Forest Biomass Supply in the Southeastern United States -- Implications for Industrial Roundwood and Bioenergy Production.

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Abstract

This analysis explores regional aggregate bioenergy potential, the interaction of logging residues and roundwood supply, and the potential supply costs of woody biomass from three southern states. Significant amounts of forest residues are potentially available within the study area: approximately 2.8 million dry tons in North Carolina, 1.8 million dry tons in South Carolina, and 1.3 million dry tons in Virginia. These quantities are sufficient to satisfy regional biomass electricity production requirements only through 2012 under a hypothetical national Renewable Portfolio Standard (RPS) and Renewable Fuels Standard (RFS), after which changes in the biomass resource stream will be necessary. Supply curves generated for multiple regions in each state indicate that forest residues vary regionally in both supply and price, and exceeding the supply of forest residues could be accompanied by a dramatic spike in resource pricing, with implications for timberland owners and users of the forest resource base.

Introduction

Between 2005 and 2030, electricity demand in the Southeastern demand region[4] is expected to increase at an annual rate of 1.5% (Energy Information Administration 2007a). New

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[4] "Southeastern demand region" refers to the South East Reliability Corporation (SERC) demand region, and includes all or portions of the following states: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi,

electrical generation capacity will be needed to meet this growing demand. At the same time, increased attention to domestic sources of energy and concern over global climate change is placing emphasis on renewables. One category of renewables receiving increasing amounts of attention is biomass.

Biomass includes agricultural crops and trees, wood and wood residues, grasses, municipal residues, and other plant and plant-derived matter. Biomass can be used for a variety of applications, including electricity generation ("bioenergy"), liquid biofuel production, residential heating, and industrial heat and processing energy. Using the most recent data available at the time of publication, biomass and biomass derived gases supplied nearly 55,000 GWh of electricity in 2006 (Energy Information Administration 2008a) and provided feedstock for nearly 6.5 billion gallons of ethanol in 2007 (Energy Information Administration 2008b), nationwide.

Forest biomass, potentially including both merchantable and non-merchantable wood, represents a key component of available national and regional biomass supply. With the recent passage of a Renewable Portfolio Standard (RPS) in the state of North Carolina (2007 N.C. Sess. Law 2007-397) and increased attention to federal renewable energy and climate change policies, forests are increasingly turned to as a source of energy. But while forest biomass is a renewable resource, the availability of forest biomass is limited over short time periods by both the amount of land in forests and the rate of forest growth. Therefore, an increased use of forest biomass for bioenergy, biofuels, or wood and paper products will likely impact all other users of the forest resource.

Missouri, North Carolina, South Carolina, Tennessee, Texas, and Virginia (Energy Information Administration, 2007a).

Interactions within the Forest Biomass Resource Base

Residues left on-site after the harvesting of roundwood can be used for bioenergy or as a feedstock for biofuel production, while roundwood itself can be used for bioenergy, biofuel, and wood and paper product production. This crossover between possible end-uses of logging residues and roundwood means that an increasing demand for forest biomass-derived bioenergy may affect the price or availability of wood resources for traditional wood products such as pulp, paper, and oriented strand board (OSB).

The possibility of interactions between uses of the forest biomass resource base has not been ignored by the literature and other relevant work in the area. Sedjo (1997) explores the relationship between prices for fuelwood, wood products, and other forms of energy such as coal, stating that industrial uses of wood for wood products constitute "the major competitor" to fuel uses of forest biomass (p565). Perlack et al. (2005) note the possibility that high oil prices and low timber prices may create conditions in which pulpwood or even small sawtimber resources could be used for bioenergy or bioproducts. Others propose that increased competition for pulpwood will drive up the price of the resource, making it less likely to be used for bioenergy absent a decline in the pulp and paper industry (La Capra Associates 2006). Still others suggest that sawtimber and other higher-value forest resources will remain too expensive to be used for bioenergy purposes (See, e.g., Hazel 2006). Outside of the U.S., research indicates that use of forest residues for energy is possible without negative impacts on the forest industry, but that tipping points exist where roundwood becomes profitable for bioenergy and competition between end-uses intensifies (Lundmark, 2006).

