

FOREST PRODUCTIVITY AND TIMBER SUPPLY MODELING IN THE SOUTH

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ABSTRACT.—The South can increase forest productivity on industrial and nonindustrial private forest (NIPF) lands. As timber markets have improved and timber prices have increased, returns from intensive management are more profitable. The interaction of timber markets, inventory, and prices are analyzed in new southern timber supply models sponsored by the Southern Forest Resource Assessment Consortium (SOFAC). Current SOFAC efforts have focused on integrating southern models and model inputs with the national Renewable Resource Planning Act (RPA) timber assessment. SOFAC researchers have developed timber supply models that can analyze timber markets trends at the subregional (survey unit) level. Growth and yield analyses prepared for the RPA indicate that substantial increases in timber productivity can occur given current technology, if fully implemented. A survey about NIPF land management practices indicates that considerable adoption of increased management intensities is projected to occur. Even higher intensities can occur on forest industry lands in the South. If these potentials are realized, we will be able to provide adequate pine pulpwood supplies at reasonable prices in the future. High-quality softwoods and hardwoods will be less plentiful. Hardwood timber supply will be relatively scarcer in the future, as reflected in increasing real prices, despite having almost 50% more standing inventory than softwoods currently.

The South has great opportunities to increase timber production on industrial and nonindustrial private forest (NIPF) lands. As timber markets have improved and timber prices have increased, returns from intensive management are more profitable. The interaction of timber markets, inventory, and prices are analyzed in new southern timber supply models sponsored by the Southern Forest Resource Assessment Consortium (SOFAC). This paper summarizes a few selected studies that we have performed as part of those SOFAC efforts, and draws some conclusions about implications for forest productivity and timber modeling in the South or elsewhere. This paper extends an earlier version presented at the 1998 Society of American Foresters annual meeting in Grand Rapids, Michigan (Cabbage *et al.* 1998), with more focus on forest productivity and regional timber supply implications.

The U.S. timber supply is analyzed in the decennial national Renewable Resources Planning Act (RPA) timber

assessments and their periodic updates (i.e., Haynes *et al.* 1995, USDA Forest Service 1988). The RPA timber analyses have generated keen interest by public and private sectors every time they have been released. All forest resources have become relatively scarcer with increasing population. The concomitant demands for timber, other commodities, amenities, and environmental benefits have increased. This scarcity has made developing and making accurate timber supply analyses more important over time.

In response to demands for more timely and more localized information about southern timber supplies, we organized a Southern Forest Resource Assessment Consortium (SOFAC) in 1994. This cooperative effort has included 16 forest products firms or consulting organizations, two states, four USDA Forest Service Southern Research Station research work units, and eight universities. SOFAC is designed to enhance our capabilities to analyze and model the southern forest and timber resource sector. Member firms and states have contributed more than \$100,000 per year, and the Economics research work units and the Southern Research Station have contributed about \$50,000 annually. Initial research efforts, which were performed by cooperating universities, focused on developing appropriate models for southern forests and timber markets. We have developed timber supply models that can analyze timber markets trends at the subregional (survey unit) level. We also have

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gathered better information that can be used in southern or national timber supply models, integrated southern with international models, and examined questions such as the effects of urbanization or investment levels on southern timber supplies. More recently, we have developed information on the most likely levels of management intensities on nonindustrial private forest (NIPF) lands, and cooperated with forest industry on related surveys on their lands. Based on the identified management intensities, we also have estimated the potential growth and yield levels that are likely to be applied on industrial and NIPF lands.

The SOFAC efforts in the South are currently being coordinated with the national timber supply analyses for the 1999 RPA. The national RPA inputs and projections will be used to drive the timber trend projections for the country, including the two broad Southeast and South Central regions. These RPA projections will then be broken down into state level and survey unit projections by the SOFAC models. The national RPA/TAMM (Timber Assessment Market Model) suite of models will use the same inputs and assumptions as the southern SOFAC/SRTS (Subregional Timber Supply) model. Communication among the national and southern researchers, as well as southern practitioners, should enhance satisfaction with the timber supply models, assumptions, and results. Some of these cooperative efforts—(1) SOFAC(SRTS)/RPA(TAMM) timber supply modeling; (2) southern management intensity; and (3) growth and yield by management intensity classes—are described below.

SUBREGIONAL TIMBER SUPPLY (SRTS) MODEL

The Subregional Timber Supply (SRTS) model is an economic simulation tool used to examine timber supply issues. It allocates aggregate harvest level requests to individual survey units in the South and to project timber inventories and prices in the future. SRTS projects timber supply for every year given assumed trends in forest land areas, future harvests, and price and inventory elasticities. The model requires forest inventory data (area, volumes, growth, and removals); assumed harvest and acreage trends; and input parameters like supply and demand price elasticities, inventory elasticities, and harvest weights for age classes and management types (Pacheco *et al.* 1997).

