Investment in Forest Management in the Southeast: Effects on Future Timber Inventories and Prices

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Abstract.—A simulation approach was used to examine the potential influence of timberland investments by nonindustrial private owners on softwood inventory levels and prices in the South. The approach involved estimating timber investment opportunities using financial analysis and forest inventory data, simulating the enrollment of these opportunities, and projecting prices. Price projections were made using two contemporary timber market models and the results were compared. The two models varied greatly in the sensitivity of price projections to changes in inventories. This leads to questions regarding the correct form of timber supply models and the modeling of timberland investments.

INTRODUCTION

According to several studies, a large pool of the timberland area in the U.S. South could be managed more intensively and at an attractive rate of return (e.g., USDA Forest Service 1988). Most of these timber investment opportunities occur on land held by non-industrial private owners. This ownership group, which accounts for 120 million acres in the South, likely represents the greatest opportunity for expanding the timber production in the U.S. The level of forest management on nonindustrial private lands could significantly influence the future course of timber markets in the South. This paper examines the opportunities for investing in nonindustrial private timberland in this region, and the possible influence that adopting these investments might have on future timber markets.

Our approach is divided into three steps. In the first, we use cost and yield data along with timber price projections to identify feasible (in terms of a real rate of return) investment opportunities in the South. These opportunities are translated into inventory effects in the second step by applying various assumptions regarding enrollment of these investments. In the final step we use two timber market models to project timber prices for a 40-year period and examine the sensitivity of these models to assumptions regarding investment/enrollment scenarios. We describe our approach in detail in the three subsections that follow.

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INVESTMENT OPPORTUNITIES

Investment in most commodities other than timber is usually modeled as a function of various actual and expected prices and costs, with expectations represented as distributed lags in previous prices/costs. In the case of timber we cannot apply this econometric approach because we have virtually no information on historical investment behavior. In addition, we have limited insight into the decision processes for this highly varied ownership group. Therefore we must proceed with some simplifying assumptions. Because we are uncertain about the validity of assumptions pertaining to future events, we conduct sensitivity analyses for these assumptions. This allows us to construct what we consider to be a reasonable range of effects.

Important assumptions that we apply to our investment analysis are 1) that private land owners are rational in the economic sense, and 2) that private owners have myopic price expectations. The latter assumption implies that they undertake management plans based on a price projection and do not adapt their plans in the short-run to changes in the actual price path. This assumption, which is in sharp contrast to those employed in investment models for other commodities, may be partially justifiable in the case of timber since the level of investment (growing stock) can always be adjusted downward, so that over-investment in the long-run is unlikely.

The economic analysis of timber investment opportunities was conducted using the model described in the South's Fourth Forest Report (USDA Forest Service 1988). This model applies costs and price data collected on a subregional level to various forest management activities and outputs to compute rates of return and present values for a variety of timber investments. These investment results were then applied to the various inventory categories which comprise the forestland base in the U.S. South. If the rate of return for an investment cleared a prespecified "hurdle or threshold rate" then the management activity was considered an investment opportunity.

For this analysis we used the base prices and costs that were developed for the South's Fourth Forest Report (these were assembled by Vaseievich 1988). We then constructed nine different investment scenarios by varying our assumptions regarding hurdle rates and softwood sawtimber prices (softwood pulp and hardwood prices are held constant). We considered three alternative hurdle rates; 4,7, and 10%, and three alternative price projections: 1) constant real prices, and 2) 1.8% and 3.7% annual real rates of increase in prices.

ENROLLING INVESTMENTS

In order to estimate the effects of investments on future timber inventories, we must: 1) define the portion of the investment opportunities which might actually be enrolled on nonindustrial lands and 2) translate investments into changes in future softwood growing stocks. We defined six enrollment scenarios by applying two timing scenarios—a) implementing all investments in the first decade of the simulation or b) implementing investments over the next four decades—and by three scenarios for the percent of investments undertaken: 1) 25%, 2) 50%, or 3) 100% . These six enrollment scenarios were applied to each of our investment opportunity scenarios defined above.
Inventories were incremented beyond our baseline case by applying the increment in estimated net annual growth for each new investment. This change in forest productivity was accumulated in the growing stock as a linear function of time, assuming a 40 year rotation period.

