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THE NATURAL RESOURCE FOR THE FOREST PRODUCTS INDUSTRY

Projecting southern timber supply for multiple products by subregion

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Abstract

While timber supply modeling has been of importance in the wood-producing regions of the United States for decades, it is only more recently that the technology and data have allowed disaggregation of supply and demand to substate regions, including product specific breakdowns and endogenous land use and plantation changes. Using southwide data and an economic supply and demand framework, the Subregional Timber Supply model was used to project timber inventory, removals, and price, for subregions of the 12 southern states through 2030. Two hypothetical demand scenarios were modeled to reflect current recessionary impacts and potential for added bio-energy demands: 1) constant demands based on average 2002 to 2007 removals, and 2) a 30-percent recession reduction (2006 to 2009) and rebound by the same percentage (2010 to 2013), followed by a 0.5 percent per year demand increase for all products. Projections indicate that pine pulpwood markets are the least volatile under both demand scenarios and small pine sawtimber are the most volatile. Larger pine sawtimber markets have moderate price decreases due to the recession, which later increase to levels near current prices. Hardwood pulpwood and sawtimber both experience recessionary price decreases, and while prices recover partially, they do not return to current levels by the end of the projection period. Also, more growth and less timberland loss shifts more timber production and harvests to the southern coastal plain areas.

Since 1958, the U.S. Forest Service has prepared periodic analyses of national timber supply and demand. The earliest reports used historical and projected harvest and timber inventory accounting to determine if a gap existed between future timber supplies and future timber demands (USDA Forest Service 1958, 1965, 1974). After passage of the Renewable Resource Planning Act (RPA) in 1974, better integration of economic theory and available data, as well as the improving availability of computing technology, allowed development of empirical national and regional timber supply and demand projections (Adams and Haynes 1980). These models provided the basis for the RPA timber assessments in subsequent years (USDA Forest Service 1982, 1989, 2001, 2007; Haynes 1990, 2003; Haynes et al. 2007). All of these reports treat the South as two regions, with five states in the Southeast and seven in the South Central.

During development of the South's Fourth Forest (USDA Forest Service 1988), the Subregional Timber Supply (SRTS) model was developed to disaggregate the RPA model demands to the USDA Forest Service Forest Inventory and Analysis (FIA) survey units across the South. Subsequently, additional inventory modeling drawn from approaches employed by Cabbage et al. (1990) was added to the SRTS

model. This approach projected timber inventory using area, growth, and removals for FIA data by forest management type. SRTS incorporated this inventory projection model into a timber market model framework in order to project inventory, removals, and price based on theoretical supply and demand interactions, for a single product for two species groups—total volume for softwoods and hardwoods.

This two species group/single product version of SRTS has been used to model the U.S. South (Abt et al. 2000, Bingham et al. 2003) and Northeast (Sendak et al. 2003) to examine timber supply and prices. It also has been used in applications to explore the influence of nonmarket values on timber market decisions by nonindustrial private forest landowners

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(Pattanayak et al. 2002, 2005). Prestemon and Abt (2002) used the SRTS model to project timber supply in the Southern Forest Resource Assessment, and Schaberg et al. (2005) used the model to analyze the impacts of wood chip mills on timber supply in North Carolina. SRTS continues to be used by forest industry analysts and state forestry agencies, and improvements are continually made to the model, some in response to updates to the FIA data that is used in SRTS. Much of the current work on the modeling framework is currently supported by the Southern Forest Resource Assessment Consortium (SOFAC) at NC State University, a consortium of firms interested in strategic resource modeling.

In this paper, the SRTS model is described, focusing in particular on the changes and improvements to the model since 2000 (Abt et al. 2000). The major improvements to the model include the addition of endogenous land use projections and multiple product allocation. We then use the most recent version to project timber supplies across the 12 southern states under a constant demand scenario (base demand) and under a recession/rebound demand scenario that reduces demand by 30 percent from 2005 to 2009, then returns demand to historical levels with subsequent increases in demand of 0.5 percent per year. Projected changes in prices, inventory, and removals across the South from these timber demands are reported, and forecasts of geographic shifts in harvest across the 51 survey units of the South for the base and recession/recovery demand scenarios are included. The impacts of these demands on land use and pine plantations are also discussed.

SRTS structure and model scenarios

Model approach

Like most natural resource assessment tools, SRTS combines an economic resource allocation module with a biological model. In SRTS, the focus is on linking timber market price and harvest feedbacks with forest resource dynamics. The model was developed to examine the impact of market-level demand assumptions on the subregional, ownership, and forest type subcomponents of the supply side of the market. SRTS is a simulation tool that allows the user to examine the potential impact of different demand and supply assumptions on market and resource futures. SRTS was initially developed to project total volume by two major species groups, softwoods and hardwoods. In its initial form, it tracked inventory, growth, and removal data for 10 year age classes, which was then developed to project volumes and inventories through time. The model and data have now been improved to tabulate aggregate data in 5 year age classes and their associated diameter distributions. This detailed tracking allowed the model to be expanded to project timber inventories by multiple product classes and species groups.

Market module. — SRTS models product demand as a function of product stumpage price and demand shifters specified exogenously by the user. The product price responsiveness (demand price elasticity) is specified, as are demand shifts over time. Demand and product specifications apply to the entire market region being modeled. The model uses constant elasticity functional forms which ensure that the user-specified elasticities hold over all price-quantity combinations.