SRTS models competitive market conditions in a homogenous timber region consisting of numerous subregions. SRTS models supply as a function of price and beginning period inventory and demand as a function of stumpage price and a demand shifter. While the market price is determined by the aggregate harvest and inventory changes, inventory is modeled separately in the subregions. Regional price changes are applied to respective

regions, and along with subregional inventory changes, determine the change in subregional harvests.

SRTS's inventory algorithm uses the average survey unit net annual growth by species, management types, and age classes, and advances volumes during the projection through the age classes. Harvest allocation across management types and age classes is based on either initial harvest across age classes, inventory across age classes, oldest first rule, or their weighted combination. One year's worth of the unharvested acres (e.g., one-tenth of the 10-year age class cells) moves to a higher age class in each period. Growth is determined by applying average growth per acre by age class.

Based on the 1995 RPA projections, SRTS was used to allocate and project timber inventory, removals, and prices for 12 southern states from 1990 to 2020. Between 1990 and 2020, southern softwoods removals would increase by 24% and hardwood removals by 39% (Pacheco *et al.* 1997). During that projection period, private southern softwood supply would substantially decrease. At the same time, prices would substantially increase, at a rate much higher than the inflation rate. Although hardwood inventory and prices appear more stable as a result of a large inventory and growth, it was predicted that in about a decade hardwood inventory would begin to decrease and prices would begin to rise more rapidly.

These projections were updated in September 1997, yielding similar results. The projections indicated softwood inventory decreases, harvest increases, and price increases. Between 1990 and 2015, softwood real stumpage prices were predicted to increase by 3.1% annually. During the same period, hardwood real stumpage prices were projected to increase by 4.7% annually (Cubbage and Abt 1998). These new SRTS runs indicated that softwood still was in short supply, accompanied by rapidly increasing prices and significant inventory declines. Higher hardwood removal levels exceeded growth and caused prices to rise rapidly.

Subsequent SRTS analyses have indicated that rapid increases in pine plantation growth rates could significantly increase softwood timber inventory levels and reduce price increases accordingly. For example, if pine plantation growth rates increased by 40% more than the base level rates of the late 1980's, softwood prices would still double from 1997 to 2010, but would then stabilize. A doubling of softwood timber productivity would essentially stabilize softwood prices at current levels. The question then becomes one of estimating how fast we can grow softwood timber in the South, how many acres of plantations we will have, and how widespread intensive management techniques will become. Imports are another constraint on the large price increases projected by SRTS

operating as a closed southern model. It should be noted that so few hardwood plantations exist that their intensive management still remains more of a hope than a potential as of yet, so hardwood timber supply projections in the South remain fairly stable in all models.

Softwoods account for 60 to 70% of total southern timber harvests, depending on the region. Pine plantations make up about 15% of the total timberland area. Presently, planted pine contributes about half of softwood removals, and its share is predicted to increase rapidly in the future. Therefore, pine plantation area and growth rates become a focus in southern timber supply analysis. The number of acres of pine plantations is crucial in southern supply projections.

To run SRTS and apply the relevant growth and yield projections, we had to determine how many acres of plantations exist in the South, and then project the likely increases. The standard Forest Inventory and Analysis definition of planted pines at the plot level is applied when the plot is classed as "planted" and the forest management type is "pine." However, many plots are classed as planted, and "mixed pine" or "hardwood" forest management types. Examination of some of the plot data suggests that many stands are probably planted pines with large amounts of natural hardwood natural regeneration—not stands planted as mixed or hardwood species. Depending on what forest management types are included, pine plantations may range from 28 million acres (planted pine type) to 32 million acres (all forest management types). Growth and yield and intensive management, or timber stand improvement to reduce the hardwood components, could greatly affect the amount of softwood timber volumes in the future.

NIPF FOREST MANAGEMENT PRACTICES AND INTENSITY

As part of our southern timber supply efforts, we also needed information on the types of forest management practices likely and the intensity of management that is likely to occur in the future. As a contributor to the RPA modeling efforts, the American Forest & Paper Association (AF&PA) surveyed forest industry management practices and intensities in the country. Similarly, we

surveyed the state foresters in each of the 13 southern states to obtain their estimates of the likely management practices and management intensities on NIPF lands in the future. To inform their responses, we also provided current data regarding each of the management practices or land area description, based on the most recent FIA survey.

