the current and future allocation of forestland among forest types, management intensities, and conversion to planted pine. Table 7 summarizes these results.

Planted pine management is described for three management intensities: standard management, superior management, and high-yield management. Standard management involves chemical or mechanical site preparation followed by planting. Superior management involves more intensive site preparation, genetically improved growing stock, woody plant control if needed, and mid-rotation fertilizer application to about 50 percent of the land. Finally, high-yield management adds herbicide application in the first and second growing seasons and fertilizing of half of the land at age 8.

Custodial even-aged management is applied in natural pine, oak-pine, and upland and bottomland hardwood stands. Generally, no treatments are made and none are planned. Higher intensity management consists of some actions, such as fertilizing or thinning, carried out in even-aged stands. When planted pine, natural pine, and oak-pine stands are harvested, plantations are established on a percentage of the harvested areas.

Since the surveys used varying definitions and management categories, their results are not exactly comparable. Assumptions had to be made about merging FI management intensity classes into three classes common to all surveys and owners categories and adjusting the results to common time periods. This limitation needs to be recognized while interpreting the results.

Planted pine accounts for about 65 percent of FI and TIMOS holdings. During the next two decades, the share of planted pine is expected to increase to about 80 percent. This expansion comes primarily at the cost of natural pine.

Upland hardwoods occupy about 40 percent of NIPF land. During the next two decades, upland hardwoods' share is expected to decrease to 35 percent. Planted pine is expected to increase from the current 10 percent to 14 percent.

FI and TIMOS have up to 5 percent of their land reserved from harvest. This category comprises land where timber will not be commercially utilized or processed in the foreseeable future due to particular landowner preferences, regulatory constraints, or other reasons. During the next two decades the share of reserved FI and TIMOS land is expected to remain unchanged; the share of NIPF reserved land is expected to roughly double to 14 percent. The amount of nonstocked land is uniform among the three ownerships and equals about 1 percent.

The growing share of planted pine is accompanied by more intensive management. While today FI and TIMOS manage from 40 to 56 percent of their planted pine in a high-yield management regime, as much as 70 percent will be so managed in 20 years. NIPF planted pine is managed less intensively. Today only a quarter of planted pine is managed in a high-yield regime, but this share is expected to increase to nearly 50 percent during the next two decades.

Natural pine, oak-pine, and hardwood forest types are managed with lower intensity than planted pine. During the next two decades, natural pine, oak-pine, and bottomland hardwood management intensities are expected to increase only moderately.

Results indicate that intensive forest management offers attractive financial returns and that planted pine management will be increasingly important. Forest management will be characterized by more widespread planting of genetically improved seedlings, application of herbicide and fertilizer, thinning, and clearcutting. These treatments increase timber growth and quality, which will shorten rotations by up to 5 years. Intensified management of natural and planted hardwood stands also has the potential for attractive returns.

5.4 Multiple-use Intentions and Outcomes on Private Land

Private forests provide a wide range of uses and benefits, including timber, watershed maintenance, soil retention, range potential, wildlife habitat, and recreation opportunities. Timber production and nontimber uses are linked in several direct and indirect ways. Timber growing may increase some nontimber benefits, decrease others, or replace existing uses with different ones (Rudis 1988). The multitude of management objectives and ways to achieve them makes it difficult to determine of multiple-use intentions of private landowners. Linking multiple-use intentions and outcomes also is difficult because forests managed exclusively for a single use, such as timber growing, still support a range of nontimber benefits.

Industrial owners, FI and TIMOS, manage their land primarily for timber. Despite timber management's predominance, nontimber uses are recognized in forest management through best management practices. In the end, these industrial forests produce timber while supporting a range of nontimber uses.

NIPF owners are much less uniform in their approaches to forest management. They have multiple objectives and their actions are far more complex than industrial owners (Conway and others 2000, Dennis 1989, Klein and others 2000, Newman and Wear 1993, Swallow and Wear 1993). Their management approaches range from very intensive management, similar to FI and TIMOS, to an entire disregard of forest management. NIPF owners who value nontimber benefits are less likely to manage their forests for timber production if it reduces these uses. NIPF owners may extend rotations if nontimber services increase with forest age and volume.

Certainly, timber is an important reason for ownership, as is improving the value of land. A comparison of industrial and nonindustrial owners indicates that the behavior of both groups is consistent with profit motives behind forest management (Newman and Wear 1993). But NIPF owners capture significant nontimber benefits and their behavior differs from FI. They produce proportionally less softwood than their land share would indicate.

