Supply for Bioenergy Production in Tennessee

Zhimei Guo\(^1\), Donald G. Hodges\(^2\), and Robert C. Abt\(^3\)

\(^1\) Graduate Research Assistant; University of Tennessee, Department of Forestry, Wildlife and Fisheries; Knoxville, TN 37996-4563; zguo4@utk.edu; (865)-974-0611 (v).
\(^2\) Professor and Director; University of Tennessee, Natural Resource Policy Center, Department of Forestry, Wildlife and Fisheries; 274 Ellington Plant Sciences Bldg.; Knoxville, TN 37996-4563; dhodges2@utk.edu; (865)-974-2706 (v).
\(^3\) Professor and Co-director of SOFAC; North Carolina State University, College of Natural Resources, Department of Forestry and Environmental Resources; Raleigh, NC 27695-8008; bob_abt@ncsu.edu; (919)-515-7791 (v).
Forest Biomass Supply for Bioenergy Production in Tennessee

Abstract:

The growing interest in the utilization of forest biomass as an alternative source for bioenergy production has become a significant issue in Tennessee. This study used the Sub-Regional Timber Supply (SRTS) model to analyze the regional aggregate forest biomass feedstock potential and the impacts of additional pulpwood demand on the regional roundwood market. Two scenarios examined the impacts of building a biorefinery facility of 20 and 50 million gallons annual capacity in the state in 2015. The other two scenarios investigated the impacts of an EIA reference case. The projection results suggest that there is sufficient hardwood pulpwood supply for feedstock of a biorefinery facility of 50 million gallons annual capacity in Tennessee. It is possible to meet the demand increase rate of the EIA reference case without affecting the hardwood pulpwood market through 2030, but not in the distance future. The additional demand for softwood pulpwood would have affected the softwood market substantially. But the impacts on hardwood market are comparatively small. Hence, it is more feasible to increase use of hardwood pulpwood for renewable energy rather than softwood pulpwood. These results will be very helpful in sustainably supplying forest biomass for bioenergy production in Tennessee.

Keyword: forest inventory, projection, removals, roundwood prices, SRTS model
Introduction

In 2006, energy consumption in Tennessee totaled 2313.2 trillion Btu. Biomass supplied around 51.9 trillion Btu, or 2.2% of the state’s total consumption, ranking 20th nationally (EIA 2009). In addition to the interest in agricultural biomass such as switchgrass, willow, and agricultural residues, the interest in the utilization of forest biomass as an alternative source for bioenergy production has been growing in Tennessee. With the announcement of the construction of a pilot biorefinery facility, forest biomass will be increasingly used for bioenergy in the near future.

Currently, 1.5 million green tons of harvesting residues are produced in the state annually. The Sub-Regional Timber Supply (SRTS) model projects the logging residue availability will increase slightly to 1.7 million green tons by 2030. The Energy Information Administration (EIA) reference case projected that there will be 5.2% annual growth of energy generation from wood and other biomass from 2007 to 2030 (EIA 2009). Assuming a 5.2% annual growth of biomass generation from forests, forest biomass demand will increase to over 5 million green tons in Tennessee by 2030. How will this additional demand for forest biomass influence roundwood market and sustainability of forest management and roundwood supply?

Different from other southern states, hardwood accounts for majority of the timberland in Tennessee (USDA Forest Service 2007). The hardwood growth and removals are much larger than those of softwood. Due to the impact of southern pine beetle (SPB) outbreak, the net growth of softwood was negative from 1999-2004. The softwood removals has an annual 20% decrease from 2005-2007, because some wood processing facilities have shut down. However, the quantity and percentage of decrease in hardwood removals is comparatively small, around 5%. In this situation, it is imperative to investigate how an increased use of forest biomass will affect roundwood market and explore the sustainability of roundwood and forest biomass supply.

Previous research has examined the interactions between traditional timber use and biomass supply. Industrial roundwood is considered one of the key factors determining forest biomass availability for bioenergy (Smeets and Faaij 2007). The price interactions between fuelwood and traditional wood products have been investigated and competition between biomass supply and conventional wood uses was recognized (Sedjo 1997, Ince 2007). Some studies suggest that it is unlikely to use roundwood for bioenergy because sawtimber is too expensive and competition for pulpwood will drive prices up (Hazel 2006, La Capra Associates 2006). However, this will depend on regional market conditions.

Given the growing demand for forest biomass for bioenergy in Tennessee, this study analyzed its impacts on roundwood markets as well as the sustainability of biomass supply and forest inventory in Tennessee. The specific objectives of this study were to: (1) examine the regional aggregate forest biomass feedstock potential in Tennessee; (2) investigate the impact of forest supply on the regional roundwood market; and (3) explore the possibility of sustainably supplying forest biomass for bioenergy in Tennessee.
Methods

This study first predicted the roundwood market, inventory, and forest removal of the base scenario with no increase in demand for forest biomass through 2030. Four scenarios of additional forest biomass supply for bioenergy production were then examined and compared.

