PINE

Potential Impacts of Increased Management Intensities on Planted Pine Growth and Yield and Timber Supply Modeling in the South

by

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Abstract

The South can increase pine productivity on its forest lands as increased timber prices make returns from intensified forest management more profitable. We determined the most likely management intensities on industrial lands resulting in five management intensity classes. They are used to estimate the potential growth and yield levels, and compare these to empirical pine yields, developed as a part of the SRTS model inputs and based on Forest Inventory Analysis (FIA) data. These comparisons indicate that projected plantation yields are much greater than empirical FIA data--almost 100% greater than current empirical yields. Projected yields were also up to 90% higher than those used in the 1995 Rangeland Renewable Resource Act (RPA) assessment. If realized, such productivity increases could prevent timber shortages. Financial analyses indicate that intensified forest management is economically feasible and offers attractive returns.

INTRODUCTION

Planted pine yield and growth rates have assumed a central role in forecasting the future timber supply in the South. This is because softwoods account for at least 60% of timber harvests in most regions. While in the past softwood harvests were obtained mainly from natural pine, at present planted pine contributes about a half of softwood harvests, and its share is predicted to increase rapidly in the future (Cubbage et al. 1999). While this paper is primarily focused on management intensities observed on forest industry lands, pine planting and management intensities are also predicted to increase on nonindustrial private forest lands (Moffat et al. 1998). These developments indicate rising southern planted pine productivity and should be adequately accounted for in timber supply analyses and development of forest policies.

U.S. timber supply is analyzed in RPA timber assessments and their periodic updates (Haynes 1990, Haynes et al. 1995). The RPA process uses two models to characterize timber resources of the United States. The Timber Assessment Market Model (TAMM, Adams and Haynes 1980, 1996) is used to model timber demand, and the Aggregate Timberland Assessment System (ATLAS) is used to model timber supply (Mills and Kincaid 1992). While RPA represents a comprehensive and interregional approach, detailed state and substate projections, required for analysis and development of private sector investments and local public polices, are provided by regional models. In response to demands for more timely and detailed information, the Subregional Timber Supply (SRTS) Model was developed (Pacheco et al. 1997). Both RPA and SRTS base their starting inventories and growth rates on empirical FIA data. The use of empirical data, however, presents a problem because empirical yields and growth rates cannot be used to model improved forest management. Thus, some experimental data on growth and yield reflecting rising productivity should be employed.

This paper is devoted to the development of basic southern planted pine growth and yield tables by management intensity classes. This growth and yield analysis was based on the TAUYIELD model, developed at the Virginia Polytechnic Institute and State University (Amateis et al. 1995). The paper begins with a brief description of the model, followed by a presentation of the management intensity classes used and the growth and yield tables developed. We developed planted pine yield tables for both unthinned and thinned stands on low, medium and high sites. For brevity, in this paper we present only the results for unthinned medium sites. Complete results for all sites are presented in a special SOFAC report (Siry 1998). Our analyses indicate that the

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South has the potential to significantly increase planted pine productivity. We also carry out capital budgeting analysis to assess the economic feasibility of intensified forest management. The paper closes with a discussion of the results and their potential applications.

This research is a part of ongoing Southern Forest Resource Assessment Consortium (SOFAC) efforts. These cooperative efforts have included 16 forest products firms and consulting organizations, two states, four USDA Forest Service Southern Research Station Research Work Units, and eight universities. The development of the basic southern planted pine yield tables represents a joint effort by SOFAC and the USDA Forest-Service intending to produce an integrated national and southern timber analyses as a part of the 1999 RPA timber assessment and to achieve a consensus view of the timber supply situation. The growth and yield tables were developed in a cooperative effort between personnel in SOFAC, the RPA timber analysis staff, forest industry representatives and the American Forest and Paper Association (AF&PA).

TAUYIELD

TAUYIELD is a stand-level growth and yield model for unthinned and thinned loblolly pine plantations (Amateis et al. 1995). The data used in the development of the model were collected from sites across much of the natural range of the species. The model consists of a system of three dynamic equations guiding height-age, survival and basal area development. Model inputs include number of trees planted and their survival rate, basal area and site index (SI). The model estimates number of trees, average height, basal area and volumes by dbh class. The performance of the model was evaluated using independent data from unthinned and thinned loblolly pine stands, indicating that the model generates reliable estimates of stand-level yields for many management scenarios.