Product supply is modeled as a function of product stumpage price and inventory. The user specifies the supply-price

elasticity by product and owner. The user can also specify the supply inventory responsiveness by owner. The product price and harvest levels by product, subregion, and owner are simultaneously determined in the market equilibrium calculations. The inventory shift for the equilibrium calculation is estimated in the inventory module described below.

In each year the output from the market module is an equilibrium harvest by product for each region-owner combination. A goal program formulation described below allocates product harvest across management types and age classes.

Inventory module. — The inventory model begins with an estimate of starting inventory by subregion, ownership, species, forest type, and 5 year age class. The inventory changes through time by adding net growth and subtracting harvest estimated in the market module. Timberland acreage change can either be user-specified or linked to price sensitive land use models. **Figure 1** shows the data flows in the model.

Goal program. — The equilibrium harvests by region, owner, and product are allocated to the inventory by management type and age class with a goal program. The link between the products and inventory is based on user-specified product definitions. A product definition is specified as a range of diameters and a percentage degrade to pulpwood. Using this information, a product mix is calculated for harvest in any management type and age class.

The objective function for the goal program is to harvest across management types and age classes for each region-owner to achieve the projected target removals mix, while harvesting consistent with historical harvest patterns for this region-owner. The “consistent with historical” requirement is defined as bounds around existing removal-to-inventory intensities. If the new product mix cannot be met with this constraint, the removal-to-inventory bounds are relaxed.

For partial harvests, the goal program defines a stocking target (volume per acre) for each management type and age class based on starting data. If the current stocking is greater than the target, harvest is considered thinning. When volume per acre reaches the target, the remaining harvest is considered to be final harvested and acres are returned to age class zero. Under most circumstances this maintains average stocking near target levels throughout the projection. Thinning intensity can be changed by modifying the target stocking level.

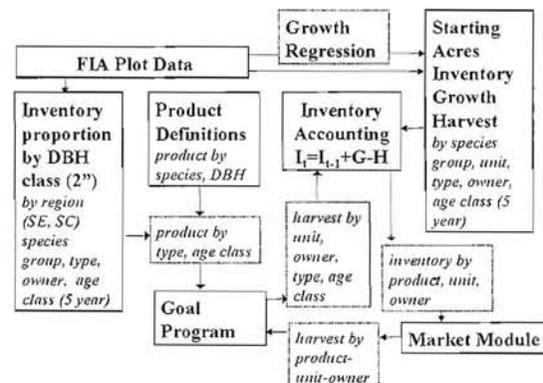


Figure 1. — SRTS data flows.

Model inputs. — The basic SRTS inventory dataset consists of estimates of growing stock inventory, growth per acre, removals, and acreage by subregion, species group, ownership, forest type, and 5 year age class. These datasets are provided with the assistance of the USDA Forest Service FIA Group in the Southern Research Station. These datasets are updated approximately every 3 months.

The FIA data are the key biological forest resource drivers for the inventory by forest management type, age class, and species groups. These data are now collected annually in all states in the South and available from the USDA Forest Service by request, or can be obtained through the FIA website (USDA Forest Service 2009). The website describes the data sets and FIA procedures, which are complex. The SRTS model uses a variation of the basic data sets with the area, inventory, growth, and removals classified into the relevant age class, management type, and species group categories.

Given the recent change in ownership structure of timberland, the distinction between the forest industry ownership and the miscellaneous corporate category is unclear. We specified corporate and non-corporate private ownership categories. The corporate category includes vertically integrated forest industry and miscellaneous corporate owners including Timber Investment and Management Organizations (TIMOs) and Real Estate Investment Trusts (REITs). Because public land harvest decisions are not necessarily price responsive, public lands are excluded from the market simulations.

For growing stock inventory, removals, and timberland acres, the input file includes regional totals by owner, management type, species group, and 5 year age class. Estimates of growth per acre, however, are based on regression models. For small regions, the growth on remeasured plots is highly variable. Rather than have the model use estimates based on the few plots that fall into any one category in the region of interest, regression is used to determine the shape over the growth curve from a broader region, while allowing the curve to shift to reflect local growth levels. Separate equations are estimated by species group, physiographic region, management type, and owner. A dummy variable is used to allow intercept shifts in the curve for each state. For example, there is one curve for the corporate-owned pine plantations in the coastal plain of Georgia. Florida coastal plain corporate-owned pine plantations would have the same shape but a different intercept. Non-corporate growth curves would have a different shape and different intercept shifts. For pine plantations, the level of the growth curve can be further calibrated to match the mean of the local region-owner data. For plots with missing ages, age is estimated using a regression on age and plot characteristics.

Most of the effort in developing a model run is accessing and summarizing the starting inventory data. This has been made more challenging by recent decisions by the Forest Service to limit distribution of ownership and county level data. There have also been challenges associated with calculating growth and removals during the transition from periodic to annual inventories. A typical input set is described in **Table 1**.

Table 1. — SRTS model inputs.