Nearly 45 percent of private owners in the South have harvested timber on about 78 percent of forestland (Birch 1997). Owners of 60 percent of forestland plan to harvest timber within 10 years, and owners of only 12 percent of southern forestland declare that they will never harvest. This outcome also indicates that private owners holding most timberland in the region respond to economic incentives and harvest timber at some point in time (Sampson and DeCoster 1997).

Overall, there are about 5 million forest owners in the South (Birch 1997). While corporate owners, which include FI and TIMOS, constitute only 1 percent of all southern owners, they manage nearly 30 percent of southern forests. Nearly 4.7 million NIPF owners manage about 60 percent of southern forestland. Their management intentions depend on personal objectives and financial constraints which can be inferred from certain characteristics, such as tract size, occupation, and income.

The average size of NIPF forest holding is quite small (Birch 1997). Two-thirds of NIPF tracts are smaller than 10 acres and three quarters are smaller than 20 acres. Owners of these small tracts control about 12 percent of forestland in the South. The small size of tracts makes regular forest management more difficult. Small tracts, for example, may be characterized by higher harvesting costs (Comolli 1981). Small tracts, therefore, are associated with lower removals and planting rates (Thompson 1996, 1997, 1999). This forestland is also less likely to be intensively managed for timber in the presence of substantial nontimber benefits. Major purposes of ownership include a place of residence, farming, recreation, and investment (Birch 1997). For a majority of NIPF owners, their forest is a part of their residence, but absentee owners also are common.

Progressing forest fragmentation may have some impact on regional timber production and nontimber uses. Between 1978 and 1994, the number of tracts smaller than 10 acres increased by 50 percent (Birch 1997). The number of new forest owners is expected to increase, and more forestland may be managed less for timber production and more for nontimber uses (Sampson and DeCoster 2000). Moreover, it also is possible that landscapes composed of many small owners with diverging objectives will make the achievement of nontimber uses ranging from wildlife to recreation increasingly difficult.

The shift towards more intensive management and pine plantations raises concerns about nontimber uses and values. Regional impacts of these trends are hard to determine because of the complexity of possible interactions. Pine plantations are criticized for low diversity, increasing herbicide use, and large even-aged stands that provide fewer opportunities for recreation, beauty, and wildlife. These negative outcomes can to some extent be mitigated by practicing thinning, prescribed burning, and partial harvesting, extending rotations, reducing herbicide use, and limiting plantation size while promoting irregular boundaries (Allen and others 1996). Some of these approaches, however, may decrease the efficiency of timber production.

Still, plantations provide nontimber benefits and may even increase their overall provision if, for example, they are established on highly erodible agricultural land. In order to fully assess their impact on nontimber products and benefits, one must consider alternative uses, adjacent land uses, and site-specific needs for nontimber benefits. Today, pine species do not dominate any ecological province in the South (Rudis 1998). It is unlikely that they will ever dominate the region, even though planted pine area is expected to grow, because of economic and environmental constraints that will eventually limit their expansion.

Forest owner surveys indicate that approximately 66 million acres are managed primarily for timber, 92 million acres are managed for a range of timber and nontimber uses, and 22 million acres are managed primarily for nontimber uses (Birch 1997, Moffat and others 2001, Siry 1998, Siry and Cubbage 2001, Siry and others 2001). Forests managed primarily for timber still support a range of nontimber uses. Forests managed for nontimber uses probably will produce less timber, but some management actions taken to enhance nontimber uses may produce some timber. Depending on circumstances, planted pine may either reduce or increase the provision of nontimber benefits. In order to determine net effects of increasing planted pine area on nontimber benefits, conditions across other forest types and owner groups throughout the region must be considered. It is apparent that the number of small forest tracks will grow in the future. This trend can make management for timber and nontimber products and uses more difficult.

5.5 "No Active Management"

Land is placed in the "no active management" category if no management actions, including timber harvest, are taken at present and none are planned in the future. The determination of the area that is not actively managed presents similar problems to the estimation of multiple-use management intentions and outcomes. Most forests in the South were managed in some way in the past. Results of surveys of forest owners show that 10 million acres have been removed from timber cutting (Moffat and others 2001, Siry 1998, Siry and Cubbage 2001, Siry and others 2001). This amount is predicted to increase to nearly 20 million acres in the next two decades. Birch (1997) estimated that owners of about 22 million acres of forestland have no harvest intentions, but some other treatments may be applied.