Our survey results indicate the projected changes for NIPF's between now and 2020 (Moffat *et al.* 1998). Planted pine area is projected to increase by 7% in the South, largely at the expense of natural pine area, which is projected to decrease by 6%. The average percentage distribution of acres in the other three forest types is projected to remain fairly steady for the next 22 years. However, the responses indicate that significant shifts will occur among individual stands after harvest. The state foresters estimated that by 2020, 62% of the harvested planted pine acres would be retained in the same type; 19% of natural pine acres; 36% of pine hardwood acres; 88% of upland hardwood acres; 93% of bottomland hardwoods; and 37% of nonstocked acres. These changes imply shifts among forest types, not loss of forest lands. The shifts will result in small changes in overall distribution of forest management types, but large variations on actual sites after harvests.

Management intensity is projected to increase dramatically for all forest types over the next 22 years, as shown in table 1. The greatest increases are in the pines, with bottomland hardwoods showing the next highest increase. If realized, these increases in management intensity will represent the largest changes in forest management ever experienced in the South. They also will do much to prevent potential timber supply shortages that have been projected based on current management practices.

On average, the state foresters responded that they believe that only a modest amount of forest land will be withdrawn from timber management, but this differed considerably for individual states. The least amount of projected land area removal came from the pines (-1% for planted pine; -2% for natural pines). Larger areas were projected to be withdrawn from the other forest types—9% less for both pine-hardwood and upland hardwood stands, and 11% less for bottomland hardwood stands.

Table 1.—Projected change in NIPF management intensity from now to the year 2020 for the South

	<u>Planted pine</u>	<u>Natural pine</u>	<u>Mixed pine hardwood</u>	<u>Upland hardwood</u>	<u>Bottomland hardwood</u>
Very intensive	+ 22	+ 14	na	na	na
High intensity	na	+ 17	+ 9	+ 5	+12

Table 2.—Projected change in clearcutting as the method of final harvest in the South

	Planted pine	Natural pine	Mixed pine hardwood	Upland hardwood	Bottomland hardwood
Southeast	- 11	- 19	- 23	- 42	- 40
South Central	+ 3	+ 3	+ 1	- 3	+ 1

Clearcutting as a method of final harvest was projected to decrease significantly in the Southeast and increase slightly in the South Central regions (table 2). The differences among regions were notable. We can only guess at the causes, but believe they could be attributed to a slight shift to even-aged management in the South Central region compared to its historical focus on uneven age management, and to a much greater shift away from even-age management in the Southeast, prompted by landowner desires, public opinion, and environmental pressures. Further investigation into these projections would be advisable.

MANAGEMENT INTENSITY AND YIELDS

As part of the SOFAC/RPA modeling efforts, we also developed the basic southern yield tables by management intensity classes. This again was done as a cooperative effort between personnel in SOFAC and the RPA timber analysis staff, as well as with forest industry representatives with AF&PA. Most growth and yield analyses were based on the TAILED (thinned and unthinned loblolly pine) model, developed at Virginia Polytechnic Institute and State University (Amateis *et al.* 1995). The natural stand yields were developed as part of the SRTS model inputs, and are based on empirical FIA data.

TAUYIELD is a stand-level growth and yield model for loblolly pine plantations. The data used in the development of the model were collected from sites across much of the natural range of the species. A system of three dynamic equations guiding height/age, survival, and basal area development constitutes the core of the model. 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.

Southern pine plantations yields were developed for a variety of Management Intensity Classes (MIC's). Management treatments include genetically improved stock, fertilization, competing vegetation control, and thinning. MIC's include MIC 6: regular seedlings; MIC 7: genetically improved seedlings; MIC 8: MIC 7 plus fertilization; MIC 9: competing vegetation control and fertilization; and MIC 10: all of the above plus

midrotation competing vegetation control and fertilization. TAUYIELD simulates thinning explicitly. The other management treatments had to be analyzed by adjusting the site index values in TAUYIELD, or they had to be developed outside the model.

The results from the SOFAC/RPA/forest industry analyses of southern pine growth and yields (table 3) indicate that projected plantation yields were much greater than historical FIA data—almost 70% more than the current empirical data. Projected yields are also up to 80% greater than those used in the last RPA modeling efforts. Such productivity increases, if realized, could easily prevent any timber shortages in the medium term, say from 2015 to 2040.

While growth and yield analyses indicate that substantially more softwood can be grown, these projections must also undergo economic tests to determine their actual feasibility. In addition, while these developments indicate that softwood pulpwood supply problems may be resolved, 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 will need to be determined and milling and marketing adjustments made.