Data	Options	For this application
Subregions	Timberland acres consistent with FIA plot design and model data requirements (≥ 2 million acres of timberland)	FIA survey units
Product classes	User specified by 2 in. DBH ^a class and percent of product class that should be counted as pulpwood	Softwood pulpwood 5 to 7 in. DBH Softwood small sawtimber, 7 to 9 in. DBH, 30% pulpwood Softwood medium sawtimber, 9 to 13 in. DBH, 20% pulpwood Softwood large sawtimber, +13 in., 20% pulpwood Hardwood pulpwood, 5 to 9 in. DBH Hardwood sawtimber, + 9 in., 40% pulpwood
Demand and supply price elasticities; supply inventory elasticity	User-specified	0.5 (demand and supply price) 1.0 (supply inventory)
Demand scenarios	Demands can vary by product by year	Constant demand (base) Recession scenario reduces demand by 30% from 2005 to 2009, then returns demand to historical levels with subsequent increases in demand of 0.5% per year
Reforestation	Can respond to land prices or can be set to exogenous level or weighted levels.	Plantation acres are set to decrease slower than other types if timberland is decreasing, and increase faster if timberland is increasing.
Land use	Can respond to timber price changes or can be set to a fixed, exogenous level	Price responsive with county demographic impacts from Hardie et al.
Ownerships	Corporate, non-corporate private	
Management types	Pine plantations Natural pine Mixed oak pine Upland hardwood Lowland hardwood	
Age classes	5 year age classes	
Minimum harvest age	15 years	

^a DBH = diameter at breast height.

Model flow. — A run is initiated by applying starting harvest to the inventory data to estimate the initial shift in supply curves by region, owner, and product. The model then shifts the aggregate product demand curve as specified by the user. Demand is modeled at the aggregate level, i.e., all of the region-owners in the model run are assumed to face the same product demand curve. Harvest, demand, or price can be specified as the exogenous demand variable, and the market module will find the equilibrium solution for the other two parameters. Given the user-specified demand shift and estimated inventory shifts from by product, region, and owner from the inventory module, the model uses a binary search algorithm to find the market clearing price. This simultaneously determines harvest shifts across regions and owners. Harvest and acreage shifts are applied and the model proceeds to the next year.

SRTS is essentially a simulation framework that allows the user to use a simple market equilibrium mechanism to explore market and inventory responses to various supply and demand scenarios. "Forecasts" using the model require estimates of supply and demand elasticities specific to subregions, owners, and products. Because these are generally not available, using results from aggregate Southwide studies has allowed us to explore the basic economic implications at a detailed level, but they do not reflect many factors that might be unique to a particular region. By applying broad regional elasticities to specific regions and products, the model undoubtedly underestimates regional and product variation. This is assumed to provide a more realistic assessment than ignoring subregional economic responses. Recent work by the Research Triangle Institute and the USDA Forest Service could provide region and product specific elasticities for future simulations.

Scenario development

For this analysis, timber prices, inventories, and removals were projected based on two demand scenarios. The first hypothetical scenario sets the current demand equal to the base year (in this case an average based on 2002 to 2007) harvest and keeps demand (not harvest) for all of the products at that level through the projection to 2030. This base demand scenario is not a forecast of the future, but allows us to illustrate how changes in demand assumptions affect forest conditions as well as product removals.

The second hypothetical demand scenario accounts for the current recession by assuming a reduction in demand from 2005 to 2009, then a comparable rebound from 2010 to 2013 (recession/recovery). Subsequent to the rebound, demands for all of the products are assumed to increase by 0.5 percent per year. This type of recession-rebound has been referred to as a "v-recession", with a sharp decline and sharp rebound, but without a long period at the lowest level. According to a recent article in the *Wall Street Journal*, the probability that the current recession will be of this type is only 15 percent (Wessel 2009). It is used here because while we have information about the decline, we do not have any forecasts of a) the length of time the economy is expected to stay at the lowest level, or b) a recovery trajectory that is different from the recession trajectory. Recent demand analyses indicate that both sawtimber and pulpwood demands have declined as much as 30 percent since 2005, with the change in pulpwood demands occurring more recently. While not

a forecast of wood products demands, this demand scenario will illustrate the capabilities of the model and will show how different demand scenarios can be expected to influence model outputs.

Product definitions. — Diameter distributions for each region (Southeast vs. South Central), owner, management type, and 5 year age class are used to calculate product removals and inventory volumes by age class. The user specifies a diameter range and a "cull" factor which determines how much volume in each product class contributes to pulpwood. In this analysis, six products defined by species (hardwood and softwood) and diameter were selected. These are further defined in **Table 1**.

Elasticities. — Both the supply and demand price elasticities can vary by product, as can the inventory supply elasticity. In this analysis, we used a 0.5 supply and demand price elasticity and a 1.0 inventory elasticity for all of the products. Previous research has been conducted on aggregate demand and supply elasticities, but values for individual products are not available in the literature. The consensus is that the supply, demand and inventory responses are inelastic (Pattanayak et al. 2002).

Land use and management type. — The addition of a land use modeling component is based on work by Hardie et al. (2000). This model predicts timberland as a function of pine timber prices, agricultural rents, and county population forecasts. Generally, the model incorporated into SRTS holds agricultural rents constant and includes county population forecasts. The timber price provided for the land use forecast derives from the previous year's SRTS model output. Pine plantation acreage is assumed to respond to timber prices, with the remainder of the land use change allocated to the other four forest types. In this analysis, land use change was tied to pine pulpwood prices, management type change was weighted to lose fewer plantations as total timberland declines, and gain more plantations as total timberland increases.