MANAGEMENT INTENSITY CLASSES AND MODELING ASSUMPTIONS

Management Intensity Classes (MICs) and basic modeling assumptions for unthinned stands are presented in Table 1. There are five MICs which represent increasing management intensities. Management treatments include genetically improved stock, fertilization and competing vegetation control. Since TAUYIELD does not allow us to model these treatments explicitly, they had to be modeled by adjusting its inputs, specifically SI values, or they had to be developed outside the model and solved through iterative runs of TAUYIELD to find appropriate values for the independent variables.

Genetically improved stock was assumed to increase volume by 14% at the culmination of mean annual increment (CMAI). The model was run to determine the CMAI and the corresponding yield was increased by 14%. Then SI was increased until this yield was achieved. This procedure resulted in 4 foot SI increase on low sites and 5 foot SI increase on medium and high sites. The impact of 200 pounds of nitrogen and 25 pounds of phosphorus fertilization was modeled by increasing yield by 400 ft^3 during the 5-year period following 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.

Table 1. Southwide Unthinned Management Scenarios

Treatment/MIC	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

Note: Planting Density 600 TPA; Site Indexes at Base Age 25: Low 50; Medium 60; High 70

RESULTS AND DISCUSSION

Planted pine yields by management intensity classes on medium sites are presented and compared with yield values used by SRTS-FIA and RPA and yield values. recorded in 1997 FIA Georgia survey in Table 2. Yields vary from 2700 ft^3 /ac for MIC 1 to 4600 ft^3 /ac for MIC 5 at age 25. The difference of

1900 ft^3/ac indicates that MIC 5 has a potential to produce almost 70% more volume than MIC 1. In unthinned stands, the largest impact on yield comes from competing vegetation control. Competing vegetation control 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 420 ft^3/ac at age 25. Finally, as initially assumed, fertilization increases yield by 400 ft^3/ac.

SRTS yields rely exclusively on empirical growth and yield developed directly from FIA data, while RPA yields rely on FIA data as well as on yield curves developed during past RPA assessments. Our analysis of southern planted pine growth and yield indicates that projected plantation yields are much higher than historical FIA data (Table 2)--from 15% (for MIC 1) to 94% (for MIC 5) more than current SRTS empirical data for average sites at age 25. Projected yields are also greater than those used in the last RPA modeling efforts. Current MIC 2 through 5 have large potential productivity increases. Such productivity increases, if realized, could ameliorate timber shortages. Whether we can achieve such large increases is a crucial question that, to a large extent, will determine whether current southern timber supply forecasts and policies should be modified.

Table 2. TAUYIELD Projected Growth and Yield Data for Selected Management Intensity Classes Merchantable Wood Volume (ft^3/ac to a 4" dob top)

MIC/Age	10	15	20	25	30
MIC 1-Traditional	309	1121	2004	2716	3158
MIC 2-Genetics	396	1353	2355	3135	3605
MIC 3-MIC 2+F	396	1353	2637	3433	3912
MIC 4-MIC 3+H	518	1670	3139	4033	4502
MIC 5-MIC 4+2ndF&H	641	2170	3645	4587	5057
SRTS-FIA	568	1138	1708	2361	3013
RPA	310	1136	1892	2382	2824
1997 FIA Georgia Survey	420	912	1540	1969	2265

Notes:
1. TAUYIELD assumes Site Index 60 at Base Age 25 and Planting Density 600 TPA
2. F = fertilization; H = herbicide application

Using the 1995 RPA timber demand data, SRTS has been used to project timber inventory, harvest and prices for 12 southern states from 1990 to 2020. The model indicates that during this period southern softwood removals would increase by 24% and that private southern softwood supply would substantially decrease (Pacheco et al. 1997). At the same time, prices would substantially increase, at a rate much higher than the inflation rate. Although hardwood inventory appeared more stable as a result of a larger starting inventory and more favorable growth/drain relationships, it was predicted that in about a decade hardwood inventory would begin to decline and prices would rise. These projections were updated in September 1997, yielding similar results. The projections indicate softwood inventory decreases, harvest increases and price increases. These updated SRTS runs indicate that softwood still was in short supply, accompanied by rapidly increasing prices and significant inventory declines (Cubbage and Abt 1997).

Subsequent SRTS analyses have indicated that rapid increases in planted pine growth rates could significantly increase pine inventory and reduce prices. If planted pine growth rates would increase by 40% above the base growth rates of the late 1980s, pine prices would still double between 1997 and 2010, but then prices would stabilize. Doubled planted pine growth rates would stabilize pine prices at current levels. These results underlie the importance of assumptions about planted pine growth and yield as varying assumptions may lead to very different timber supply outlooks for the South.