Another evidence of forest management activities is the extent to which owners have a written management plan. Birch (1997) finds that such written management plans were reported by only 5 percent of owners, but that those owners hold 40 percent of private forestland. Written management plans were primarily prepared for tracts larger than 5,000 acres. While the lack of a written management plan does not indicate the lack of management activities, it implies that some land is managed quite extensively.

Given the limited evidence, it is concluded that about 10 million acres of private forests in the South get no active management. Forest owner surveys and continued forest fragmentation suggest that this area will increase over the next two decades to about 20 million acres.

5.6 Impact of Forestry Incentives Programs

Current and past forestry incentives programs have focused primarily on providing assistance to NIPF owners in tree planting, management planning, and improving forest management practices. They have increased timber production, investment returns, and environmental benefits.

The Forest Incentive Program (FIP), a Federal cost-sharing program enacted in 1973, was aimed at increasing timber supply by promoting tree planting, timber stand improvement, natural regeneration, and firebreak construction (Gaddis and others 1995). From 1974 through 1992 the program's cost-sharing incentives exceeded $200 million in the South and funded tree planting on nearly 2.5 million acres (40 percent increase), timber stand improvement on 0.3 million acres, and site preparation on nearly 10,000 acres. The program was most intensively implemented in the 1970s. In the 1980s and early 1990s, inflation increased treatment costs and reduced real FIP appropriations. The program was terminated in 1995. Timber supply was predicted to increase by 1 billion ft^3 each year due to the program (Gaddis and others 1995). The program was characterized by retention reaching 90 percent. It generated rates of return of about 10 percent.

The Forest Stewardship Program (FSP) and the Stewardship Incentives Program (SIP) were authorized in 1990 to replace FIP. FSP is operated in cooperation with State forestry agencies and assists in enhancing and protecting multiple forest values on NIPF land by developing forest management plans (New and others 1997). From 1990 to 1994 FSP developed 13,000 forest management plans covering 2.5 million acres in the South. FSP cost-sharing amounted to $27 million. By 2000 FSP management plans were primarily developed and implemented for growing trees, improving wildlife habitat, harvesting trees, and improving water resources (Esseks and Moulton 2000). About 80 percent of prepared plans in the South were being implemented.

An FSP-approved forest management plan is a prerequisite for cost-sharing support under SIP. From 1992 to 1994, SIP in the South provided nearly $9 million in support for 4,000 owners with nearly 0.5 million acres (Gaddis and others 1995). The majority of funding was spent on tree planting activities. SIP and FIP supported tree planting on nearly 0.5 million acres in the South.

The Forest Legacy Program (FLP) is a Federal program aimed at environmental protection (Sampson and DeCoster 1997). FLP was designed to protect environmentally sensitive and valuable forest areas that are threatened by conversion to nonforest uses. This program supports State and Federal efforts through direct acquisition and conservation easements purchased from NIPF owners. The Rural Forest Management Program (RFMP) provides matching funds to State agencies to support their technical and financial assistance programs for conservation planting on NIPF land (USDA Forest Service, 2001).

State forestry assistance programs provide numerous services, including timber marketing, firebreak construction, forest management planning, forest seedlings sales, rental or loan of equipment, and literature and educational videos (Cubbage and Haynes 1988). Some States also enacted incentives programs. Expenditures for State cooperative forestry and landowner assistance programs in the South amounted to nearly $52 million in fiscal year 1998 (National Association of State Foresters 2001).

Forest industry firms also provide technical assistance to NIPF owners (Cubbage and Haynes 1988). Assistance ranges from forest regeneration to timber stand improvement and harvesting. These programs often require that tracts be of a minimum size and within a maximum distance from the mill. Land management practices are often performed for free or at a reduced cost to NIPF owners. Forest industry firms that offer these programs include, for example, Georgia Pacific (Forest Management Assistance Program), Stone Container Corporation (Land Owner Assistance Program), Louisiana-Pacific Corporation (Tree Enterprise Program), and Rayonier (Landowner Assistance Management Program)(Thompson 1995).

Overall, the majority of forestry incentives programs have promoted tree planting and more intensive forest management, better marketing of forest products, improved protection of existing resources, and enhanced planning. They have resulted in substantial increases in tree planting and more widespread development of forest management plans. The results and returns are generally satisfactory. Some critics have argued that these programs simply substitute public funds for private funds that would be invested in any case. While some capital substitution is possible, forestry incentives programs undoubtedly have resulted in substantially increased inventories and future timber supplies (Gaddis and others 1995, Lee and others 1992, New and others 1997).