**PRICE EFFECTS**

The final step in our analysis is to examine changes in price projections associated with shifts in nonindustrial timber inventories in the South. Most econometric models of the timber market use inventory levels to shift timber supply functions through time (e.g., Adams and Haynes 1980, Robinson 1974, and Newman 1987). Inventory levels in this situation can be viewed as a scarcity measure, so that decreasing growing stocks, with all else constant, shift the timber supply function inward. It follows that investments which augment timber inventories shift supply outward and result in a decrease in the market price for timber.

To estimate price effects we used two contemporary market models. One is the Timber Assessment Market Model or Tamm (Adams and Haynes 1980), the model used by the U.S. Forest Service to project national timber markets. The other is Newman's (1987) regional market model of the U.S. South. The two models differ in their regional scope and also employ different forms of the timber supply equation. Newman takes the classical approach and models supply as a linear function of price and inventory. In contrast, the supply variable in the Tamm model is the ratio of cut to standing inventory, modeled as a function of timber price. These two forms imply different kinds of supply shifts arising from shifts in softwood inventories. Our intent is to examine the relative sensitivity of these two supply models to plausible shifts in inventory. Again, our point of departure is the latest (at the time of this analysis) production run of the Tamm model for the 1989 RFA Assessment (USDA Forest Service 1989). The base projections should be considered preliminary.

For our analysis with the Tamm model, we extracted the timber supply equations for the southeastern region of the U.S., using them to project timber prices for our investment/enrollment scenarios. Supply equations are specified in Tamm for industrial and nonindustrial ownerships, respectively as follows:

\[ \frac{dI}{dt} = 0.01113 + 0.0002139 p_s + 0.005583 d_{82} + 0.01004 d_{83-84} + 0.01244 d_{85} + 0.01431 d_{86} \]

\[ \frac{dS}{dt} = 0.01298 + 5.133 \times 10^{-5} p_s + 0.003692 d_{83-84} + 0.003591 d_{85} + 0.004891 d_{86} \]

2 The source of the equations is a personal communication with Darius Adams, 2/89.
where $C^t$, $I^i$, $C^o$, $I^o$ are cut and inventory values for industrial and nonindustrial private ownerships respectively, and $P_s$ is the price of stumpage. $d_{22}$ is a dummy variable for the year 1982 and so on.

To construct our simulation model, we solved these equations for $C^i$ and $C^o$ and defined projections for the exogenous variables. These are total harvests ($D^t$) harvest from public lands ($S^o$), and softwood inventories ($I^i$ and $I^o$). Endogenous variables were $C^i$, $C^o$, and $P_s$ for a total of seven variables. By equating supply and demand we defined a system of seven linear equations with seven unknowns 3. The system has the general form:

$$\begin{bmatrix}
P_s \\
S^o \\
S^i \\
D^t \\
I^i \\
I^o
\end{bmatrix} = A \begin{bmatrix}
P_s \\
S^o \\
S^i \\
D^t \\
I^i \\
I^o
\end{bmatrix}$$

where $A$ is a 7 x 7 matrix of coefficients and $h$ is a 7 x 1 vector of right hand side values containing values for the 5 exogenous variables and constants for the supply equations. After setting the values of exogenous variables, we solved for the endogenous variables in each period by inverting the $A$ matrix and postmultiplying by $h$. We can examine the influence of changes in inventory projections on price projections by substituting our projections into the $h$ vector and solving for new $P_s$, $C^o$, and $C^i$. We also constructed a simulation model using the southwide market model developed by Newman (1987). His market model for softwood sawtimber has the following form:

$$D^t = g (P_s, P_p, w, r, D^{t-1})$$

$$S^i = f (P_s, P_p, I^o)$$

where $P_p$ is the price of lumber, $w$ is a wage rate, $r$ is the capital rate for the solid wood products industries, $P_p$ is the softwood pulpwood price, and $I^o$ is total regional softwood inventories. We constructed the simulation model by solving for the reduced form equations for $P_s$ and $S^i = D^t$:

$$P_s = -1.14 \times 10^{-9} I + 1.771 P_p + 4.4967 P_f - 11.8899 w$$

$$+ 319.311 r + .000081 S^{i-1} - 473.325$$

$$S^i = 0.003285 I - 5.721 P_p + 1070.9 P_f + 56615.2 w$$

$$+ 505062.1 r + 0.3873 S^{i-1} + 765566.2$$

3 While the supply equations are nonlinear after solving for $C$—there is a $P_s \times I$ term in both equations—we can "linearize" the system because $I$ is an exogenous variable. That is, we multiply inventory by the original coefficient to define the $P_s$ coefficient in the equation.
Again after specifying exogenous variables and setting identities, we have an exactly identified system of equations which can be solved for the endogenous variables (in this case, $p$, and $s^t$).

Forecasting with these models requires projections of the exogenous variables. We assumed that lumber prices would follow the course defined by the baseline Tamm run. In addition we assumed that harvest levels from public lands would also follow this baseline run, and that pulpwood prices as well as wage and capital rates in the wood products sector would remain constant in real terms. The inventory projections were taken from the baseline run, and then altered for the various investment/enrollment scenarios.

While total harvests are endogenous, that is they are predicted variables, in Newman’s model, our use of only the supply equations form Tamm precludes endogenous harvests. We conducted our simulations for the case where total harvests follow the baseline projections, but also considered a case where total harvests adjusted according to shifts in inventory. We were not interested in predicting shifts in harvest but in examining the sensitivity of the models to these kinds of shifts. We based our shifts in total harvests on the management intensity implied by historical and projected cut-inventory ratios for industrial and nonindustrial ownerships in the Southeast. Implicit rotation rates, defined by dividing annual cuts by inventories (Table 2), indicate some important differences in management intensity on these ownerships.

Table 2. Implicit rotation ages in the Southeast defined by the base run of Tamm. Rotation age is calculated by dividing the cut by the inventory for each ownership.

<table>
<thead>
<tr>
<th>Year</th>
<th>Industry</th>
<th>Other-private</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>41</td>
<td>61</td>
</tr>
<tr>
<td>1990</td>
<td>30</td>
<td>52</td>
</tr>
<tr>
<td>2000</td>
<td>28</td>
<td>52</td>
</tr>
<tr>
<td>2010</td>
<td>27</td>
<td>51</td>
</tr>
<tr>
<td>2020</td>
<td>26</td>
<td>49</td>
</tr>
<tr>
<td>2030</td>
<td>24</td>
<td>49</td>
</tr>
</tbody>
</table>

Implicit rotation ages would decline considerably for both ownerships over the projection period. Still, by 2030 average rotation age on other-private lands would be considerably higher than on industrial lands, reflecting differences in the intensity of management on the two ownerships. This gives us a feel, though no definitive measure, for how intensity might shift as new investments are undertaken on nonindustrial lands. We adjusted harvest levels by assuming that new investments would be managed in a way which is similar to industrial owners. That is, we applied the industrial rotation ages to increments in the growing stock to compute increased harvests for each simulation period.

In sum, we projected prices for shifts in inventories using the two models. For Newman’s model, we simply adjusted inventories from the base case and projected total harvests and stumpage prices. For the Tamm model we took two approaches. First we adjusted inventories while holding harvests at their baseline values. Second, we adjusted harvests as well as inventories. Stumpage prices and harvest by ownership were projected by the Tamm model.
Results and Discussion

We divide the discussion of our results, as with the description of methods into three sections. First we present the results of the investment analyses which define areas of potential investments on other private lands in the South. Next we examine the shifts in inventories which are indicated by our simulations of the enrollment of the potential investments. Finally we examine the sensitivity of price-projections to these shifts in inventories.