RPA projections also depend heavily on assumptions made about increasing planted pine growth rates in the South. RPA assumes significant increases in the area of pine plantations and their growth rates and projects that between 1'990 and 2040 softwood harvests in the United States would rise by 35% and that southern private lands would be the major source of any softwood timber harvest expansion for the next 50 years (Adams and Haynes 1996, Haynes et al. 1995). These projections indicate the importance of increased management intensity in meeting future timber harvest needs. Growth rates used by RPA increase rapidly for future years, based on the premise of enhanced technology. The 1993 RPA assessment update forecasts that between 1991 and 2020 harvests on southern forest industry land would increase by 50% and net growth by 124%. While southern forest industry softwood inventory is projected to expand sharply, private softwood inventory is projected to decline steadily after year 2000.

The data collected suggest that higher management intensities are well within our grasp using existing technology for softwoods. And these higher management intensities are projected to be widely applied on industry and even on NIPF lands. Preliminary applications of the higher management intensities indicate that within 30 years, we could increase softwood timber inventory in the South from about 95 billion cubic feet currently to 175 billion cubic feet in 2030, compared to prior RPA base level increases to only about 120 million cubic feet. These in turn can be compared to recent SRTS projections of declines in southern softwood inventory, and the somewhat similar projections of softwood declines in the short run that were made in the 1995 RPA.

The number of acres of intensively managed pine plantations is crucial for southern timber supply projections. FIA defines planted pine at the sample plot level when the plot is classified as planted and the forest management type is pine. A large number of plots are classified as mixed pine or hardwood management types. Some of these plots, however, probably fall in planted pine stands with large amounts of natural hardwood regeneration. Depending on classification, the area of pine plantations may range from 28 million acres to 32 million acres. Intensified management can help reduce hardwood competition and increase the amount of softwood volume available at harvest.

If intensified forest management is practiced on a large number of acres, this optimistic view of rising inventory to meet increasing harvest levels seems more likely. This becomes a question of economics. The South has the technology to grow softwoods much faster, but the question is if this technology will be applied on a sufficient scale to have a major impact on regional timber supplies. Therefore, these projections must also undergo economic tests to determine their feasibility given current market conditions.

FINANCIAL, ANALYSIS

In order to obtain a better idea of how economically feasible intensified forest management is, we have examined planted pine growth and yield scenarios using Capital Budgeting (CB) techniques which discount the cash flows of the investments. The basic cash flow assumptions for the analysis on a per acre basis are summarized in Table 3. There are six management cost categories. On average, it is assumed that site preparation costs $140. Seedlings and planting cost $70. The use of genetically improved seedlings raises this cost to $75. Tax and administration expenses are $8 annually. Fertilization costs $50 per treatment. It was assumed that in MIC 4 herbicides are applied at year 1 and cost $50. Two types of herbicide treatments were assumed in MIC 5: (1) herbaceous treatment occurs at year 0 and costs $35, and (2) woody plant treatment occurs at year 3 and costs $50. There are only three revenue categories: two timber and one non-timber. The final harvest at year 25 produces pulpwood and sawtimber, which generate $25/cord and $350/MBF respectively. Cords and board feet are alternative units produced by TAUYIELD (Amateis et al. 1995). Hunting leases are assumed to generate $3 annually.

Basic financial measures commonly used in forestry--net present value (NPV), soil expectation value (SEV), internal rate of return (IRR) and annual equivalent (AE)--are presented in Table 4. These financial measures were calculated using a 6% real discount rate. In addition, a 1% annual timber price appreciation was factored in. NPVs vary from $359 for MIC 1 to $939 for MIC 5. Similar relationships apply to SEVs, which vary from $468 for MIC 1 to $1224 for MIC 5. Real IRRs for MICs vary from about 10% to 12%. All calculated criteria indicate that intensified forest management generates positive and apparently attractive financial returns.

'able 3. Summary of Input Costs and Revenues for Medium Sites

INPUT COSTS	$/ac	Timing
Site Preparation	140	0
First Generation Seedlings + Planting	70	0
Second Generation Seedlings + Planting	75	0
Tax and Administration	8	1-25
Fertilizer	50	MIC3-4@15, MIC5@8&13
Herbicide	50 35/50	MIC 4@1 MIC 5@0&3
REVENUES	**$/unit**	**Timing**
Hunting Lease	$3	1-25
Pulpwood	$25/cord	final harvest@25
Sawtimber	$350/MBF	final harvest@25

These criteria indicate that a move towards higher management intensities promises higher returns, reaching the highest level of return in MIC 5. The comparison of MICs with the traditional SRTS growth and yield data indicates that intensified forest management is a superior investment strategy. All MICs are characterized by higher NPVs and SEVs than the SRTS base, with MIC 5 being more than three times higher. IRRs associated with intensive management are also higher when compared with the SRTS scenario. Thus the higher MIC yields, which are much higher than SRTS yields, provide adequate financial returns for the higher input costs.