Logging residual production and utilization. — Residual production can be tracked by species and survey unit. FIA logging residual factors per total cubic foot of growing stock removals are used by the survey unit to calculate logging residuals from total harvest by species. This feature allows improved modeling of the use of residuals in bioenergy and biofuels in response to policies requiring increases in the use of renewable energy sources.

Southern timber supply projections

Two hypothetical demand scenarios were modeled to illustrate the model operation and outcomes. The timberland, harvest, and inventory data used in these model runs was from the latest FIA database (**Table 2**). The market responses for the six products and two demand scenarios are compared in **Figures 2 through 7** (showing price, inventory, and removals projections for 2005 to 2030). **Figure 8** shows total timberland and distribution over management types for 2005 to 2030, and **Figure 9** shows acres by age class in pine plantations for 2005 to 2030. **Figure 10** shows the geographic variability in changes in softwood inventories over the projection period for the recession/recovery scenario. These projections illustrate the model performance under user-supplied demand scenarios.

Table 2. — FIA survey dates used in this analysis (data version 21).

State	FIA data year
Alabama	2006
Arkansas	2005
Florida	2005
Georgia	2005
Kentucky	2004
Louisiana	2005
Mississippi	2006
North Carolina	2005
Oklahoma	1993
South Carolina	2006
Tennessee	2005
Texas (east)	2006
Virginia	2006

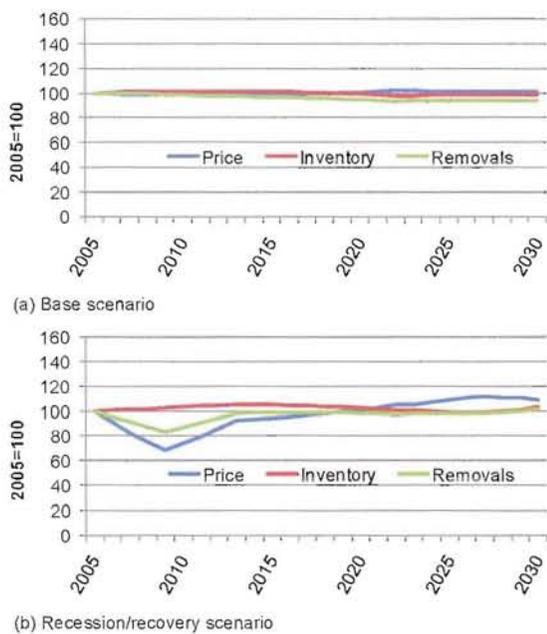


Figure 2. — Market responses in price, inventory, and removals for pine pulpwood in both the base and recession/recovery scenarios from 2005 to 2030.

The base scenario holds all six product demands constant at the average demand level from 2002 to 2007. The base scenario shows less market variability over time, as expected, and shows that some of the products (pine pulpwood) appear to be in long term equilibrium under this hypothetical scenario. Note that since pulpwood consists of the smallest diameter classes plus some proportion of the other products, it actually is a component of all age classes. This diversification across age classes tends to make this product class the least sensitive to transitional changes. The highest variability over time is in the pine small sawtimber product markets, which consists of a portion of a single (7 to 9 in.) diameter class.

Incorporation of the recession/recovery led to a reduction in demands for all products beginning in 2006, with full recovery not occurring until after 2013. At that time, a

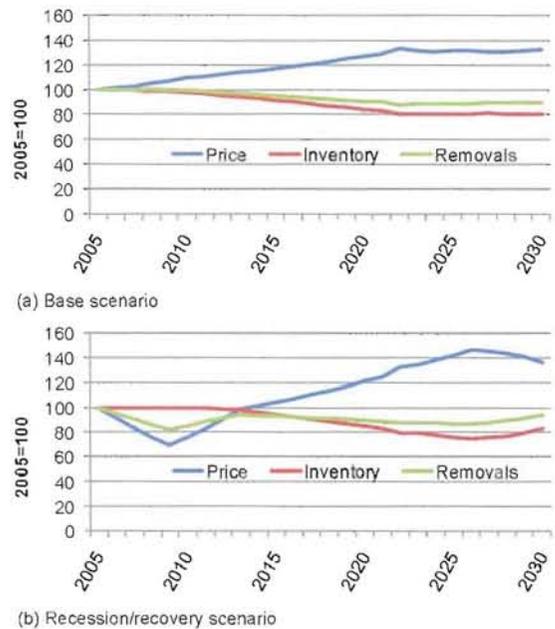


Figure 3. — Market responses in price, inventory, and removals for pine small sawtimber in both the base and recession/recovery scenarios from 2005 to 2030.