According to the size of currently proposed mills, one scenario examined the potential impacts of a biorefinery facility of annual capacity of 20 million gallons being built in TN in 2015. The consequences of a higher annual capacity of 50 million gallons were also investigated. Since biorefinery facilities need clean chips as feedstock, it was assumed that 200 or 500 thousand green tons of pulpwood will be used as feedstock annually under these two scenarios, based on the conversion factor of 100 gallons per green ton (Timber Mart-South 2008). As hardwood acreage and annual removals are much larger than softwood in Tennessee, this study assumed that the annual biomass consumption of the facility consists of 15% of softwood pulpwood and 85% of hardwood pulpwood.

Based on the EIA reference case of 5.2% annual growth of woody biomass demand, this study projected the impacts of 150 thousand green tons of annual pulpwood demand increase from 2009 to 2030. One scenario examined the market, inventory and removal response if annual additional demand consists of 15% of softwood pulpwood (i.e., 22,500 green tons) and 85% of hardwood pulpwood (i.e., 127,500 green tons). The other scenario explored the possibility of increasing merely hardwood pulpwood supply for bioenergy.

SRTS was used for the analysis (Abt 2008). The demand driven mode was used, which assumed that harvest and price respond to a change in demand. The demand price elasticities are 0.5 for all roundwood products. The effect of increasing demand for pulpwood will depend on supply. The supply price elasticity was assumed to be 0.5 for all wood products, which indicated that a 1% change in price would increase harvest by 0.5%. The supply inventory elasticities were set to 1.0 for all SRTS runs. The SRTS model used the 2005 USDA Forest Service Inventory and Analysis (FIA) data for the projection.

Empirical Results

Constant Demand

The roundwood market with no demand increase for pulpwood was projected as a base case for comparison (Figure 1). It indicated that the softwood pulpwood removals will increase slightly, but remain lower than 2005 removals through 2030. The softwood pulpwood inventory will be stable through 2017 and then increase to 120% of the 2005 inventory. The softwood pulpwood price will fluctuate substantially during this period. It will be almost the same as 2005 price through 2016, then decrease by 20% due to the increase in inventory, and finally rise to more than 150% of the 2005 price. Softwood sawtimber generally follows the same trend as softwood pulpwood. The changes in inventory and removals are very small, but the fluctuation
in sawtimber price will be greater than that of pulpwood. The price will increase to 130% in 2016 and over 170% in 2030.

The hardwood pulpwood and sawtimber market follow the same trend. The inventories will keep growing and the increase will be over 40% by the end of the projection. The removals will increase slightly. Since inventory is growing much faster than harvest, the prices for both pulpwood and sawtimber will continue to decline; in 2030, they will be 40% lower than 2005 prices.

Figure 1. The projection of roundwood market with no demand increase for pulpwood.

*Roundwood Market with Facility built*

The market impacts of building a biorefinery facility of annual capacity of 20 million gallons in 2015 are shown in Figure 2. An annual additional demand for 30,000 green tons of softwood pulpwood increased the harvest slightly. By 2030, the removals will grow to 90% of the 2005 harvest level. The inventory had no apparent response to the additional demand for pulpwood. The softwood pulpwood price exhibited a small increase to 2016 and then a doubling of 2005 prices by 2030.
In general, the hardwood market remained unchanged, except for the small increases in removals and price of hardwood pulpwood to 2016 due to the additional demand for 170,000 green tons of hardwood pulpwood (Figure 2). By the end of the projection, the removals and price of hardwood pulpwood were slightly larger than those with no pulpwood demand increase for biorefinery facility.

Building a biorefinery facility of annual capacity of 50 million gallons in Tennessee in 2015 produced much more significant effects, especially in the softwood market (Figure 3). The additional annual demand for 75,000 green tons of softwood pulpwood increased the harvest from 2015; as a result there is a large increase in softwood pulpwood prices (150% of the 2005 price). Due to the increase in inventory, the price fell through 2012. However it increased to over 250% of the 2005 price by 2030, because of the increase in harvest and decrease in inventory. By 2030, the removals equaled 2005 harvest levels. The projection of softwood sawtimber still follows the same trend as the base case, except for the slightly lower inventory and higher price by the end of projection relative to the no demand increase case.

Figure 2. The projection of roundwood market with a facility of annual capacity of 20 million gallons being built in 2015.
Figure 3. The projection of roundwood market with a facility of annual capacity of 50 million gallons being built in 2015.

Due to the annual additional demand for 425,000 green tons of hardwood pulpwood from 2015, hardwood pulpwood removals increased continuously through the end of the projection. As a result, prices increased to 2016, but declined after that because of the continuously increasing hardwood pulpwood inventory. By the end of the projection, the inventory of hardwood pulpwood was slightly smaller and the removals and price were slightly higher than those with no pulpwood demand increase for biorefinery facility. The impacts on the hardwood sawtimber market are little.