The results of the investment analyses, displayed in table 1, show a wide range of potential investment acreages in the South. The range of acreages is bracketed on the high end by the scenario with the highest prices (3.8% rate of increase) and the lowest discount or hurdle rate (4%). The low end, as expected, is defined where prices are held constant and the discount rate is high (10%). Notice the relatively small variability across rows in Table 3 when compared with the variability across columns. That is, our results vary much more across discount rates than across rates of price increase. This indicates that time preferences of timber owners, and capital rates rather than their perceptions of the timber market are the critical factors for determining levels of investments and therefore nonindustrial timber supplies, in a normative context.

Table 3. Results of timber investment opportunity analysis. Numbers are millions of acres of potential investments defined for combinations of discount rates and annual rates of price increase.

<table>
<thead>
<tr>
<th>Interest Rate</th>
<th>Rate of Price Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Constant</td>
</tr>
<tr>
<td>4%</td>
<td>Southeast</td>
</tr>
<tr>
<td></td>
<td>Southcentral</td>
</tr>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>7%</td>
<td>Southeast</td>
</tr>
<tr>
<td></td>
<td>Southcentral</td>
</tr>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>10%</td>
<td>Southeast</td>
</tr>
<tr>
<td></td>
<td>Southcentral</td>
</tr>
<tr>
<td></td>
<td>Total</td>
</tr>
</tbody>
</table>
The results of applying our six enrollment scenarios to investment opportunity acres are displayed in Table 4 for the Southeastern subregion (results for the Southcentral are not displayed but follow the same pattern). Variability in the inventory levels (displayed for the year 2030) reflects the results of the investment analysis. If we assume that all opportunities are enrolled over the next decade, then inventories would increase from 33% to 105% over the baseline value in 2030 (the baseline values from Tamm were constructed under the assumption that about 15% of the investments under the 4% discount rate, 1.8% price increase rate scenario would be adopted). This increase would be dampened considerably by spreading enrollment over 4 decades. In the Southeast, inventory would then increase 14% to 44% over the baseline by 2030.

Table 4. The effect of enrolling investments on softwood growing stock inventories in the Southeast. Numbers are levels of growing stock projected for the year 2030. The baseline projection is 36729 million cubic feet.

<table>
<thead>
<tr>
<th>Interest Rate</th>
<th>Rate of Price Increase</th>
<th>1.8%</th>
<th>3.7%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Constant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enrollment Period</td>
<td>1 Decade</td>
<td>4 Decades</td>
<td>1 Decade</td>
</tr>
<tr>
<td>Percent Enrolled</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25% 4</td>
<td>40548</td>
<td>38325</td>
<td>41272</td>
</tr>
<tr>
<td>50% 5</td>
<td>51181</td>
<td>42772</td>
<td>52630</td>
</tr>
<tr>
<td>100% 7</td>
<td>72448</td>
<td>51666</td>
<td>75346</td>
</tr>
<tr>
<td>25% 4</td>
<td>37502</td>
<td>37052</td>
<td></td>
</tr>
<tr>
<td>50% 7</td>
<td>45090</td>
<td>40226</td>
<td></td>
</tr>
<tr>
<td>100% 10</td>
<td>60267</td>
<td>46572</td>
<td></td>
</tr>
<tr>
<td>25% 4</td>
<td>34639</td>
<td>35855</td>
<td>36072</td>
</tr>
<tr>
<td>50% 7</td>
<td>39364</td>
<td>37830</td>
<td>42231</td>
</tr>
<tr>
<td>100% 10</td>
<td>48814</td>
<td>41782</td>
<td>54547</td>
</tr>
</tbody>
</table>
We chose two of these investment/enrollment scenarios for examining price projections. On the high side, we selected what we considered the highest, plausible investment scenario, defined by a 3.8% annual rate of price increase and a 4% discount rate with 50% enrollment of investment opportunities over 4 decades. This scenario would cause inventories to rise 18% increase over the baseline by 2030. For the low side, we considered the case of no new investments on nonindustrial lands. Recalling that our baseline includes about 15% of the investments, this would cause a decline in growing stock inventory of 8% from the baseline in 2030.