Analysis Overview

An increase in demand for forest residues as a feedstock for bioenergy or biofuel may exceed supply and compete with roundwood supply. The likely resource price increase would affect all resource uses. As it is ultimately public policy that initially will drive the market for alternative feedstock sources such as forest biomass, a key first step in crafting such policy is identifying the tradeoffs of increased forest biomass use.

Consumption of woody biomass for energy will be driven by prices for possible substitute sources of renewable energy and the costs associated with growing, harvesting, and developing technologies for transforming fiber to energy. Energy markets and technology development are difficult to forecast. However, it is possible using current data and costs to estimate the raw material costs associated with using woody biomass.

The supply analysis presented here explores the relationship between current timber harvests and forest residue availability in the Southeastern U.S., focusing on North Carolina, South Carolina, and Virginia, with a focus on bioenergy production. Our study has three central objectives. The first objective is to estimate the availability of residues by region, as well as variations in supply costs across physiographic regions and species in the three states. A second objective is to explore the cost implications of different assumptions about how residue demand will relate to roundwood demand. The third and final objective is to relate the regional availability of residues to projected increases in bioenergy production to gauge potential scarcity.

Methods

To estimate the aggregate availability of residues by region, as well as variations in supply costs across regions and species, we use current harvest, residues, and price data to establish a starting point for biomass supply. We then combine this supply estimate with information about the pulpwood market to develop biomass supply curves that reflect regional residues availability and pulpwood market information. Finally, we use Energy Information Administration (EIA) projections under two separate policy scenarios to determine whether the estimated supply of available residues in the region is sufficient to meet expected demand.

The Residues Market

Logging residues have been promoted as an under-utilized resource that can be quickly procured for energy demands. Given the high proportion of delivered wood costs associated with collection and transportation, the low cost of residues on the ground does not necessarily translate into a low cost supply to the energy producer. As the market for forest biomass residues is still developing, the percentage of total residues that are available at successively higher costs is unknown. Estimates vary widely.

This analysis assumes a stumpage price of $1/green ton for residues. Some residues may be available at no cost from landowners as part of ongoing harvest operations, but other residues will have to be purchased. Thus, $1/green ton represents a rough approximation of the current market. As harvest technologies evolve and competition increases price will adjust; the analysis presented below can be easily modified to reflect different assumptions about the residues market.

Data for current removals and residue quantities are based on U.S. Forest Service Southern Research Station (SRS) Timber Products Output (TPO) 2005 data (U.S. Forest Service 2007). Using data generated by TPO survey results, logging residues in each county are aggregated into survey units (Table 1). A volume to weight conversion factor of 17.22 dry tons per thousand cubic feet was derived for softwood and 17.99 dry tons per thousand cubic feet was dervied for hardwood using cubic feet/cubic meter and cubic meter/green ton conversion factors listed in Timber Mart-South 2007. We assume a moisture content of 50% in converting green tons to dry tons. Estimates of pulpwood removals come from the latest version of the Subregional Timber Supply (SRTS) model.[5] Timber Mart-South (TMS) stumpage and delivered prices for softwood and hardwood pulpwood are listed in Table 2. Since TMS price regions do not correspond to survey units, some price estimates below reflect spatial averages of TMS regions.

Not all residues are available for use. Other studies of biomass supply have assumed a technical recovery rate of 40% (Walsh et al. 2000), whereas this analysis assumes 50% of available residues will be utilized. Increases in harvest efficiency are important to the future economic viability of forest residues (Grushecky et al. 2007), and we believe that this higher estimate better characterizes increases in harvest efficiency that will accompany the development of a forest residues market. However, the implications of increased harvest efficiency and increased rates of residues removal must be weighed against potential impacts on site productivity, especially for low-productivity sites (see, e.g., Scott & Dean, 2006).