6 Discussion and Conclusions

Timber management in the South has changed substantially over the past few decades, and current trends indicate that change will continue. As some forest owners adopt more intensive forest management, the production potential of forests increases accordingly. Genetic improvement of trees and intensified application of fertilizer, herbicide, and thinning will rapidly increase growth and yield of southern pines as well as shorten rotations. These benefits have important implications for long-term timber supply.

The South will increase softwood production using existing management technologies. By applying known technologies on a large scale, the South can almost double softwood growth rates. These higher management intensities are projected to be widely applied on FI and TIMOS land and even NIPF land. As a result, the South may be able to better meet increasing harvest demands than previously thought. Effects depend on the number of acres devoted to intensive management and on economic feasibility of intensive management. The economic analysis indicates that intensive forest management offers attractive returns.

These results, however, must be interpreted cautiously. It will be necessary to accurately model market adjustments to such changes. Higher growth rates will moderate price increases and thus reduce returns on investments in timber growing. Future supply increases could therefore be reduced. Furthermore, rapidly growing pine plantations can provide wood fiber, but quality and grade questions still must be considered. Questions about lumber quality, needs for pruning, ability to make reconstituted fiber products, and other factors still need to be addressed. And the technical properties of fast-grown planted pine need to be determined, and milling and marketing adjustments made.

Finally, the results presented here apply mostly to southern pines. At present, it is not really known to what extent southern hardwood production might be increased through intensive management. In comparison with planted pine management, intensive hardwood management in the South has been neglected. Vast and available hardwood resources of lower value than pine have discouraged investments in intensive hardwood management. Further, most hardwood forests belong to NIPF owners, who do not generally support the development of industry-like approaches. Futhermore, with more than 40 commercial species in southern hardwood forests, silviculture there is complex. To date, active hardwood management has yielded only small increases in natural stand productivity and mixed results in plantations. Recent hardwood research results suggest, however, that substantial productivity increases are possible in both natural and planted stands. But they rely on progress in silviculture, genetic improvement, and clonal forestry. While these results are promising, much effort is still required to develop effective and widely applicable hardwood technology that is comparable with southern pines technology. Dwindling hardwood resources and changing market conditions may provide the required stimuli.

7 Needs for Additional Research

Additional research is needed to better assess the status and trends of forest management practices in the South. More work also is needed to better assess rotation lengths and particular stand structures (even-aged, two-aged, and uneven-aged). Additional effort is required to better evaluate the impacts of increasing planted pine yields. First, planted pine acreages and management intensities need to be determined. Productivity increases will likely moderate timber price increases and reduce investment incentives. It is necessary to accurately model market adjustments to such changes. In comparison with planted pine, hardwood research in the South has been neglected. Most pressing needs include research into productivity improvements in natural and planted stands from treatments such as weed management, other silvicultural operations, genetic improvement, and clonal forestry. More research is also needed to determine multiple-use objectives and outcomes of forest management in the South, especially on NIPF land.

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10 Tables and Figures

Table 1--Current status and trends in annual use of forest management practices by forest type based on FIA data

Treatment	Planted Pine	Natural Pine	Oak-pine	Upland Hardwood	Bot. Hardwood	Not Stocked	Total	Percent change bw FIA surveys
	Forest Management Type							
	thousand ac per year							%
Clearcut	435.1	188.4	347.4	778.4	266.9	6.4	2,022.7	9.5%
Partial Cut	344.4	577.2	663.2	1,322.3	395.8	6.2	3,309.2	12.4%
Thinning	308.2	179.8	97.6	46.7	10.5	0.0	642.8	2.5%
TSI	285.1	362.7	163.2	116.5	12.4	1.5	941.5	74.4%
Site Prep.	709.0	66.4	195.7	179.5	28.8	3.4	1,182.7	1.0%
Burning	667.7	761.2	409.2	392.1	53.5	4.8	2,288.5	-3.5%
Planting	1,237.1	n.a.	226.0	165.7	12.4	2.0	1,643.3	25.2%
Natural Reg.	n.a.	300.2	319.1	815.7	242.9	23.5	1,701.5	18.0%

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Table 2--Current status and trends in annual use of forest management practices by owner based on FIA data

