Projecting the Industrial and Nonindustrial Timber Resources of Louisiana with STRIPS
by
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Abstract
The Southern Timber Resource Inventory Projection System (STRIPS) was modified to break out the loblolly/shortleaf pine forest types in Louisiana by industrial versus other ownerships. The model's overall projection results for the state did not change significantly with this modification. Comparisons of softwood and hardwood area, growth and inventory reveal only minor differences between the original projections and the projections with the modified model. Both models project the total pine inventory to decline by 2.8 billion cu. ft. between 1991 and 2010, with the majority of this decline occurring on non-industrial natural loblolly/shortleaf pine areas. Both versions of the model also project hardwood inventories to remain relatively stable, with slight declines toward the end of the projection. The results show several differences in the projections of industrial and non-industrial loblolly/shortleaf pine ownerships. The area of industrial pine—planted and natural combined—is projected to increase, while the area of pine in other ownerships is projected to decrease. In addition, industrial pine acres are projected to be converted to planted pine at a faster rate than on other ownerships. Finally, the volume-class distribution for industrial pine acres at the end of the projection was substantially more skewed toward smaller volume classes than on the other ownerships.

INTRODUCTION
In the seven years since the spotted owl was listed as an endangered species, the South has become the unrivaled wood basket of the U.S. Harvests from Southern timber inventories are at all-time highs, and in many cases harvests now exceed growth. Timber supply modeling and projection has always been one of the mainstays of forest economists, and the increased harvesting in the region has raised concern about timber supplies to new levels.

Timber inventory projection is a subset of the field of timber supply analysis. Many approaches have been proposed for projecting regional timber inventories. Examples of timber inventory projection models include: the Timber Resource Analysis System (TRAS) (Larson and Goforth 1974), the Timber Resource Inventory Model (TRIM) (Tedder 1983), the Aggregate Timberland Assessment System (ATLAS) which replaced TRIM (Haynes 1990), the Georgia Regional Timber Supply model (GRITS) (Cubbage et al. 1990), the Southeastern Regional Timber Supply (SERTS) model which replaced GRITS (Pacheco, et al. 1996), and the Southern Timber Resource Inventory Projection System (STIRPS) (Tucker and McDill 1996, Tucker 1996).

All timber inventory projection models aggregate and classify data about diverse forests in different ways. Some of the more basic variables commonly used to classify forest inventory data are region, forest type, age class, volume class, site class, and ownership. For this paper, STRIPS was modified to break out the loblolly/shortleaf pine forest types in Louisiana by industrial versus other (non-industrial) ownerships. Figure 1 shows the distribution of timberland in Louisiana by ownership for the last three Forest Inventory and Analysis (FIA) surveys. The single largest ownership group in the state is non-industrial private forest (NIPF) landowners. Forest industry is the second-largest ownership group, and a relatively small area is publicly owned. Breaking out all three of these ownerships would result in too few data for the public ownerships. We assumed that publicly owned pine lands would be managed more like NIPF pine lands than like industry pine lands, so industry lands were broken out from all other ownerships.

The most basic question considered here is

![Figure 1. Louisiana timberland area by ownership — 1974, 1984 and 1991. (Source: FIA data.)](image)

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whether the predictions of the model would be significantly altered by disaggregating the loblolly/shortleaf pine forest types into the two ownership classes. Ownership patterns affect management practices and the mix of forest product outputs obtained from the forest. Pine management, in particular, tends to differ considerably between different ownerships, with industry typically managing more intensively. Figure 2 illustrates this by showing, by ownership, the area clearcut, established and planted in the loblolly/shortleaf pine type between the 1984 and 1991 FIA surveys. While industry clearcut a larger proportion (18.2%) of their loblolly/shortleaf pine lands over this seven-year period than the other ownerships, they also established 71% more acres in that type than they harvested. In contrast, NIFP owners clearcut only 14.1% of their loblolly/shortleaf pine lands, and the area established in this type by NIFP owners was 10% less than the area clearcut. Public pine lands were the least likely to be clearcut, and 20% more loblolly/shortleaf pine acres were established on that ownership than were clearcut. Of the newly established acres on both industry and public ownerships, a high proportion — more than 80% — are in relatively fast-growing plantations. On NIFP lands only 55% of the newly-established acres in this type were planted.