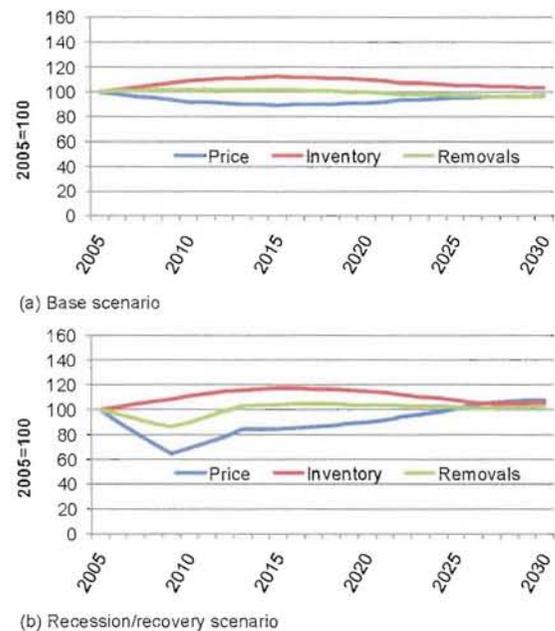
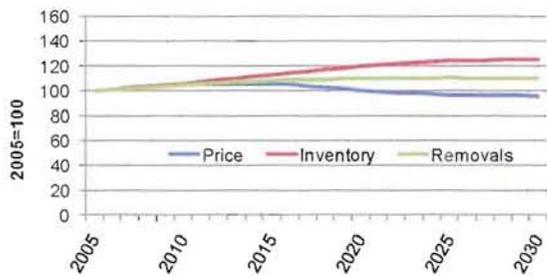
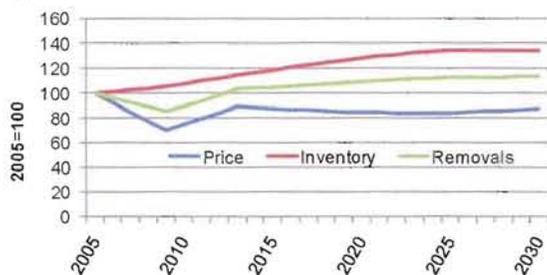


Figure 4. — Market responses in price, inventory, and removals for pine sawtimber in both the base and recession/recovery scenarios from 2005 to 2030.

demand increase of 0.5 percent per year was assumed, which could include increases from both traditional and renewable energy wood users. The recession/recovery scenario shows how inelastic supply leads to a greater price than harvest impact. The recession also changes the land use and planting rates, which have long-term impacts on age class distributions and product supply. These reactions and comparisons across the scenarios are discussed in more detail below.

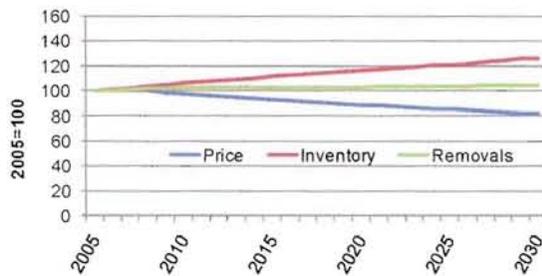


(a) Base scenario

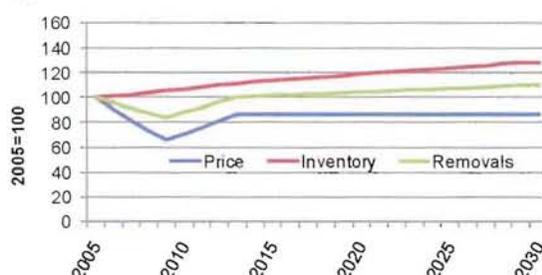


(b) Recession/recovery scenario

Figure 5. — Market responses in price, inventory, and removals for pine large sawtimber in both the base and recession/recovery scenarios from 2005 to 2030.

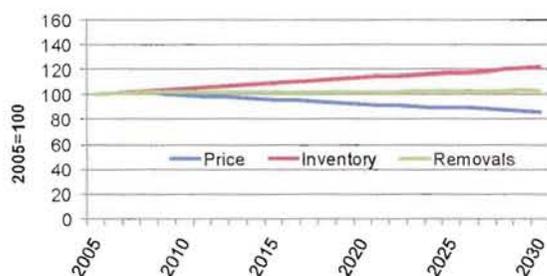


(a) Base scenario

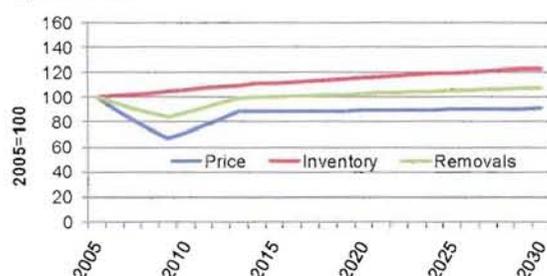


(b) Recession/recovery scenario

Figure 7. — Market responses in price, inventory, and removals for hardwood sawtimber in both the base and recession/recovery scenarios from 2005 to 2030.



(a) Base scenario

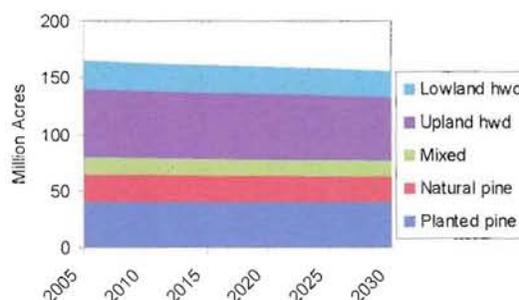


(b) Recession/recovery scenario

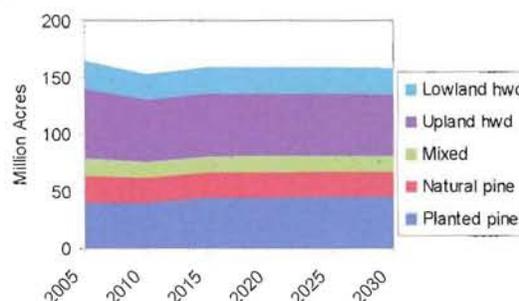
Figure 6. — Market responses in price, inventory, and removals for hardwood pulpwood in both the base and recession/recovery scenarios from 2005 to 2030.