Treatment	Public	Forest Industry	Misc. Corporate	Non-Industrial Private	Total	Percent change bw FIA surveys
	Ownership					
	thousand ac per year					%
Clearcut	90.9	578.4	207.3	1,146.1	2,022.7	9.5%
Partial Cut	156.7	847.6	293.6	2,011.4	3,309.2	12.4%
Thinning	52.0	306.0	65.9	219.0	642.8	2.5%
TSI	189.5	382.0	65.1	304.9	941.5	74.4%
Site Prep.	66.0	633.6	104.6	378.6	1,182.7	1.0%
Burning	440.8	833.7	195.6	818.4	2,288.5	-3.5%
Planting	70.2	696.3	131.9	744.8	1,643.3	25.2%
Natural Reg.	89.4	264.2	152.1	1,195.7	1,701.5	18.0%

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Table 3--Southwide unthinned management scenarios[a]

Treatment	MIC 1 Traditional	MIC 2 Low	MIC 3 Medium	MIC 4 High	MIC 5 Very High
First Generation Genetics	N/A	Increase yield by 14% at CMAI	Increase yield by 14% at CMAI	Increase yield by 14% at CMAI	Increase yield by 14% at CMAI
Fertilization (N and P)	N/A	N/A	Age 15	Age 15	Low: age 10,15 Med.: age 8,13 High: age 5,10
Competing Vegetation Control	N/A	N/A	N/A	Increase SI by 5 ft	Increase SI by 7 ft

[a] Planting density = 600 trees per ac; medium sites (SI=60); SI=site index; MIC=management intensity class; CMAI=culmination of mean annual increments.

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Table 4--Southeast and South Central thinned management scenarios[a]

Treatment/MIC	MIC Traditional	MIC2 Low	MIC3 Medium	MIC4 High	MIC5 VeryHigh
First Generation Genetics	N/A	Increase yield by 14% at CMAI	Increase yield by 14% at CMAI	Increase yield by 14% at CMAI	Increase yield by 14% at CMAI
Fertilization (N and P)	N/A	N/A	At time of thinning	At time of thinning	At time of thinning
Competing Vegetation Control	N/A	N/A	N/A	Increase SI by 5ft	Increase SI by 7ft
Thinning Regime: Southeast	All sites:1 thinning	All sites:1 thinning	Allsites:1 thinning	Allsites:1 thinning	Low:1 thinning; Med., High:2 thinnings
Thinning Regime: South Central	Low: 1thin; Med., High: 2 thinnings	Low: 1thin; Med., High: 2 thinnings	Low: 1thin; Med., High: 2 thinnings	Low: 1thin; Med., High: 2 thinnings	All sites: 2 thinnings

[a] Planting density = 600 trees per ac; medium sites (SI=60); SI=site index; MIC=management intensity class; CMAI=culmination of mean annual increments.

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Table 5--Comparison of TAUYIELD projected growth and yield data for unthinned MICs with FIA data and modeling assumptions. Merchantable wood volume (Ft^3/ac to a 4 in. d.o.b. top)[a]

	Stand Age				
MIC	10	15	20	25	30
			Ft^3/ac		
MIC 1: traditional	309	1,121	2,004	2,716	3,158
MIC 2: genetics	396	1,353	2,355	3,135	3,605
MIC 3: MIC2+F[b]	396	1,353	2,637	3,433	3,912
MIC 4: MIC3+H[b]	518	1,670	3,139	4,033	4,502
MIC 5: MIC4 +2nd F&H	641	2,170	3,645	4,587	5,057
SRTS-FIA	568	1,138	1,708	2,361	3,013
1993 RPA	310	1,136	1,892	2,382	2,824
1997 FIA Georgia survey	420	912	1,540	1,969	2,625

[a] TAUYIELD assumes SI 60 at base age 25 and planting density is 600 trees per ac; SRTS-FIA, 1993 RPA, and 1997 FIA Georgia survey data are average for all sites; MIC=management intensity class.

[b] F=fertilization; H=herbicide application.

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Table 6--Summary of financial analysis of loblolly pine by MIC for medium sites (pulpwood $25/cord, sawtimber $350/MBF) at 6 percent real discount rate[a]

	Rotation	Yield	NPV	SEV	IRR
	Years	Ft^3/ac	$/ac	$/ac	%
	Southwide unthinned				
SRTS-FIA	30	3,013	416	504	9.6
MIC 1	30	3,158	440	532	9.7
MIC 2	29	3,531	601	737	10.6
MIC 3	28	3,763	648	806	10.9
MIC 4	28	4,373	860	1,070	11.3
MIC 5	27	4,846	990	1,249	11.9
	SE thinned				
MIC 1	29	2,718	411	504	9.8
MIC 2	28	2,968	550	684	10.8
MIC 3	27	3,203	615	776	11.2
MIC 4	27	3,640	768	966	11.4
MIC 5	25	3,899	1,082	1,411	13.0
	SC thinned				
MIC 1	29	2,718	411	504	9.8

MIC 2	28	3,429	564	702	10.9
MIC 3	27	3,514	782	987	12.1
MIC 4	26	3,847	1,043	1,337	12.9
MIC 5	25	3,899	1,082	1,411	13.0

[a] Assumed 1 percent real annual timber appreciation; MIC=management intensity class.