Table 4. Summary of Financial Analysis of Loblolly Pine Investments by Management Intensity Class (MIC) for Medium Sites. Base Case Scenario (Pulpwood $25/cord, Sawtimber $350/MBF)
'inancial Return Measures @6% Real Discount Rate

Management Alternative	Final Harvest (cu.ft/ac)	NPV ($/ac)	SEV ($/ac)	IRR (%)	Annual Eq. ($/ac)
SRTS-FIA Empirical	2361	290	378	9.4	23
MIC 1: Traditional	2716	359	468	9.9	28
MIC 2: Genetics	3135	526	685	10.9	41
MIC 3: MIC2+F	3433	581	758	11.2	45
MIC 4: MIC3+H	4033	798	1040	11.7	62
MIC 5: MIC4+2ndF&H	4587	939	1225	11.8	73

Notes:
1. Rotation age 25
2. Assumed 1% real annual timber price appreciation
3. F = fertilization; H = herbicide application

Even though our analysis indicates that intensified forest management is economically feasible and offers potentially attractive returns, several problems remain. It will be necessary to model accurately market adjustments to such projected changes. Higher inventories will moderate price increases, and thus reduce investments, which would reduce future supply increases. There have been markedly higher timber prices in the South, as well as significant reductions in agricultural production as price supports have been phased out. This new economic reality has shifted considerable interest to more intensive forest management on NIPF lands. The interaction of timber markets, landowner preferences, timber investments and world demand for wood products will influence the eventual level of management intensity on southern NIPF lands.

These developments indicate that softwood pulpwood supply problems could be resolved by intensive management. But questions remain with respect to softwood sawtimber and hardwood supply. New plantations can provide wood fiber, but quality and grade questions still must be considered. Questions such as lumber standards, needs for pruning, ability to make reconstituted fiber products, and other factors will still make softwood supply challenging. We have never grown wood in the South as fast as these models project and its technical properties need to be determined and milling and marketing adjustments made. Intensive forestry is not projected to increase southern hardwood timber inventory significantly. Neither the hardwood plantation technology or softwood substitution are projected to make much difference in hardwood supplies in the next few decades,

We must be cautious with interpreting our results even with respect to softwood pulpwood supply. The scale of this dramatic change from current practices and the long history of NIPF under-productivity makes us cautious about accepting, without reservation, these potential growth and yield figures for southern pine and the projected management intensities derived from the forest industry and NIPF surveys. The most recent 1997 Georgia FIA survey may help to illustrate this point (Table 2). With the exception of the youngest age class, Georgia yields are consistently lower than any MIC, SRTS or RPA yields. Georgia's youngest age class yields correspond to MIC 3, and falls between average SRTS and RPA yields. It is possible that the acreage of young, intensively managed pine plantations in Georgia has increased since the preceding survey and that the 1997 survey indicates increased productivity in these young plantations. Similarly, there may not be many intensively managed pine plantations in older age classes to reflect higher yields. As a result, Georgia yields corresponding to older ages remain considerably lower than yields developed in this study. If this is indeed the case, in about a decade we should begin to see increasing yields in older age classes as well. Therefore, the policy implications of projected timber surpluses--such as increasing government regulation with regard to forest protection or reducing timber harvest from public lands--are also problematic.

CONCLUSIONS

The South will increase softwood timber production using existing technologies. By applying known technologies on a large scale, the South can almost double softwood growth rates. If optimistic softwood growth and yield and resultant timber supply projections are indeed realized, we could ameliorate or even eliminate projected southern softwood timber supply problems, at least for pulpwood, and maybe even have a surplus of softwood fiber in the South. This depends on the number of acres devoted to intensive forest management and its economic feasibility. Our initial analysis indicates that intensive forest management is economically feasible and offers attractive returns. Because actual timber supply depends on many other factors, it is yet unclear whether we can actually achieve these potential timber growth rates across the projected area. Therefore, any modifications to timber supply forecasts and private and public policies affecting the availability of the resource should be made cautiously, making sure that additional analyses confirm these optimistic growth and yield and financial return model results.

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