The Pulpwood Market

Our analysis is limited to the pulpwood market as it is this segment of the forest resource base that will be impacted first by an increase in forest biomass demand. The prices and quantities shown in Tables 1 and 2 describe current market conditions for regional biomass supply from residues. However, availability of residues also depends on the production of

[5] A detailed discussion of the SRTS model can be found in Prestemon and Abt, 2002.

existing wood-based industries; after residues are exhausted biomass consumption will depend on roundwood supply where it will compete with pulpwood.

There are two basic components of roundwood supply used in this analysis. The current harvest and price information provides one point on the supply curve. With this “point” on each region’s supply curve and information about the slope (or supply price elasticity) we can derive the pulpwood supply curve. For this analysis we assumed that the supply curve was of the constant elasticity form:

Pulpwood Supply: $\ln Q = \alpha + \varepsilon \ln P$, *where* ε *is the constant supply-price elasticity.*

<u>Supply Curve Generation:</u>

If residues and roundwood are considered potential sources of the same product (e.g. wood fiber from chips) then the assumptions made above generate two points on the supply curve. The first point is the quantity of available residues in the region at the assumed $1/green ton price. The second point is the current price of pulpwood where residues and current pulpwood harvest are assumed to be available.

Based on this assumption, α and ε in the pulpwood supply equation can solved so that the supply curve contains both points. The supply curves estimated using this method are price elastic ($\varepsilon > 1$) for all but three of the 24 survey-unit/species combinations, ranging from .44 to 2.60. However, such an approach generates curves that seamlessly link residues and roundwood, and treating residues and roundwood the same may be unrealistic. Empirical estimates of pulpwood supply from several sources as reviewed in Pattanayak et al. (2002) also indicate the supply price for pulpwood is inelastic ($\varepsilon < 1$).

To address the above shortcomings, we develop an alternative approach. This alternative approach assumes a constant stumpage price elasticity of 0.3 for pulpwood in North Carolina, South Carolina, and Virginia.[6] It also assumes that all available logging residues are used before biomass consumers purchase roundwood. Accordingly, a supply curve can be derived using the constant elasticity functional form with ε assumed to be 0.3, and current pulpwood price and quantity determining the supply curve's location for each region-species-state combination. Shifting the curve by adding the quantity of logging residues, the supply curve for total biomass (pulpwood and logging residues combined) is generated. Similarly, adding the difference between stumpage price and delivered price to the stumpage supply curve generates supply curves for delivered biomass.

Both supply curves described above yield logically consistent estimates of how much biomass would be available at different prices. They do not incorporate existing use of roundwood. For example, once residues are exhausted at $1/green ton, new biomass consumers do not have the option to purchase $1.50/green ton roundwood. Once they enter the roundwood market they represent an incremental demand over and above current use. The supply curves below reflect this reality, with wood cost increasing to current roundwood prices after residues are exhausted.

Projected Increases in Bioenergy Production

This study also compares estimates of regional resource supply against projected bioenergy production. Estimates of biomass electricity production from 2003 to 2030 in response to a hypothetical national RPS and Renewable Fuel Standard (RFS) are provided by

[6] The elasticity 0.3 is based on an approximation of stumpage price elasticities of private timber supply in South-central and Southeastern regions as reported in Adams & Haynes, 1996. Also cited in Pattanayak et al. 2002.

Energy Information Administration (2007b). This hypothetical RPS/RFS would require 25% of national electricity and liquid transportation fuel sales to be derived from renewable resources by the year 2025. Forest resources may be used to satisfy both RPS and RFS requirements, but this analysis examines only the bioenergy production implications of the policy scenario. Thus, demand pressures for forest biomass and other potential biofuel feedstock are likely to be greater than those captured here.

A first step in our comparison of regional biomass supply against bioenergy demand is to establish a relationship between biomass electricity production in North Carolina, South Carolina, and Virginia and the larger region using reported bioenergy production data from 2003 to 2006 (Energy Information Administration 2006; 2007c; 2008a). From 2003 to 2006, mean annual electricity generation from wood/other biomass in North Carolina, South Carolina, and Virginia comprised approximately 28% of annual wood/other biomass electricity generation in the larger South East Reliability Corporation (SERC) region. The mean annual three-state wood/other biomass electricity capacity for these years was approximately 35% of SERC regional wood/other biomass capacity. Within the category of wood/other biomass, woody biomass comprised 100% of reported installed capacity in North Carolina, South Carolina, and Virginia, and 97.7% of generation.