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Table 7--Summary results of forest management surveys by ownership group

Management Category	Forest Industry		Timberland Investment Management Organization		Nonindustrial Private	
	2000	2020	2000	2020	2000	2020
	% forestland area					
LAND DISTRIBUTION						
Planted Pine	63	81	69	81	10	14
Natural Pine	11	2	9	3	14	10
Oak-pine	4	2	2	1	14	13
Up.Hardwood	6	1	3	1	40	35
Bot.Hardwood	12	11	9	8	14	12
Not Stocked	1	1	3	1	1	1
Reserved	3	2	5	5	7	15
MANAGEMENT INTENSITY						
Planted Pine						

Standard	14	2	6	2	11	8
Superior	46	25	38	28	64	46
High Yield	40	73	56	70	25	46
Natural Pine						
Lower	61	71	59	40	79	52
Higher	39	29	41	60	21	48
Oak-pine						
Lower	95	95	75	73	85	76
Higher	5	5	25	27	15	24
Up. Hardwood						
Lower	97	89	95	82	91	86
Higher	3	11	5	18	9	14
Bot.Hardwood						
Lower	91	81	93	81	88	76
Higher	9	19	7	19	12	24
		CONVERSION TO PLANTED PINE				
Planted Pine		78		84		32
Natural Pine		13		12		12

Oak-pine	7	4	32
Other	2	0	24

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Figure 1--Planted pine yields, Southwide unthinned.