Product market response

With constant demand in the base scenario, if product markets are in long term equilibrium, few changes in inventory, removals, or prices would be expected. Because product supplies are variable over time depending on age class structure, there are changes in price and harvest even with these constant demands. For the recession/recovery scenario, all of the product markets show a response to the recession, rebound, and subsequent recovery.



(a) Base scenario



(b) Recession/recovery scenario

Figure 8. — Acres of timberland in the five broad management types for 2005 to 2030 from the base and recession/recovery scenarios.

Figure 2 shows that the pine pulpwood market is the least volatile of the six product markets, under both demand scenarios. Comparing the index values for prices and removals illustrates the inelastic market response — price changes more than harvest. In this market, as in others, the rebound does not return the market (price or removals) to the prerecession levels until after 2020, in part because the harvest reduction

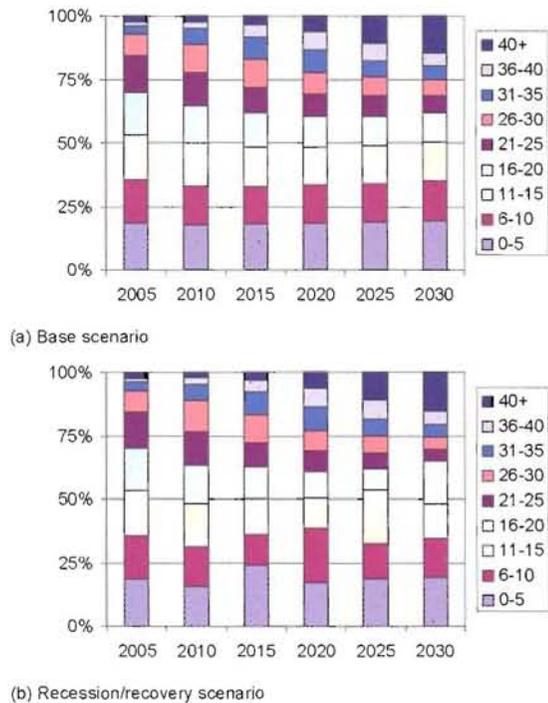


Figure 9. — Distribution of pine plantation acres across 5 year age classes from 2005 to 2030 for base and recession/recovery scenarios.

leads to an inventory increase that keeps prices below pre-recessionary levels.

Pine small sawtimber (Fig. 3) is perhaps the most volatile product, which, as discussed above, results in part from the small inventory and narrow diameter range of this product. A slow down in all harvests during the assumed recession leads to a reduction in planting, which has consequences in all products, but larger effects on this market from 2020 through 2028, reflecting the 8 years of reduced harvest during the recession.

Pine sawtimber (Fig. 4) and large sawtimber markets (Fig. 5) show a small effect of rising inventories (declining prices) in the base demand scenario. Sawtimber and large pine sawtimber markets show similar outcomes for prices, inventory, and removals for the recession/recovery scenario. For both market scenarios, however, the pine sawtimber market returns to current market levels, while the large sawtimber market shows the effect of increasing inventories on continually declining prices. Price, removals, and inventory for pine sawtimber return to prerecession levels by the end of the projection period.

Hardwood sawtimber and pulpwood markets have nearly identical responses in both the base and recession/recovery scenarios (Figs. 6 and 7), with inventories rising throughout the projection, and prices not recovering to prerecession levels. Both markets show a response to the recession and recovery, as expected. Availability is a key issue in modeling hardwood markets. Supply curves in SRTS are shifted based on changes in total product inventory. There may be an increasing divergence between total hardwood inventory and available inventory based on ownership goals, tract size, and access. While these results suggest that the total inventory is

increasing through time, further research is needed to determine how much of this inventory is available for harvest.

Land use and management type changes

One of the more significant and long-lasting effects of the recession/recovery is shown in Figure 8, which shows total timberland acres for each year of the projection and the proportion of timberland in each of the five management types. Land use changes little in the base scenario, as would be expected, because timber prices change little. Greater changes occur with the recession as pine pulpwood prices decline, leading to declines in timberland. As noted above, we assumed these price effects had smaller effects on pine plantations than on the other management types. The rebound raises timberland acres, and timberland area ends the recession/recovery projection at a higher level than in the base scenario.

