ANALYSIS OF HURRICANE HUGO TIMBER SUPPLY IMPACTS: WELFARE EFFECTS FOR SOUTH CAROLINA

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Abstract.—Economic implications of decreased timber supply in South Carolina due to hurricane Hugo are examined using estimates of changes in consumer and producer surplus. The approach used is a "with" and "without" Hugo comparison. The baseline, "without" scenario, simulates South Carolina inventory without the occurrence of Hugo. This is compared to a projection based on the Forest Service’s Hugo survey. Timber inventory is projected using the ATLAS model. Regional supply and demand shifts are estimated using the SubRegional Timber Supply (SRTS) model. Together they produce compatible inventory and stumpage price projections. Comparison of producer and consumer surplus are made and aggregate welfare impacts are estimated. Note that these results are preliminary and subject to revision. The focus in this paper is on the modeling approach, not the price or inventory levels.

INTRODUCTION

Hurricane Hugo swept through the coastal plain and piedmont of South Carolina on September 21, 1989 damaging over one third of the state's timberland. The inventory reduction was estimated to be 1.3 billion cubic feet of which one billion was in softwood management types.

The immediate destruction wrought by Hurricane Hugo will have long run impacts on the future of South Carolina’s timber economy. The objective of this study is to estimate long run inventory, price and welfare impacts which result from the loss of private timber inventory.

In this study we project statewide inventory using two different scenarios. The baseline projection estimates state inventory levels that would have been likely if Hurricane Hugo had not occurred. The second, with Hugo, projection models inventory trends based on what was left after the Hurricane.

The long run difference in inventory projections is a result of the different starting inventories, the resulting change in age class distribution, and the price and harvest consequences of the shift in supply. It is doubtful that South Carolina’s demand for growing stock will be unaffected by Hugo. In this paper, however, we are modeling the inventory effect given the same demand scenario.

The change in welfare for producers and consumers was calculated by integrating the appropriate areas of the estimated supply and demand relationships resulting from the economic analysis.

MODELING APPROACH

The period of analysis for this study is from the year 1990 to 2025. This will allow for at least one rotation of inventory recovery.

For the purpose of this study South Carolina is considered to be an autonomous trade region. The ameliorating affect of stumpage flows between South Carolina and the coastal plain of Georgia or North Carolina are ignored. Within the state of South Carolina, the inventory is subdivided into damage regions which reflect the various degrees of damage sustained from the hurricane. The damage regions are heavy, light, and no damage as defined by the USDA Forest Service. Private and industrial ownerships are modeled separately within each category. The exclusion of publicly owned forest inventory was due to the small number of FIA plots available to support an extensive modeling effort (3 damage classes x 3 management types x age class) and its uncertain prospects for contributing to future timber supply.

Within ownerships, inventory is divided into three types, 1) planted pine, 2) natural pine/oak-pine, and 3) bottomland/upland hardwood management types. The effect on hardwoods will be examined in a later phase of this project.

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Data

These models are currently structured to allow for the projection of only a single product (growing stock) and a single market price. SRTS models price as an index. In this case, initial price was calculated as an average of the pulpwood and sawtimber prices weighted by their proportion of total state removals as reported in the industry summary of 1988 (Davenport and Tansey 1990). The starting price for the baseline projection is calculated from third quarter 1989 Timber Mart-South data (Timber Mart South 1989). The third quarter of 1989 was the last data period prior to Hurricane Hugo. The weighted price for the with Hugo simulation is calculated using the fourth quarter 1990 data. It is assumed that the interim fifteen months gives a more stable starting point for the price series.

Starting inventory information was provided by the Forest Inventory and Analysis (FIA) survey. The 1977 (Snyder 1978, Craver 1979, Sheffield and Hutchison 1979) and 1986 (Tansey 1986, 1987, 1987a) South Carolina state FIA surveys are used to establish the baseline starting inventory. The 1977 and 1986 survey inventory levels were adjusted to 1975 and 1985 using average annual rates of change. This is done primarily for reporting purposes and the five-year increment used in the model. An additional special FIA survey of post-Hugo inventory was completed in 1990 and provided the starting inventory for the with Hugo projection (Sheffield and Thompson 1992).