**EIA Reference Case**

The projection indicated that increasing both softwood and hardwood pulpwood demand for EIA reference case affected roundwood markets significantly (Figure 4). An annual increase in softwood demand by 22,500 green tons resulted in a continuous increase in harvest. By 2030, it exceeded 2005 removals. The inventory exhibited a very slight increase and then a decrease to close to 2005 levels. Consequently, the price of softwood pulpwood increased to more than 400% of the 2005 price. The projection of softwood sawtimber market generally followed the same trend as with no biomass demand increase. But the inventory decreased to slightly less than the 2005 inventory by 2030. The price increased to 190% of the 2005 price, higher than the base case by the end of the projection.

The removals of hardwood pulpwood continuously increased from 2009 and reached around 140% of 2005 removals, because of the 127,500 green tons of annual hardwood demand increase. The inventory continued growing, but the increasing rate was less than the base case. Since the removals increased at a faster rate than inventory, the price hardwood pulpwood
continued to rise. By 2030, it equaled 110% of the 2005 price, but the impacts on hardwood sawtimber market were minimal.

![Softwood Pulpwood](chart1)

![Softwood Sawtimber](chart2)

![Hardwood Pulpwood](chart3)

![Hardwood Sawtimber](chart4)

Figure 4. The projection of roundwood market in the EIA reference case (annual additional demand consists of 15% of softwood pulpwood and 85% of hardwood pulpwood).

The responses of roundwood markets to increasing merely hardwood pulpwood demand for bioenergy for EIA reference case are shown in Figure 5. The softwood market was similar to the base case except the slightly higher increase in softwood pulpwood price. The inventory and removals of hardwood pulpwood continuously increased from 2009. The increasing rate of inventory was lower than that of the base case. The removals increased at a faster rate and the removal index exceeded the inventory index by the end of the projection. As a result, the price of hardwood pulpwood continues to rise and it reached 120% of the 2005 price by 2030. The projection of hardwood sawtimber market is similar to the base case except for the slightly lower inventory index and higher price index in 2030.
Figure 5. The projection of roundwood market in the EIA reference case increasing merely hardwood pulpwood demand for bioenergy.

Discussion

The projection of roundwood markets indicated that the softwood prices are very sensitive to market changes in Tennessee. The softwood inventory did not grow significantly during the projection period. Changes in removals can easily affect inventory, resulting in great changes in softwood prices. Both the softwood pulpwood and sawtimber prices increased by more than 50% in 2030, even with no additional demand for softwood pulpwood. This probably can be explained by the relatively small softwood acreage in Tennessee and great impact of SPB outbreak.

Comparatively, the hardwood market was insensitive to additional demand for pulpwood. The projection suggested that the hardwood inventory grows constantly and significantly through 2030. An increase in removals cannot greatly influence inventory. Therefore, hardwood prices declined through 2030 with no additional demand for roundwood. An annual hardwood pulpwood demand increase by 150,000 green tons for bioenergy will not lead to decline in inventory and high price of hardwood pulpwood in the next two decades. The impacts on hardwood sawtimber market in Tennessee are even less. The possible reason could be that the current removals of roundwood are low due to the shutting down of some wood processing industries in the past few years.

This study projected the responses of the inventory, removals, and roundwood prices on additional demand for pulpwood for bioenergy production in Tennessee. Nonetheless, the supply of pulpwood and logging residues under these four scenarios did not meet the demand for
forest biomass, since the price increase dampens some of the harvest (Abt 2000). Therefore, other sources of forest biomass such as wood-processing industry residues and urban wood waste need to be considered for the demand.

Conclusion

The projection suggested that with annual additional demand for 425,000 green tons of hardwood pulpwood from 2015, the inventory still grows at a faster rate than removals. Therefore, there is potential to supply more hardwood pulpwood as feedstock for biorefinery facility. This implies that there is sufficient hardwood pulpwood supply for the feedstock of a biorefinery facility of 50 million gallons annual capacity in Tennessee.

With the 150,000 green tons of annual hardwood demand increase from 2009, the removals increased at a faster rate than the inventory (Figure 5). By the end of the projection, the removals index reached slightly higher than the inventory index. Though the hardwood pulpwood price in 2030 was only 20% higher than 2005 price, it will keep rising. Therefore, it is possible to meet the 5.2% annual growth of forest biomass demand without affecting the hardwood pulpwood market during the projection period. However, the demand increase rate of the EIA reference case cannot be met in the long term in Tennessee.

The additional demand for softwood pulpwood would have great impacts on the softwood market. An annual additional 30,000 green tons of softwood pulpwood demand from 2015 will double the price for softwood pulpwood by 2030. An annual increase in softwood demand by 22,500 green tons will result in a price increase of 400% of 2005 price. But the impacts on hardwood market are comparatively small. Hence, it is more feasible to increase use of hardwood pulpwood for renewable energy rather than softwood pulpwood in Tennessee. These results will be very helpful in sustainably supplying forest biomass for bioenergy production in Tennessee. Future study should consider the impacts of land use changes as well as markets in neighboring states on biomass supply in Tennessee.

Literature Cited