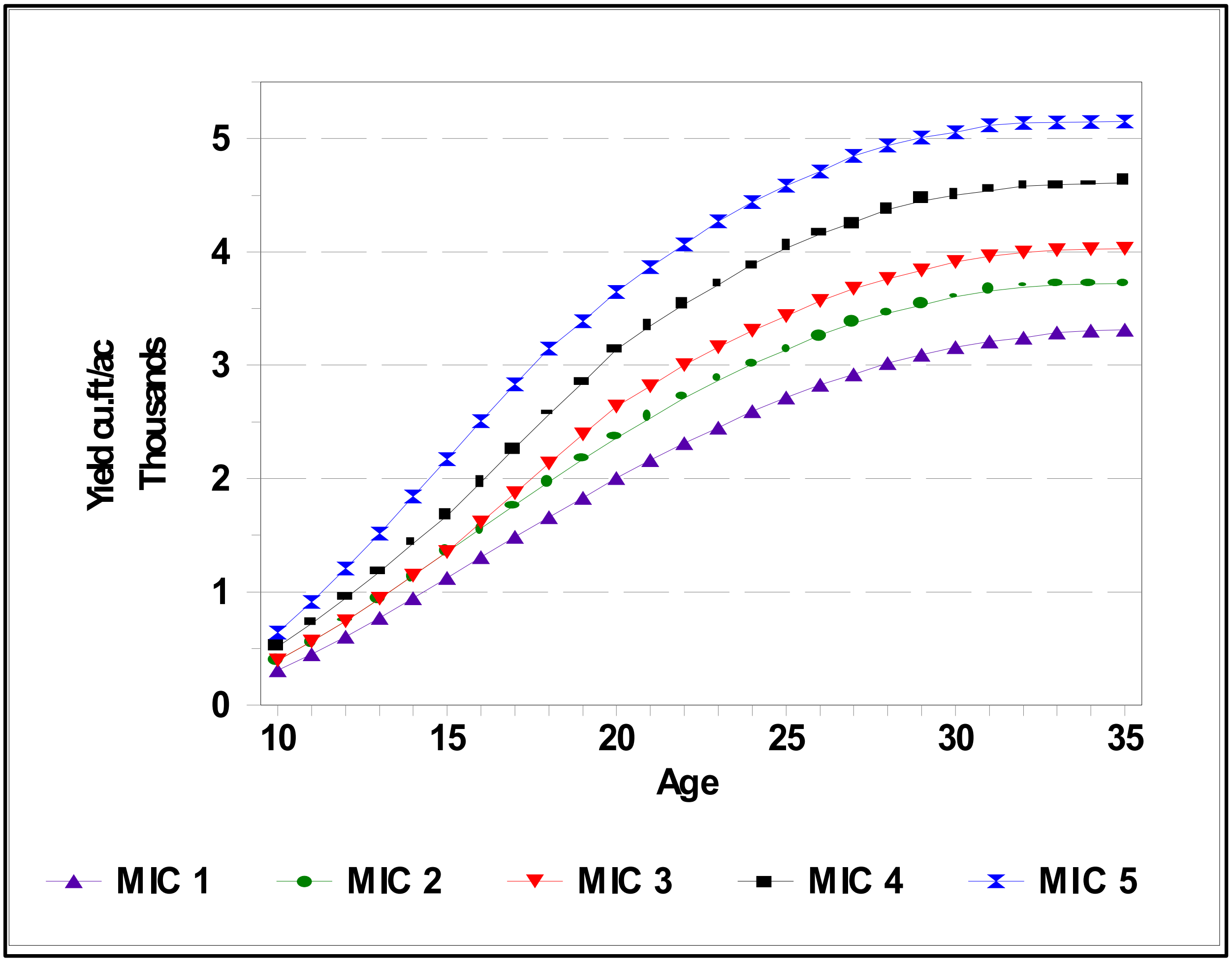

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Figure 2--Planted pine yields, Southeast thinned.