We used both models to project prices for the baseline and the high and low cases described above. The responses of the two models differ dramatically. In Figure 1 we display the price projections resulting from the use of Newman’s model. The results indicate that price projections are almost completely insensitive to shifts in inventory (to test the model further we examined a doubling of inventory and still found no significant effect). Total harvest levels (Figure 2) were also quite insensitive to shifts in inventory. The only discernable shift would occur with the high case, where output increased by about 6%.

![Figure 1. Price projections using Newman's model.](image)
Figure 2. Harvest projections using Newman's model.

We obtained quite different results using the simulation model based on TMM. The price projections (Figure 3) shifted considerably in response to changes in inventory. For the high case, where inventory was increased by 18% by 2030, prices were 49% lower by 2030. For the low case, an 8% decline in inventory resulted in a 23% increase in price. The directions of the shifts therefore match our expectations based on theory.

Figure 3. Price projections using TMM supply equations (no harvest adjustment).
We tested the TAMI simulation model further by expanding harvests as well as inventories. Again, this was accomplished by adjusting cuts in proportion to inventories and assuming that these new investments produce yields similar to industrial forests. With harvest levels adjusted in this manner, the high case actually resulted in a price increase of roughly the same magnitude as the price decline recorded when harvests were held constant (Figure 4). For the low case with adjusted harvest levels, prices also shifted by roughly the same magnitude but with opposite sign.

![Graph](image)

**Figure 4.** Price projections using TAMI supply equations with adjusted harvests.

**Concluding Remarks**

The product of our simulation analyses is a set of observations and questions related to research needs regarding timber investments and timber supply. Our investment analyses support the results of a similar analysis conducted for the South’s Fourth Forest Report. Many acres of investment opportunities are indicated in the South. In addition, the profitability of these investment opportunities is less affected by changes in price projections than by shifts in the applied discount rates. Such an
insensitivity to price signals has been observed in previous behavioral studies of nonindustrial forest owners (e.g., Royer 1987). These studies have also found that nonindustrial owners are more likely to invest when up front regeneration costs are reduced. Our results regarding sensitivity to discount rates seem consistent with this finding.

Our simulations of price effects raise an important issue. It is that two recent models indicate very different sensitivities to inventory shifts. We do not try to reconcile the differences here but observe that the form of the timber supply equation has not been firmly established in the literature. Effects of a shift in inventory on supply for the models described here differ, not only in magnitude, but also in their form. With supply as the dependent variable (Newman's model), increases in inventory simply shift the level of the supply curve. When the cut:inventory ratio is used as in TAMP, changes in inventory shift the level and also shift the slope of the supply curve. This shift in slope is demonstrated in Figure 5, where supply curves for our three scenarios are calculated for the year 2030 using the cut:inventory equation from TAMP. The appropriate form of the timber supply equation is unclear and remains an important research question.

![Figure 5. TAMP supply curves calculated with three inventory levels in 2030.](image_url)
Shifts in supply which arise from inventory adjustments suggest that our assumptions regarding myopic price expectations is unrealistic. That is, it is quite possible that some investments would prove unprofitable ex post. This suggests an adaptive modeling approach, which would allow for price feedbacks to investment plans over time (e.g., Wear and Parks 1988). A recursive programming approach which schedules investments based on price signals in each period would be one way of simulating this adaptive behavior.

**Literature Cited**