![Figure 2. Loblolly/shortleaf pine acres clearcut, established and planted between 1984 and 1991, by ownership class. (Source: FIA data.)](image)

The modified model was used to project Louisiana’s forest inventory from 1991 to 2010. We expected the disaggregated model to provide new and interesting insights into how management differences between ownerships would influence the future state of the resource. In the final section of this paper, we show how pine lands on the different ownerships are projected to change in the next two decades.

**THE STRIPS MODEL**

STRIPS is an applied state timber inventory projection model which does not require economic inputs such as supply, demand, or price data (Tucker and McDill 1996). STRIPS is similar to GRITS (Cubbage et al. 1990). However, unlike GRITS, which projects aggregate timber volumes through age classes, STRIPS projects the volume by forest type of four species groups — pine, cypress, soft hardwoods, and hard hardwoods — on individual FIA plots. Plots are classified in STRIPS by forest type and volume class. STRIPS does not use stand age because this variable is generally missing in the South Central FIA region. The FIA data include a stand age variable for each plot for each survey. However, the age field for the majority of the plots in the South Central region has been classified as "92", which is a code that means "mixed age."

STRIPS does not require any behavioral information, mill data, or consumer demand data. However, STRIPS does require inventory, growth and harvesting data. As with most of the models mentioned earlier, FIA data were used to estimate the inventory growth and removals rates for STRIPS. Total harvest levels are specified exogenously. A combination of FIA removals estimates and severance tax removals data were used to estimate harvest levels for this study. Severance tax data were used to give annual variations, but they were adjusted so that the average removals over the most recent survey cycle are closer to the removals estimates from the FIA data. For projecting from 1991 to 1995, adjusted annual removals rates from severance tax data were used. For 1996 and beyond, total removals were assumed to remain flat at a constant rate equal to the average removal rate between 1992 and 1995. This is probably a very conservative assumption; if recent trends continue removals will continue to increase. However, our projections suggest that recent removals rates may prove unsustainable, and higher prices may prevent removals rates from increasing further.

FIA plots are the basic projection units in STRIPS. The plot attributes recognized by STRIPS are forest type, area, and volume by species group. Four species groups are recognized: pine, cypress, hard hardwoods, and soft hardwoods, following FIA definitions. The total plot volume is simply the sum of the volumes in each species group. Plots are classified into eight volume classes, starting with 0 cu. ft./ac., and increasing in 500 cu. ft./ac. intervals, up to greater than 3,000 cu. ft./ac. The nine forest types normally used for STRIPS in Louisiana are:

- planted longleaf slash pine,
- natural longleaf slash pine,
- planted loblolly/shortleaf pine,
• natural loblolly/shortleaf pine,
• oak-pine,
• oak-hickory,
• oak-gum-cypress,
• elm-ash-cottonwood, and
• non-stocked.

For this study, the loblolly/shortleaf pine types were broken down further into four forest type/ownership groups:

• industry planted loblolly/shortleaf pine,
• other planted loblolly/shortleaf pine,
• industry natural loblolly/shortleaf pine, and
• other natural loblolly/shortleaf pine.

This resulted in a total of eleven forest type/ownership groups. For brevity, these forest type/ownership groups will be referred to below simply as forest types.

STRIPS projects the state of a plot one year forward by first adding an estimate of growth to the volume by species group for each plot. These growth estimates are based on each plot’s forest type and volume class. Next, plots are selected to be clearcut or partially harvested. The area to be harvested from each forest type and volume class is based on the proportion of the area harvested from that forest type and volume class over the previous survey cycle, adjusted proportionately to produce the exogenously-specified removals target for that year. Plots within a forest type and volume class are selected randomly for harvest. Multiple projections are run and averaged to wash out any effects due solely to this random process.