Having established a relationship between SERC regional and North Carolina, South Carolina, and Virginia biomass electricity capacity and generation, regional projections for biomass electricity production contained in Energy Information Administration 2007b can be scaled down to the three state study area. Rounded, conservative estimates of the three-state study area's share of regional biomass electricity capacity (35%) and generation (30%), as well as the percentage of biomass electricity production assumed to be from woody biomass (100%), are then compared against projections of future woody biomass consumption under two separate policy scenarios: a reference case and a national RPS/RFS. Three-state projected consumption is considered at both 30% and 35% of SERC regional consumption because published EIA Renewable Energy Annual reports do not contain the state-level consumption data necessary to establish a relationship between state and regional consumption.

The relationship between forest residue supply at varying price points as reported in Walsh et al. (2000) for North Carolina, South Carolina, and Virginia are also compared to that of the larger SERC region in order to determine whether any intra-regional shifts in supply are expected with increasing biomass demand. As the percentage of available biomass in the three state study area is consistent across all price points, it is assumed that this relationship between the three state study area and the larger region would remain constant over time, thus allowing state-level estimates of future biomass-derived electricity to be estimated.

Results and Discussion

Analysis of Forest Biomass Supply

As noted in Figures 1-6 and delineated in Table 3, total availability of forest residues is significant, but varies by state: approximately 2.8 million dry tons in North Carolina, 1.8 million dry tons in South Carolina, and 1.3 million dry tons in Virginia. Assuming a weight-to-energy conversion factor of 8,500 BTU/pound for dry tons (e.g., Kaminski 2004), this translates into an energy potential of over 100 Million MMBTU. These supply estimates vary with those generated by other, recent analyses. La Capra Associates (2006) estimated annual availability of forest residues in North Carolina at approximately 4 million dry tons, significantly greater that the 2.8 million dry tons estimated in this analysis. Despite both studies basing estimates on U.S.

Forest Service Forest Inventory and Analysis (FIA) and/or TPO data, it is unclear what data year TPO data La Capra Associates rely on for their calculations. Harvest, transportation, and other costs are also handled differently, and the analysis is conducted at different scales (county versus survey unit). The analysis in Milbrandt (2005) treats FIA and TPO data differently than the present study, is based on 2002 data, and includes other removals as well as logging residues in generating a three-state supply of over 7.1 million dry tons. An earlier study, Walsh et al. (2000), used a recovery factor of 0.4, further deducting the amount of residues found on steep slopes, and arrived at a three-state forest residues total of approximately 5 million dry tons.

The individual supply curves produced by this analysis also highlight several interesting results. The coastal plain regions and the South Carolina piedmont have enough residues to sustain a large capacity of biomass use, but there is a relatively high cost for roundwood when residues are exhausted (Figure 1). For the softwood data in the study area there is a high positive correlation between TMS roundwood price and FIA harvest level ($r > .5$). That relationship does not exist in hardwoods, where the North Carolina and Virginia border area exhibits high residue availability and low roundwood prices (Figure 2). Since aggregated and interpolated prices by survey unit are used, prices at a higher spatial resolution would be needed to further explore the tradeoff between high residue availability and high roundwood prices.

The same relationship between price of residues and roundwood is also reflected in the state supply curves, generated by aggregating individual survey units and utilizing a weighted stumpage price to determine the current cost of pulpwood (Figures 3 and 4). A dramatic spike in resource pricing or cost shift is incurred for exceeding the supply of forest residues, seen for example in Figure 3, expressed as a rapid increase in the price of South Carolina hardwood following the exhaustion of residues.