The Economic Model: SRTS

The SubRegional Timber Supply (SRTS) market model is used to model the economic effect of the inventory changes through time. SRTS models demand as function of price and an unspecified shifter. It models supply as a function of price and beginning of period inventory assuming a constant elasticity (logarithmic) functional form. SRTS uses projected harvest and aggregate supply to determine price and reallocate harvests between region-owner units. (Abt et al. 1993)

It is assumed that demand increases as projected in the South’s Fourth Forest study (USDA Forest Service 1988). We used the harvest trend in the without Hugo case to determine the implicit demand shift through time (Abt et al. 1993). This sequence of demand shifts was then applied to the post Hugo inventory model.

Table 1 shows the demand and supply elasticities used for the results reported here. These correspond generally to the elasticities for the Southeast in Haynes and Adams(1985).

The Inventory Model: ATLAS

The Forest Service model ATLAS (Aggregate Timberland Assessment System) (Mills and Kincaid 1991) was used to project timber inventories for the two scenarios. ATLAS is an age-class based model that moves acres through time based on user specified management assumptions and yields. Timber inventory was modeled by damage region, ownership, and management type (3 damage regions x 2 ownerships x 2 softwood management types). Each was projected separately in order to determine aggregate inventory. Table 2 illustrates the ATLAS configuration which is specific to the Hurricane Hugo study.

The acreage shifts, or conversion rates, used in the inventory projection are consistent with published trends for South Carolina (Allig 1985). The trends are used in both projections, though it is likely that stand conversion to planted pine types would be more rapid than anticipated as a result of Hurricane Hugo. This one-time rapid conversion could have a significant impact on the projected prices and welfare effects. Potential consequences will be explored in future models. The only accelerated conversion accounted for in this projection is that which occurred after Hurricane Hugo but before the completion of the 1990 FIA post-Hurricane Hugo survey.

The yield tables are constructed differently for the baseline and with Hugo scenarios. For the baseline projection, empirical yield tables are developed using the FIA survey data. It is assumed that current inventory structure most accurately describes stand yield in each five-year age class. Using empirical yields also allows for the implicit incorporation of site indices.

For the with Hugo scenario, yield tables for damaged stands were constructed using a planted pine growth model and a natural pine model to reflect changes in growth and yield patterns due to tree loss at different ages. The yield tables for undamaged stands are the same in both scenarios.

Market-Inventory Model Linkage

ATLAS projects individual inventories for the 12 region-owner-type units for a five-year period. This inventory is passed to the SRTS market model. The percent change in aggregate inventory is used as a shifter for the aggregate supply curve. Supply curve shifts and assumed harvest level determine a new price. The new price is applied to the supply curves of the six individual region-owner units to determine the new harvest allocation for each region-owner. The allocation of harvest across management types within a region-owner units is not modeled economically. It is determined by a combination of initial harvest proportions, current inventory proportions, and/or current growth proportions.

The harvest request for the next period is then passed back to ATLAS, and the sequence is repeated for the next five-year period to the end of the projection horizon. Figure 1 shows
the conceptual relationships between the inventory model and the economic model.

The sequencing of this link is different in the baseline projection and the with Hugo projection. The difference is due to the need to hold demand rather than harvest constant between the two projections. The baseline simulation is projected first using the harvest trends from the South's Fourth Forest. Along with supply shifts due to inventory, SRTS uses these harvest levels to determine price and the implicit demand shift for the period. The with Hugo run takes the more traditional economic approach to use demand (as estimated above) and supply to determine harvest. Though, the demand curve is assumed to be the same, harvest declines due to the decrease in supply.