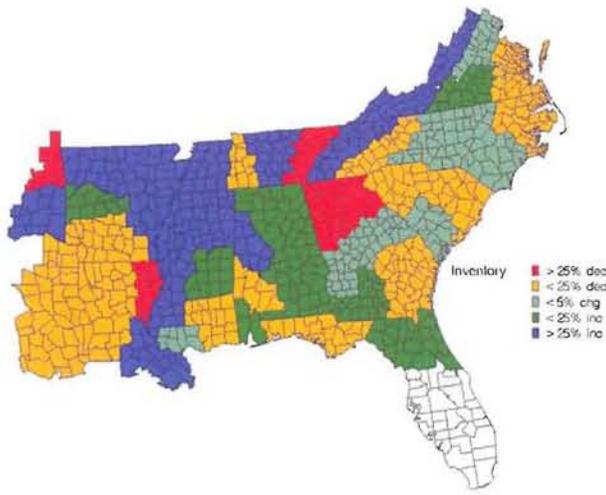
Pine plantation age structure over time

Over a relatively short recession as modeled in our recession/recovery, one notable impact is the decline in pine plantations that occurs in part because less land is available for planting when harvests decline, but also because planting is expected to respond to timber prices, declining when prices decline throughout the recession. Figure 9 shows the age class distribution of pine plantation acres across age classes for 2005 to 2030 for both demand scenarios. Both the base and recession scenarios show an accumulation of land in the oldest age classes, indicating that once plantations “escape” from pulpwood to pine sawtimber harvests, the lower demands for sawtimber allow inventories to accumulate. The younger age classes show the differences between the two demand scenarios. The base scenario, as with land use, shows little change in planting rates, which is consistent with the smaller changes in prices and removals from the constant product demands. Under the recession/recovery, however, there are noticeable differences in planting rates reflected in the smaller quantities in the youngest age classes in the middle years of the projection.

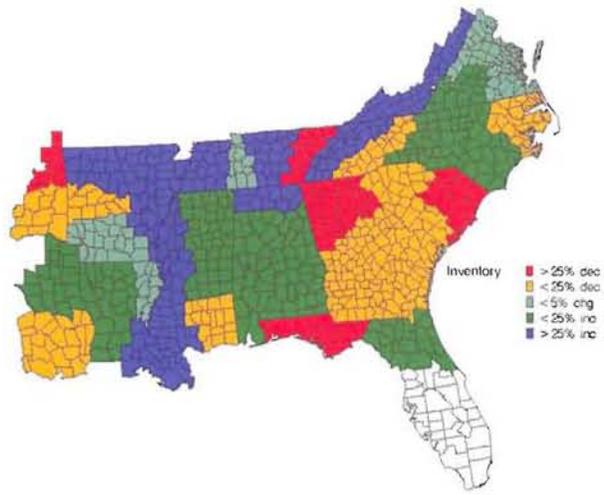
Subregional shifts in harvest

As the model name indicates, the Subregional Timber Supply Model provides the ability to project trends in inventory, removals, and price by subregions. While region-wide projections are useful, they may mask important differences in wood supply in a local area, and in fact South-wide trends are never uniform throughout the region. This feature is one of the principal advantages of the model, as well as an important reason for its widespread use for strategic planning and “wood basket” analyses. The model can be used for small areas, but approximately 2 million acres of private timberland are needed in each subregion for the data to be reliable enough for projections. To illustrate the standard SRTS projection outcomes, Figures 10(a) through 10(d) show the projections of SRTS results from 2005 to 2030 for the four pine products. These maps were developed from the recession/recovery scenario, although the relative shifts (percentage changes) maps from the base scenario are not very different.

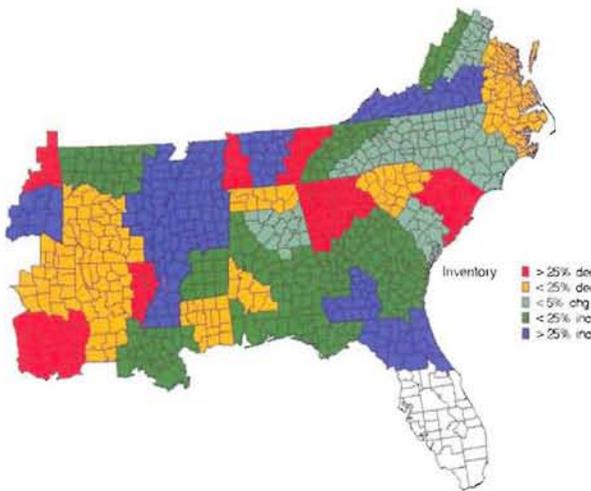
The percentage changes shown in Figure 10(a) for pine pulpwood inventory should be interpreted cautiously. For example, large percentage shifts in the Mississippi Delta do not represent enough volume to affect markets. Conversely,



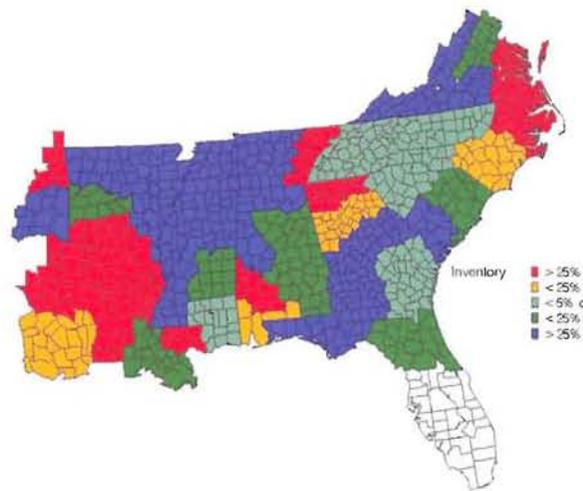
(a) Pine pulpwood inventory change 2005-2030



(b) Pine small sawtimber inventory change 2005-2030



(c) Pine sawtimber inventory change 2005-2030



(d) Pine large sawtimber inventory change, 2005-2030

Figure 10. — Initial inventory and inventory change from 2005 to 2030 by subregion and product class from the recession/recovery scenario, in terms of percentage change in pine inventory from 2005 to 2030.

projected decreases (between 5% and 25%) in some of the most important pulp wood baskets — southeast Georgia, southern South Carolina, and the West Gulf could be significant. There is little change for much of the rest of Alabama, South Georgia, North Carolina, and part of Mississippi. Even so, these declining pulpwood trends in several areas reflect the decrease in planting noted above.