Residues availability also reflects the concentration of harvest in the coastal plain for both softwoods and hardwoods (Figure 5). Harvesting and transportation costs also vary by physiographic region (Figure 6). Such regional variation within forest biomass availability and price throughout the Southeastern United States has been identified in past biomass research (see, e.g., Young et al., 1991), and has tremendous implications for the economic feasibility of biomass as a bioenergy feedstock. While this analysis considers only the aggregate supply of and demand of forest biomass for bioenergy purposes, biomass can only be considered a viable feedstock if it can be sourced near the point of processing or end-use. This is because transportation costs play a strong role in the delivered price of the resource. Even at 50 miles or less, transportation costs alone can rise as high as $10-$30 per dry ton.[7] As such, *economically available* supply of residues for bioenergy is likely to be less than the gross totals estimated here due to difficulties in siting power plants close enough to feedstock sources to make the resource economical.

Projected Increases in Bioenergy Production

Under the reference case and assuming a constant proportion of 35% of total SERC regional capacity, total woody biomass bioenergy capacity in North Carolina, South Carolina, and Virginia is projected to increase by 29% in 2020 over 2006 levels. Assuming a constant proportion of 30% of total SERC regional generation, three-state bioenergy generation could increase by 124% in 2020 compared to 2006 levels. Maintaining these same assumptions, but factoring in the potential impacts of a hypothetical national RPS and RFS, the increases in bioenergy capacity and generation in North Carolina, South Carolina, and Virginia are much

[7] Calculated from Perlack et al. (2005). Figures are based on an estimated cost of $0.20 to $0.60 per dry ton-mile and assuming a 50-mile haul.

more substantial – capacity increases by 517% and generation increases by 647% in 2020, relative to 2006 levels.

Regional residue supply is sufficient to meet projected bioenergy demand in the study area only in the immediate future. As noted in Table 3, approximately 101 million MMBTU of potential forest residue energy exists in North Carolina, South Carolina, and Virginia. This amount is sufficient to meet projected woody biomass electricity production in the study area through the year 2012 with a national RPS and RFS, and at least through 2020 without (Figure 7). After this, other sources of biomass, either roundwood or other, non-forest biomass, must be introduced to meet additional demand. Within the state of North Carolina, sufficient residues are available to supply over 47 Million MMBTU, or 3,666 GWh at an assumed heat rate of 13,000 btu/kWh. This amount is sufficient to satisfy the expected contribution of woody biomass to the North Carolina state RPS through 2021 and beyond.[8]

Conclusion

Here, we identify and explore some general relationships that are likely to play key roles in the development and expansion of the forest biomass bioenergy market. Our results show that regional biomass supply is a function of current harvest levels, current roundwood prices, and the price elasticity of roundwood supply. Each of these factors varies by region and over time. The analysis also finds that a significant amount of forest residues are available within the states of North Carolina (2.8 million dry tons), South Carolina (1.8 million dry tons), and Virginia (1.3

[8] Although no specific targets are set for woody biomass within the legislation authorizing the North Carolina RPS (2007 N.C. Sess. Law 2007-397), electricity from wood-fired boilers is anticipated to comprise 12.5% of annual RPS targets (Bill Holman, pers. comm.. Nicholas Institute, Duke University, February 18, 2008). The RPS requirement for 2021 and thereafter is 12.5% of year 2020 sales. Year 2020 sales are estimated to be 162,713 GWh (North Carolina Climate Action Plan Advisory Group, 2008), and 12.5% of that figure is 20,339 GWh. The anticipated contribution of woody biomass for 2021 is therefore 12.5% of 20,339 GWh, or 2,542 GWh.

million dry tons), but are in themselves insufficient to satisfy long term biomass electricity production requirements imposed by a hypothetical national RPS and RFS. Sufficient quantities do exist within the state of North Carolina to meet the expected contribution of woody biomass to NC state RPS targets through 2021 and beyond.