After removals have been allocated, some plots are moved to different forest types to reflect management activities and natural processes. The area moved from each forest type is determined by four Markovian forest type change matrices:

• for undisturbed plots with 500 cu. ft./ac. or less,
• for undisturbed plots with more than 500 cu. ft./ac.,
• for partially harvested plots, and
• for clearcut plots.

Plots are selected to be moved from one forest type to another by sorting the list of plots in the source forest type by how well they match the profile of plots in the target forest type. Plots are selected off the top of the list until an appropriate area has been moved. Forest type profiles are based on the average proportion of volume in each species group for each forest type and volume class. Once growth, removals and forest type change have been applied, STRIPS begins a new projection year.

STRIPS can be calibrated to project volume by species group and area by forest type nearly perfectly from one FIA survey to another. To do this, growth rates are adjusted using one calibration parameter for each of the four species groups, and the rates of forest type change are adjusted using one calibration parameter for each forest type. For calibration, STRIPS is set up to repeatedly project from one survey to the date of the next survey, iteratively improving the values of the calibration parameters on each projection. The model is calibrated when the projected volumes by species group match the corresponding target volumes for each species group and the projected forest type areas match the target areas for each forest type.

A key assumption of the STRIPS model is that management decisions and growth rates during the projection period will be similar to those observed in recent FIA survey cycles. Parameter files used to allocate growth and removals are developed from historical FIA data. STRIPS is also calibrated to accurately project the state of the resource over the most recent survey cycle. To the extent that management decisions and growth rates during the projection period will differ from those observed in the recent FIA data, STRIPS projections will not be accurate.

**STRIPS PROJECTIONS FOR LOUISIANA**

Our original STRIPS projections (with nine forest types) for Louisiana, Texas, and Mississippi were reported in Tucker and McDill (1996). The projection results from this study (with eleven forest types) did not differ significantly from the earlier results for Louisiana. Inventory, growth and removals projections for Louisiana’s softwoods and hardwoods are presented briefly here.

Figure 3 shows the projected inventory, growth and removals for pine. Pine inventory is projected to decline by 34.1% over the 19-year period, from 8.4 billion cu. ft. to 5.6 billion cu. ft. The transition of acres from the natural pine forest type into the planted pine forest type is primarily responsible for pine growth remaining stable throughout the projection, even though total inventories is projected to decline. Pine growth as a percent of the pine inventory is projected to increase from 5.7% in 1991 to 8.6% in 2010. Unfortunately, even with our conservative removals assumptions, projected pine removals are more than 10% of the projected inventory by 2010. The original STRIPS model also projected a decline of 34.1% in the pine inventory between 1991 and 2010. Figure 4 shows the projected inventory, growth and removals for hardwood. Hardwood inventory is projected to remain relatively stable throughout the projection. Hardwood inventory is
projected to increase to over 9.0 billion cubic feet and then begin a slight decline around the turn of the century when removals begin to exceed growth. Hardwood growth is projected to decline gradually over time. Projected hardwood inventory in 2010 is 8.57 billion cu. ft. with the modified version of STRIPS. In the original projection, hardwood inventory was projected to decline gradually to 8.50 billion cu. ft. — a difference of less than one percent.

Note that while total removals are constant for 1996 and later years, projected pine removals decline and hardwood removals increase. This is because the model assigns removals more-or-less proportionate to inventory. As the pine inventory becomes a smaller component of the total inventory, projected pine removals decline. Similarly, projected hardwood removals increase because hardwoods constitute a growing proportion of the total inventory.

Cypress is an important species group in Louisiana. Cypress projections with the modified model were similar to the projections with the original model. To save space, they are not repeated here.

It is encouraging that the overall projection results of the model are similar, whether or not ownership differences are recognized. This gives us more confidence that the model’s predictions are robust with respect to how the data are aggregated. The fact that both models are calibrated to project the actual volume and acreage over the 1984-1991 survey cycle provides one possible explanation why the projection results are so similar. The most surprising result is that there is a bigger difference, albeit still small, in the hardwood projections than in the softwood projections. Recall that only the loblolly/shortleaf pine forest types were disaggregated. This result is a reminder of the many interactions that can occur in modeling.