As discussed, the small pine sawtimber class is the most sensitive to projection changes, since it comprises a narrow diameter range. The projections for this class differ moderately from the pulpwood projections (Fig. 10(b)). The Mississippi Delta and mountain survey units still have large percentage increases, but again over a small base. For the key east central states of Georgia and South Carolina, however, there are moderate to large decreases in pine small sawtimber, as well as in west Florida. There are moderate increases in pine small sawtimber in all of Alabama, the pine regions of Mississippi and Louisiana, and northeast Texas.

Pine sawtimber projections are different. Alabama, South Georgia, north Florida, and North Carolina all have stable to increasing amounts of pine sawtimber, as does the less meaningful Delta region. But, the West Gulf region generally has declining inventories, which would adversely affect its traditional sawtimber based forest products sector. Noticeable projected pine sawtimber decreases also occurred in South Carolina and the northeast North Carolina/southeast Virginia survey units.

There are projected increases in pine large sawtimber throughout most of the South except for the West Gulf survey units in south Arkansas, east Texas, Louisiana, as well as the same eastern North Carolina and Virginia survey units. These trends may reflect not only a large inventory of pine sawtimber, but also that some of these large trees are not readily accessible, which may be a false indicator of large pine timber availability.

Although maps are not provided here, SRTS also projected that the Southwide hardwood pulpwood inventory would

increase moderately through 2030. Hardwood pulpwood had the greatest increases in the survey units in the mountains and Cumberland Plateau, with moderate increases in most of Florida, Georgia, and North Carolina. The northeast North Carolina/southeast Virginia survey units and North Florida, however, had substantial projected inventory decreases. The southern survey units from Alabama to East Texas all had moderate to large decreases in hardwood pulpwood.

Hardwood sawtimber varied somewhat from the pulpwood projections. The mountains and Cumberland Plateau survey units all had projected increases in hardwood sawtimber inventory; most coastal survey units had projected decreases in hardwood sawtimber inventory. The core Delta survey units and the northeast North Carolina/southeast Virginia survey units had large projected decreases in hardwood sawtimber inventory.

These projections by survey unit and forest product illustrate the utility of SRTS. Aggregate Southwide projections consistently indicated increases in total inventory based on the moderate increases in demand after the recession. For many of the major pine wood-using survey units and product combinations, however, there were some projected decreases in inventory levels, and associated price increases. Adding significant new demands, such as biomass production, in these units would lead to larger decreases in inventory and larger price increases. Furthermore, some regions that have promising percentage increases in inventory, such as the Mississippi Delta and Cumberland Plateau, do not actually have large pine wood volumes, so harvesting the small amounts wood will be costly. And some regions, such as northeast North Carolina and Southeast Virginia, do not appear to have sustainable harvests in the medium term.

Conclusions

SRTS has become part of the evolving set of timber supply models that have been developed in the United States over the last several decades. The SRTS model integrates economic theory, including land use and timber markets, with forest growth dynamics to simulate the impact of changes in both demand and supply conditions for individual or aggregated subregions of the U.S. South. These more recent extensions of SRTS allow more detailed analyses and user-defined product categories on a smaller area, such as a survey unit, and also include the impact of land use change. The ability to differentiate between large regional projections and smaller areas such as survey units is important for wood products, since they still are linked closely to local markets due to high wood transportation costs and fairly fixed mill locations. Regional totals may be misleading for practical strategic planning and policy analyses, and SRTS provides a means to decompose these projections to smaller areas.

The modeled demand scenarios illustrate that lower recessionary demands will result in expected lower harvests and prices and higher inventories. The shift among regions and across products reflects the inventory levels and harvests that existed at the start of the forecast, as well as expected changes in available inventory resulting from changes in planting rates and land use.

SRTS is a market simulation model based on empirical relationships between supply, price, land use, reforestation, and inventory, not an economic optimization or engineering

model. SRTS was developed to examine medium run (5 to 25 yr) changes in timber markets response to changes in demand. Long-run forecasts or structural changes in markets could alter the fundamental relationships embedded in the model.

The simple economic framework and reliance on FIA data also require careful interpretation. First, FIA data is subject to sampling error for each component, including timberland area, product class, species group, and other variables. Second, SRTS assumes that historical market relationships and management decisions will hold in the future. But, policy, biophysical, demographic, and economic relationships are dynamic. Third, the economic assumptions about price, inventory, and demand elasticities, especially by product, region, and owner, are uncertain. Even in the econometric studies that estimate elasticities, only about 30 percent of the variation is explained by these relationships. SRTS is used for strategic planning and for public policy analyses and provides a consistent approach for examining the sensitivity of different market assumptions and policies on timber inventory, harvest, and growth over time.

The SRTS model is revised periodically and updated to address questions of policy or management interest, such as bioenergy feedstocks and management intensity. In addition, changes in the FIA database result in continual changes to the model structure and present continuing challenges as privacy and national consistency concerns change the availability, update frequency, and structure of the database. Additional research regarding hardwood availability, economic responses of planting rates, and incorporating silvicultural responses to emerging markets is underway.

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