Should demand for woody biomass exceed the supply of forest residues, our findings suggest that all users of forest resources will be affected by the resulting spike in resource pricing. Biomass demand for pulpwood will not simply be added to current demand, except possibly in the very short run. As prices increase marginal wood consumers in existing markets will be displaced. How this will unfold will depend on a variety of factors including the harvest level of roundwood, the demand price elasticity of biomass consumers versus current consumers, and market factors including long term contractual supply agreements. All of these relationships will evolve over time. As global competition and business cycles affect the pulpwood markets on the demand side, age class structure and ownership change of the resource will evolve on the supply side. An industry dependent on residues from another industry will have to navigate the tradeoffs between cost savings and supply security. Policy makers must have a strong understanding of the available resource base and be aware of these tradeoffs when considering incentives or programs to encourage increased levels of forest biomass for bioenergy or biofuel.

It is important to note, however, that these findings are based on assumed levels of state and regional bioenergy production and the proportion of energy production coming from woody biomass. Thus, our findings are susceptible to shifts in price, technology, policy, or a combination of one or more of these factors. It should also be noted that increases or decreases in harvests can influence the availability of residues in any given year, as the actual annual supply of residues is a function of harvest activity. This is especially important in light of recent

SRTS runs that suggest that moderate increases in demand for forest products (.5%/year) lead to gradual increases in logging residuals over coming decades, but with significant shifts in the importance of individual survey units and species groups. Finally, the regional averages on which we base our analysis allow us to capture differences due to physiographic regions (mountain, piedmont, coastal plain), current harvest patterns, and prices. They do not, however, provide a basis on which to base decisions on plant siting within a region, as individual locations may not reflect regional average costs or production.

Several aspects require further investigation. A first step is to expand the current analysis to include the entire South. Furthermore, the analysis of future bioenergy production contained herein includes only forest residues, and does not evaluate the specific price and supply implications of increasing bioenergy roundwood demand; incorporating demand elasticities by market will shed light on which users are likely to be squeezed out by rising roundwood demand. Assuming all logging residues are available for $1/green ton is obviously overly simplistic, so another task is to incorporate recent empirical work by the Southern Forest Resource Assessment Consortium (SOFAC) so as to better characterize regional variation in price sensitivity and the potential price shifts that could come with greater utilization. This would also allow for the identification of those survey units possessing “competitive advantages”, or high residual availability and/or low roundwood costs.

It would likewise be interesting to calculate the weighted average price of woody biomass inputs at different scales and then run demand scenarios for biofuel or bioenergy to determine how many facilities could be sustained. Finally, greater attention should be paid to other exogenous factors affecting the forest land base and the management of forest resources, such as loss of forest land to other uses, the emergence of carbon offset markets, and shifting biofuel and bioenergy policy. The recent dramatic expansion of the national RFS under the Energy Security and Independence Act of 2007 (P.L. 110-140) represents one such shift in the policy landscape that will likely influence the results and conclusions generated here.

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Table 1. Total logging residues by state.

State	Region	Softwood	Hardwood	All
		…………(thousand ft^3)…………		
NC	1	51,202	34,975	86,177
	2	45,681	39,562	85,243
	3	33,939	68,131	102,070
	4	7,139	36,958	44,097
	NC total	**137,961**	**179,626**	**317,587**
SC	1	53,947	19,114	73,061
	2	47,898	13,049	60,947
	3	52,681	21,829	74,510
	SC Total	**154,526**	**53,992**	**208,518**
VA	1	23,812	29,986	53,798
	2	22,315	32,849	55,164
	3	4,086	12,065	16,151
	4	627	10,141	10,768
	5	2,384	16,182	18,566
	VA Total	**53,224**	**101,223**	**154,447**
NC, SC, VA Total		**345,711**	**334,841**	**680,552**

Table 2. Pulpwood stumpage, delivered, and estimated harvest and transport costs.

State	Region	Stumpage Price (2006 $/green ton)		Delivered Price (2006 $/green ton)		Harvest/Transport (2006 $/green ton)	
		Softwood	**Hardwood**	**Softwood**	**Hardwood**	**Softwood**	**Hardwood**
NC	1	6.07	3.54	22.39	21.14	16.32	17.60
	2	6.07	3.54	22.39	21.14	16.32	17.60
	3	5.37	4.14	21.80	21.55	16.43	17.41
	4	4.68	4.75	21.21	21.96	16.53	17.21
SC	1	7.03	8.96	23.96	25.53	16.93	16.57
	2	7.03	8.96	23.96	25.53	16.93	16.57
	3	6.92	8.46	23.05	23.84	16.13	15.38
VA	1	7.21	2.63	25.46	22.60	18.25	19.97
	2	6.77	2.83	26.01	21.98	19.24	19.15
	3	6.77	2.83	26.01	21.98	19.24	19.15
	4	6.33	3.04	26.56	21.36	20.23	18.32
	5	6.33	3.04	26.56	21.36	20.23	18.32

Table 3. Total amount of available residues in North Carolina, South Carolina, and Virginia.