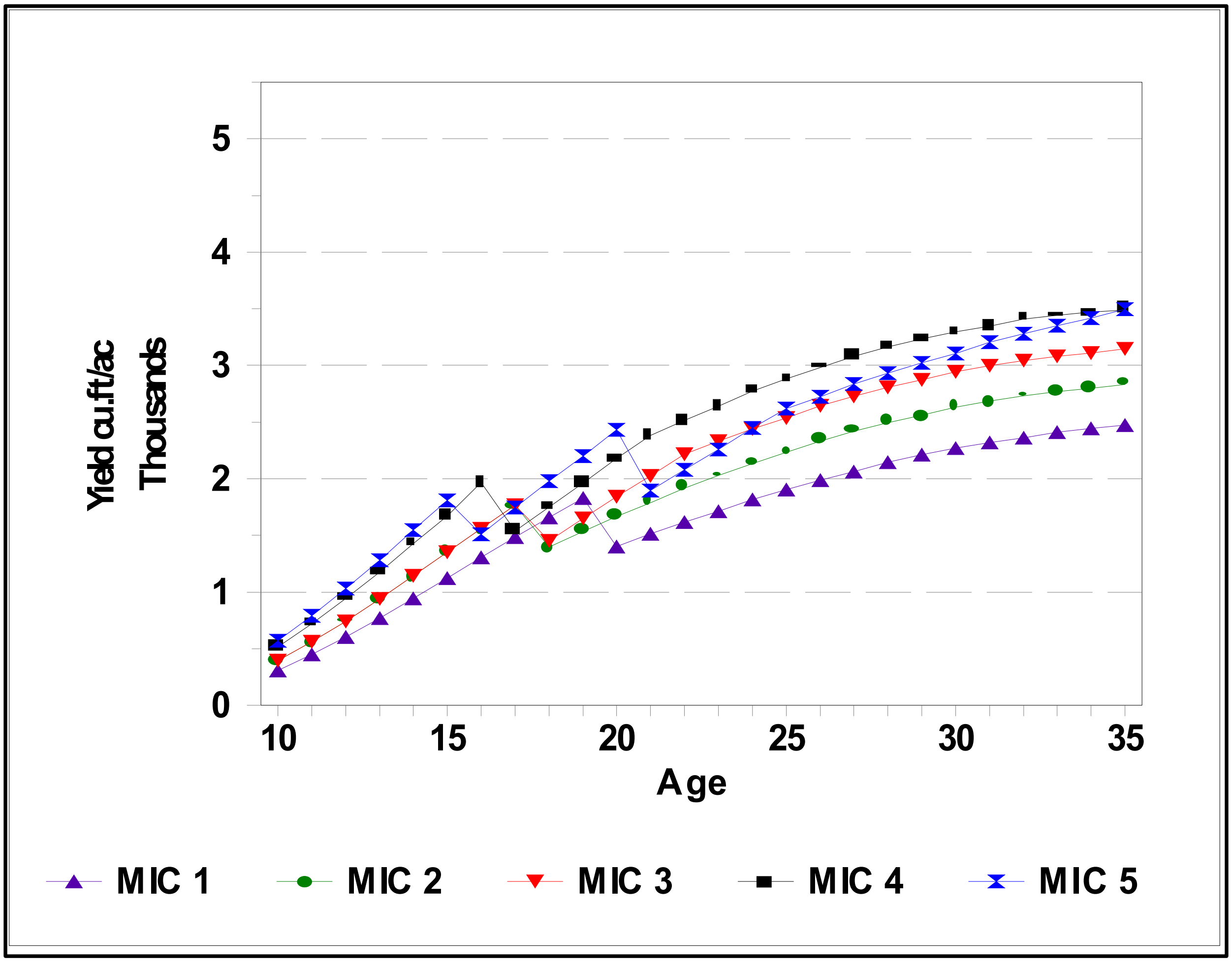

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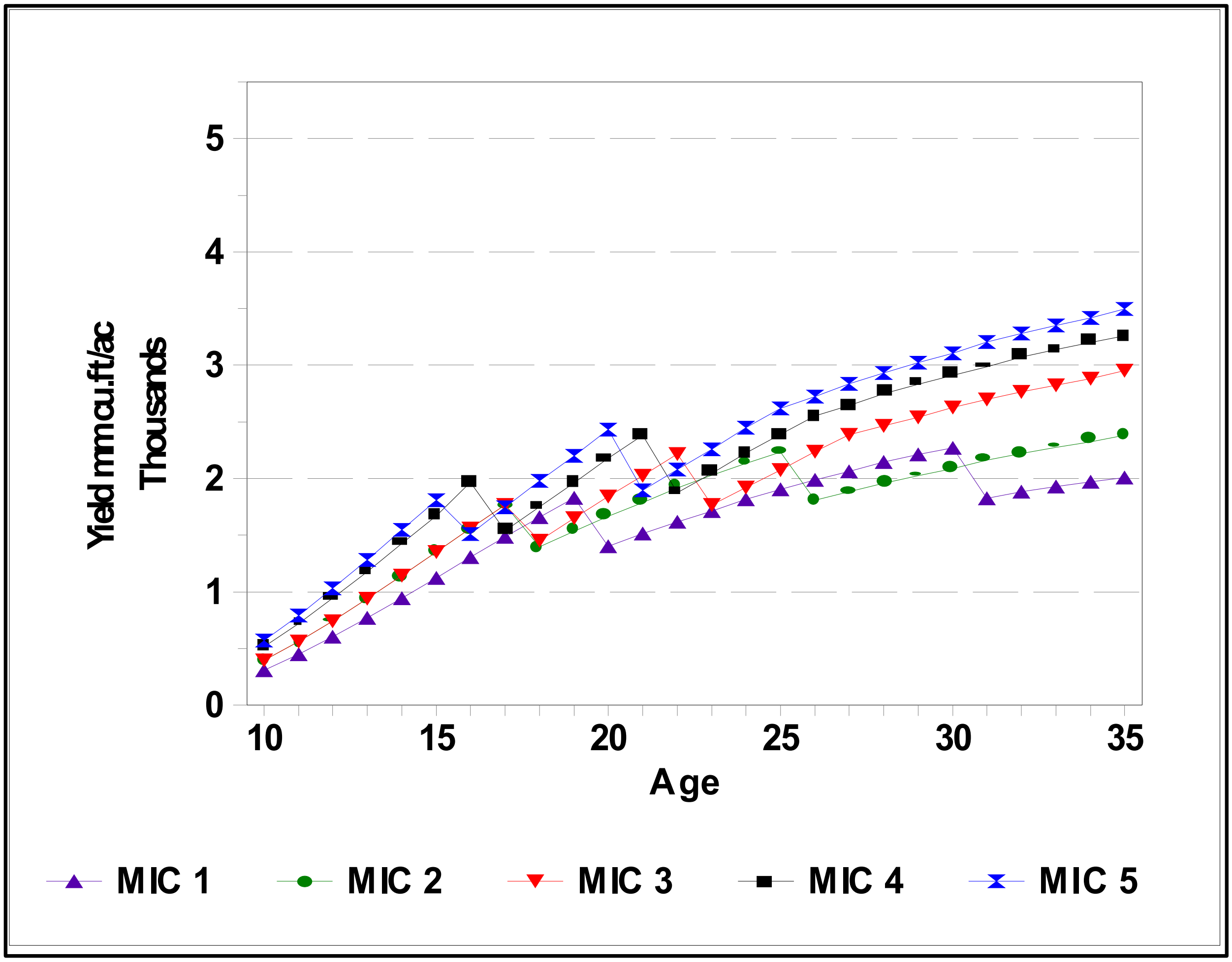
Figure 3--Planted pine yields, South Central thinned.



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