**Figure 3.** STRIPS projections of pine inventory, growth, and removals for Louisiana — 1991 to 2010.

**Figure 4.** STRIPS projections of hardwood inventory, growth and removals for Louisiana — 1991 to 2010.

**OWNERSHIP RESULTS**

In this section, we present some of the projection results for the different ownerships. Since only the loblolly/shortleaf pine types were broken out by ownership, the focus is on the results for those forest types.

Figure 5 shows yield curves based on the growth models used in STRIPS for planted and natural loblolly/shortleaf pine on industry lands and on other ownerships. The figure shows total volume, which includes hardwood volume. A larger proportion of the total volume will be hardwood on the naturally-regenerated plots. While the growth models are not age-based, we can produce yield vs. age curves by projecting the volume on a plot that starts with no volume. Only the industry-planted curve has the sigmoid shape we would expect. For the other forest types, growth continues to increase at an increasing rate over the 50-year period. Up to age 35, the projected volume on planted-industry plots is greater than on all other classes. However, beyond that age, both other-planted and industry-natural plots will have more volume than industry-planted plots. This is not not be affected by this since almost all the industry-planted plots will be clearcut before age 35.

Figure 6 shows the area projections for the four loblolly/shortleaf pine ownership/origin combinations. The total area of loblolly/shortleaf pine is projected to increase slightly. By 2010, the area in natural loblolly/shortleaf pine — on both industry and other ownerships — is projected to decline by 1.02 million acres from the 1991 level. However, over the same period, the total area in planted loblolly/shortleaf pine is projected to increase by 1.4 million acres. The area in the industry-planted type is projected to nearly double over the projection period. Although the area in the
The figures show a dramatic projected shift from a relatively even distribution across volume classes in 1991 to a distribution composed primarily of the smaller volume classes in 2010. This trend is largely due to shifts in the distribution of industry lands. The projected distribution on other ownerships remains relatively balanced.

other-planted type is projected to increase, this increase is less than the decrease in the other-natural type. Thus, the total area of loblolly/shortleaf pine on the non-industry ownerships is projected to decline.

Figure 7 shows the pine inventory on loblolly/shortleaf pine plots by ownership and origin. Currently, the bulk of the pine inventory is in natural stands on the non-industrial ownerships, but the volume on the other-natural type is projected to decline by more than half by the end of the projection. In spite of the sharp projected increase in the area in the industry-planted category, the inventory on that forest type is not projected to increase proportionately. This indicates that the volume per acre on that forest type is projected to decline.

Figures 8 and 9 show the distribution of loblolly/shortleaf pine acres by volume class and by origin and ownership for 1991 and 2010, respectively.
billion cubic feet over the 19-year projection, with the majority of this decline occurring on non-industrial natural loblolly/shortleaf pine forests. Hardwood inventories are projected by both versions of the model to remain relatively stable, with slight declines toward the end of the projection. Currently and throughout the projection, over one third of the total land area of Louisiana is in the loblolly/shortleaf pine types. In 1991, over 32% of the total volume is in the loblolly/shortleaf pine types. By the end of the projection, however, only 25% of the total volume is in these types.

Significant shifts in land area by origin and ownership are projected for the loblolly/shortleaf pine types. The total area of loblolly/shortleaf pine types is projected to increase over the projection period. However, the area of loblolly/shortleaf pine on the non-industry ownerships is projected to decline slightly. Both ownership groups show a trend toward increased

![Figure 9. STRIPS yield curves (total volume) for loblolly/shortleaf pine types, by origin and ownership.](image)

areas in plantations and less area in natural stands. However, industrial pine acres are projected to be converted to planted pine at a faster rate than on other ownerships. In spite of this shift, total growth on the pine types is not projected to increase significantly. This is because of a shift in the distribution of area by volume class from higher volume classes, with higher growth per acre, to lower volume classes. This projected shift is particularly dramatic on the industrial ownerships.

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Literature Cited