	Softwood	Hardwood	Total	Total Energy Potential (MMBTU)
	…………………….. (dry tons)……………………..			
NC	1,187,844	1,615,736	2,803,580	47,660,860
SC	1,330,469	485,658	1,816,127	30,874,159
VA	458,259	910,501	1,368,760	23,268,920
Total	*2,976,572*	*3,011,895*	*5,988,467*	*101,803,939*

Table 1. Total logging residues by state. Regions correspond to FIA survey units (NC: 1-Southern Coastal Plain, 2-Northern Coastal Plain, 3-Piedmont, 4-Mountains; SC: 1 Southern Coastal Plain, 2-Northern Coastal Plain, 3-Piedmont; VA: 1-Coastal Plain, 2-Southern Piedmont, 3-Northern Piedmont, 4-Northern Mountains, 5-Southern Mountains). (Source: U.S. Forest Service 2007 and Subregional Timber Supply Model (SRTS))

Table 2. Pulpwood stumpage, delivered, and estimated harvest and transport costs. Regions correspond to FIA survey units (NC: 1-Southern Coastal Plain, 2-Northern Coastal Plain, 3-Piedmont, 4-Mountains; SC: 1 Southern Coastal Plain, 2-Northern Coastal Plain, 3-Piedmont; VA: 1-Coastal Plain, 2-Southern Piedmont, 3-Northern Piedmont, 4-Northern Mountains, 5-Southern Mountains). (Source: Timber Mart-South 2007)

Table 3. Total amount of available residues in North Carolina, South Carolina, and Virginia.

Figure 1. Delivered incremental softwood biomass supply by survey unit (NC: 1-Southern Coastal Plain, 2-Northern Coastal Plain, 3-Piedmont, 4-Mountains; SC: 1 Southern Coastal Plain, 2-Northern Coastal Plain, 3-Piedmont; VA: 1-Coastal Plain, 2-Southern Piedmont, 3-Northern Piedmont, 4-Northern Mountains, 5-Southern Mountains). Prices are in 2006 $/dry ton.

Figure 2. Delivered incremental hardwood biomass supply by survey unit (NC: 1-Southern Coastal Plain, 2-Northern Coastal Plain, 3-Piedmont, 4-Mountains; SC: 1 Southern Coastal Plain, 2-Northern Coastal Plain, 3-Piedmont; VA: 1-Coastal Plain, 2-Southern Piedmont, 3-Northern Piedmont, 4-Northern Mountains, 5-Southern Mountains). Prices are in 2006 $/dry ton.

Figure 3. Incremental biomass supply by state and species (SW-softwood, HW-hardwood). Prices are in 2006 $/dry ton.

Figure 4. Delivered incremental biomass supply by state and species (SW-softwood, HW-hardwood). Prices are in 2006 $/dry ton.

Figure 5. Incremental biomass supply by physiographic region and species (SW-softwood, HW-hardwood). Prices are in 2006 $/dry ton.

Figure 6. Delivered incremental biomass supply by physiographic region and species (SW-softwood, HW-hardwood). Prices are in 2006 $/dry ton.

Figure 7. Projected additional woody biomass bioenergy consumption in North Carolina, South Carolina, and Virginia, under both reference and national, year-2025 25% RPS/RFS scenarios. Available forest residues are indicated by the horizontal line. For a given year, the range of consumption estimates is based on total North Carolina, South Carolina, and Virginia woody biomass bioenergy consumption comprising from 30% to 35% of total SERC regional consumption.