CONCLUSIONS

The USDA Forest Service and the Southern Forest Resource Assessment Consortium (SOFAC) are cooperating to produce an integrated national and southern timber analyses as part of the 1999 RPA timber assessment. These efforts stem from desires to achieve a consensus view of the timber supply situation in the country, and to involve all the groups that rely on the RPA documents for making public and private decisions. Southern timber supply models are being used to complement the national models, and the lead Forest Service researchers in the Pacific Northwest are cooperating with Forest Service and academic forest economists in the South. Forest industry

Table 3.—TAUYIELD projected growth and yield data for selected management intensity classes wood volume in cubic feet per acre

MIC/Age	10	15	20	25	30
MIC 6 - 1st gen	309	1121	2004	2716	3158
MIC 7 - 2nd gen	396	1353	2355	3135	3605
MIC 8 - 7 + fert	396	1353	2637	3433	3912
MIC 9 - 8 + herb	518	1670	3139	4033	4502
MIC 10 - 9 + f&h	641	2170	3645	4587	5057
SRTS-FIA	568	1138	1708	2361	3013
ATLAS-RPA	310	1136	1892	2382	2824

Assumes Site Index 60 and Planting Density 600 Trees Per Acre. Management Intensities include: MIC 6: regular seedlings; MIC 7: second-generation seedlings; MIC 8: MIC 7 plus fertilizer; MIC 9: herbicides + fertilizer; MIC 10: all of the above plus midrotation herbicides and fertilizer. SRTS-FIA is based on regressions of FIA data by region; ATLAS-RPA is based on national RPA growth and yield data as of 1998.

is participating in the model development through subcommittees in AF&PA, as well as through SOFAC. Two states have contributed to SOFAC, and the state foresters have provided inputs via a survey on NIPF forest management practices.

The SOFAC cooperative effort has been successful at gathering inputs and providing a structured means to discuss them for the national RPA timber assessment. In-house SOFAC expertise provided a means to quickly develop MIC's and scenarios for the South, as well as survey NIPF management intentions. SOFAC funding expedited development of the core SRTS model, which will be used to disaggregate national RPA projections into subunits in the South, or for other timber supply simulations. Complementary timber models and analyses have been performed at several other institutions. SOFAC is still an experiment in cooperative forest economics research. It has provided an excellent vehicle for developing and focusing southern timber supply modeling efforts, as well as funding more theoretical or experimental efforts. As the 1999 RPA analyses are completed and southern timber supply skills become more widespread, SOFAC too will need to evolve to continue to be successful. A balance between applied and fundamental research and applications will be needed. Further work will need to be performed to examine implementation of the higher MIC's; better softwood and hardwood market components will need to be developed; timber availability will need to be assessed; and land area and government interventions may need to be examined.

The data collected suggest that higher management intensities are well within our grasp using given technology for softwoods. And these higher management intensities are projected to be widely applied on industrial

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 of only about 120 billion cubic feet. These, in turn, can be compared to recent SRTS projections of declines in southern softwood timber inventory, and somewhat similar projections of softwood declines in the short run that were made in the 1995 RPA. The suddenly optimistic timber inventory increases seem improbable, despite their apparent mathematical elegance. We are now in a process of examining these southern softwood growth, yield, and area projections to determine the most reasonable inputs and outputs. Timber availability and quality also are continuing questions. Intensive forestry is not projected to increase southern hardwood timber inventory significantly. Neither the hardwood plantation technology or softwood substitution is projected to make much difference in hardwood supplies in the next few decades.

If the optimistic softwood growth and yield and 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 surfeit of softwood fiber in the South. The long history of NIPF "underproductivity" and the fairly large change from current practices still must make us cautious about blindly accepting the potential growth and yield calculations and our NIPF management intensity survey results. Nor are we sure how to accurately model the market feedbacks of such projected changes. Higher inventories will dampen projected softwood timber price increases, and thus reduce investments, dampening future supply increases. There have been markedly higher

timber prices in the South, as well as significant reductions in cropping as agriculture price supports have been phased out. This new economic situation has shifted considerable interest to more intensive forest management on NIPF lands. The interaction of timber markets, landowner opinions, timber investments, and world demand for wood products will influence the eventual level of management intensity on southern NIPF lands. The policy implications of projected timber surpluses—such as allowing more environmental protection or government regulation or less timber harvest from public lands—also are contentious. Whether we can actually achieve the potential timber growth increases across the many acres projected is moot. These and other questions will continue to make our timber supply modeling and analyses interesting for years to come.

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