Figure 2 illustrates the modeling approach. The line labeled "Without Hugo" is the baseline supply curve for any time period and the "With Hugo" is the corresponding supply curve for the with Hugo run. In the baseline harvest level for each period is known and the supply curve is determined as inventory is passed from ATLAS. The price is determined at the point of intersection of the supply curve and harvest level, the demand curve is implemented through this point. In the with Hugo run, the inventory is passed to SRTS as before and the aggregate supply curve "With Hugo" is determined. Since the demand curve is the same as in the baseline projection, the resulting equilibrium harvest level and price can be determined.

WELFARE MEASUREMENT

Welfare change was measured as changes in consumer and producer surplus.

Welfare effects correspond closely to the projected price impacts. Producer surplus is the area left-bounded by the y axis, upper-bounded by the price line and lower-bounded by the supply curve. Similarly, consumer surplus is that area left-bounded by the y axis, lower-bounded by the price line and upper-bounded by the demand curve. The welfare estimates are calculated as changes rather than as absolutes.

In the stumpage market, producers are the forest landowners, and consumers are users of stumpage or primary owners of processing facilities. The producers of stumpage lose income associated with volume loss. Those who have a residual forest after the hurricane, however, will realize gains from the higher prices. The consumers who face more competition for reduced supply lose due to reduced production and higher input prices.

Figure 3 illustrates changes in consumer and producer surplus from a shift in supply. Figure 3(a) shows the loss in consumer surplus from both an increase in price and a decrease in quantity. In Figure 3(b) area \( a \) represents gains to producers due to the increased price. Area \( b \) represents the loss to producers from decreased harvest. The difference of area \( a \) and \( b \) is the net gain to producers.

RESULTS

Note that these results are preliminary. Further testing of the inventory model and availability of the 1992 survey may significantly change these projections. The focus in this paper is on the modeling approach.

Inventory

The inventory projections show a moderate reduction in aggregate inventory levels (Figure 4). The long run inventory trend is essentially parallel to the baseline run. Given the same level of demand, the small reduction in harvest does not allow the inventory to recover through time.

Price

Since supply and demand are inelastic, the decrease in inventory leads to a relatively small decrease in harvest, but a relatively greater increase in price. Price trends follow the same path but at a higher level (Figure 5). If a more elastic demand curve were used to reflect substitution of wood in neighboring states, the harvest would decrease more and inventory could recover.

Welfare

The preliminary results of this model project losses to consumers to exceed the gains to producers over the 35-year horizon. Figure 6 shows the relative distribution of gains and losses over time which are directly related the price trends. The present value of the loss in consumer surplus is $6.1 billion while producers gain a present value of $3.9 billion using a four percent discount rate. The net social welfare loss is approximately $2.2 billion.

CONCLUSION

Hurricane Hugo severely affected both the short and long run timber economy of South Carolina. Though the net social welfare loss was substantial, the distribution of the loss is also important. These preliminary welfare impacts show the potential size of the impact and its distribution among consumers and producers of timber.

The welfare effects reported in this paper are sensitive to the assumptions described above. For example, the welfare impacts to the consumers of pulpwood would be different than those experienced by sawmills since degrade may create an
oversubundance of pulpwood. The welfare impacts to producers were mitigated to some extent by salvage operations. From a broader perspective, some of the losses to the timber sector may have been offset by gains in other parts of the state economy, e.g. home construction.

ACKNOWLEDGEMENTS

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LITERATURE CITED


### Table 1--Demand, supply, and inventory elasticities.

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### Table 2--ATLAS model configuration for hurricane Hugo economic impact study.

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<td>Light</td>
<td>Non Industrial Private</td>
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<tr>
<td>No Damage</td>
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Figure 1. Economic and inventory modeling linkage.

Figure 2. Modeling approach: comparison of two scenarios.
Figure 3a. Change in consumer surplus.

Figure 3b. Change in producer surplus.

Figure 4. Aggregate inventory level projections.
Figure 5. Simulation price trends.

Figure 6. Distribution of nominal welfare impacts to producers and consumers.