WOOD *to*
ENERGY
Community Economic Profile

Virginia: Chesterfield and Fluvanna Counties

Matthew Langholtz, Douglas R. Carter, Alan W. Hodges, Annie Oxarart, & Richard Schroeder

In the southern United States, communities with increasing populations and nearby forests may be able to consider using woody biomass to generate energy. A variety of other factors must also be considered, such as the price of existing energy sources, competing markets for wood, community acceptance, and the economic availability of wood resources. Many counties in Virginia have forests in close proximity to growing populations. To gain a better understanding of the range of possibilities for economic availability and the local economic impacts of using wood for energy, Chesterfield and Fluvanna counties were selected for analysis in this community economic profile.

From the coastal plain in the east to the Appalachian Mountains in the west, Virginia is a scenic state with abundant and diverse natural resources. About 62 percent of the landscape is forested, with the majority of the counties having over 50 percent forest cover. Oak-hickory hardwood forests and loblolly-shortleaf pine forests dominate the forested landscape. More than three-fourths of the forestland is privately owned by non-industrial landowners and another 6 percent is owned by the forest industry. In addition, 17 percent of the forestland is publicly owned, which includes well-known Shenandoah National Park, George Washington and Jefferson National Forests, and several state parks (USDA 2006). The forest industry is an important component of Virginia's economy and ranks first in the state's manufacturing industries for employment and wages. The industry contributes $30.5 billion dollars annually and employs more than 248,000 people (Virginia Department of Forestry 2006). Virginia's forests also provide benefits such as erosion protection, cleaner air and water, recreational opportunities, natural beauty, and wildlife habitat.

Located in east-central Virginia, Chesterfield and Fluvanna counties are home to growing communities and forests. Chesterfield County is on the southwest corner of Richmond; the towns of Bon Air, Chester, and Chesterfield increase in size as the Richmond metropolitan area expands. Several Civil War sites, historic coal mines, the Appomattox and the James Rivers, Lake Chesdin, and Pocahontas State Park attract many visitors and enhance residents' quality of life. In addition, the small town of Ettrick, located on the Appomattox River, is home to Virginia State University. Fluvanna County, on the southeast side of Charlottesville, is the third fastest-growing county in Virginia. Among the farmland, pastures, and forests are growing communities such as Columbia, Palmyra, and Fork Union. The James and Rivanna Rivers along with Lake Monticello offer residents and visitors natural settings to enjoy fishing, canoeing, and other outdoor activities. The county's central location, nearby highways, low taxes, and attractive land prices have drawn several industries to the area, including furniture and technology companies.

According to the U.S. Census Bureau (2007), both Chesterfield and Fluvanna counties experienced significant population growth from 2000 to 2006 (Table 1). These new residents, developments, and businesses create the need for additional energy sources.

Dominion Virginia Power has fossil fuel power plants located in both Chesterfield and Fluvanna counties, which supply large of amounts of energy to the surrounding areas; however, the local availability of wood resources can provide opportunities for communities to use renewable and sustainable fuel sources to meet growing energy demands. Wood can also be used by a smaller facility, such as a hospital or school.

Table 1. *Population Data for Selected Virginia Counties*

County	2000	2006	Population Growth from 2000 to 2006
Chesterfield	259,903	296,718	14.2%
Fluvanna	20,047	25,058	25.0%

Woody biomass from urban wood waste, logging residues, and forest thinnings, for example, can be used to generate energy. Using wood to generate electricity provides many potential benefits such as reduced greenhouse gas emissions, healthier forests, and local jobs and other economic impacts. For more information on these topics see the *Climate Change and Carbon*, *Sustainable Forest Management*, and *Environmental Impacts* fact sheets. All of our materials are available at http://www.interfacesouth.org/woodybiomass.

To estimate the amount of wood that could be available in a community, we include three sources: urban wood waste, logging residues, and pulpwood. While other woody biomass resources exist and could be added to the resource assessments, we include only these resources, for which cost and supply data are available. Urban wood waste is generated from tree and yard trimmings, the commercial tree care industry, utility line clearings, and greenspace maintenance. Logging residue is composed of the leftovers from forest harvesting, such as tree tops and limbs, and poorly formed trees. Pulpwood refers to small diameter trees (3.6 to 6.5 inches diameter at breast height) that are harvested for manufacturing paper, purified cellulose products, (including absorbents, filters, rayon, and acetate), and oleoresin products (including pine oils, fragrances, cosmetics, and thinners). This profile excludes secondary woody waste from sawmills and furniture makers, which is available but may already be used within the industry to produce energy. See the fact sheet, *Sources and Supply,* for more information.

Economic factors, including fuel costs and the creation of local jobs, are major determinants of the feasibility of bioenergy projects. Assessing the economic availability of biomass requires learning about the delivered cost of wood, the quantity of available wood, and its geographic distribution. This information is then used to create biomass resource supply curves, which express price per unit of biomass at a range of potential quantities of consumption. The following summary uses these methods to assess the economic availability of wood resources for Chesterfield and Fluvanna counties in Virginia. More information about the development of this supply curve can be found on the Web site in *Assessing the Economic Availability of Woody Biomass*.

Cost Calculations

The delivered cost of woody biomass to a facility is the sum of the amount paid to buy the wood from the original owner (procurement), the harvest cost, and the transportation cost. Although rail transportation could be used in some cases, woody biomass is typically transported by truck. The cost of transportation depends on the time it takes a truck to travel from the harvest site to the facility. Haul times to the central delivery point in each county are calculated using a software program called ArcGIS Network Analyst Extension (Figure 1).

Assuming that haulers drive the speed limit on the quickest route available to them, we calculate total transportation times for the forested areas around the delivery point, and then increase haul times (and thus costs) by 25 percent to account for delays, such as traffic and stops. These haul-time areas delineate potential "woodsheds" or areas that can provide wood for a specific community or biomass user. If demand is established in more than one area in proximity, woodsheds can overlap, causing competing demand for biomass.

The total delivered cost is derived from the sum of the procurement, harvest, and transportation costs for urban wood waste, logging residues, and pulpwood. This is calculated at 15-minute increments up to one hour from each delivery point. Delivered costs allow us to see the progression of the most- to least-expensive woody biomass resources. For example, if urban waste wood were delivered within the one-hour limit, the total delivered cost would be $19.46 per dry ton, or $1.25 per million British thermal units (MMBtu). However, if pulpwood were delivered from the same distance, the delivered cost would increase to $49.14 per dry ton, or $3.04 per MMBtu, primarily because pulpwood is more expensive than urban wood waste.

Physical Availability

In addition to the delivered cost of wood, knowing how much of each type of woody biomass is available is necessary to construct supply curves. Annually harvested pulpwood and annually available urban wood waste and logging residues within Chesterfield and Fluvanna counties are shown in Table 2.

For urban wood waste, it is assumed that 0.203 green tons (40 percent moisture content) of urban wood waste is generated per person per year (Wiltsee 1998). This includes municipal solid waste wood from yard waste and tree trimming but excludes industrial wood (e.g., cabinet and pallet production) and construction and demolition debris. This average yield was multiplied by county population estimates and reduced by 40 percent to estimate total annual county yield of urban wood waste. For example, in Chesterfield County, this results in 35,000 green tons of urban wood waste per year.

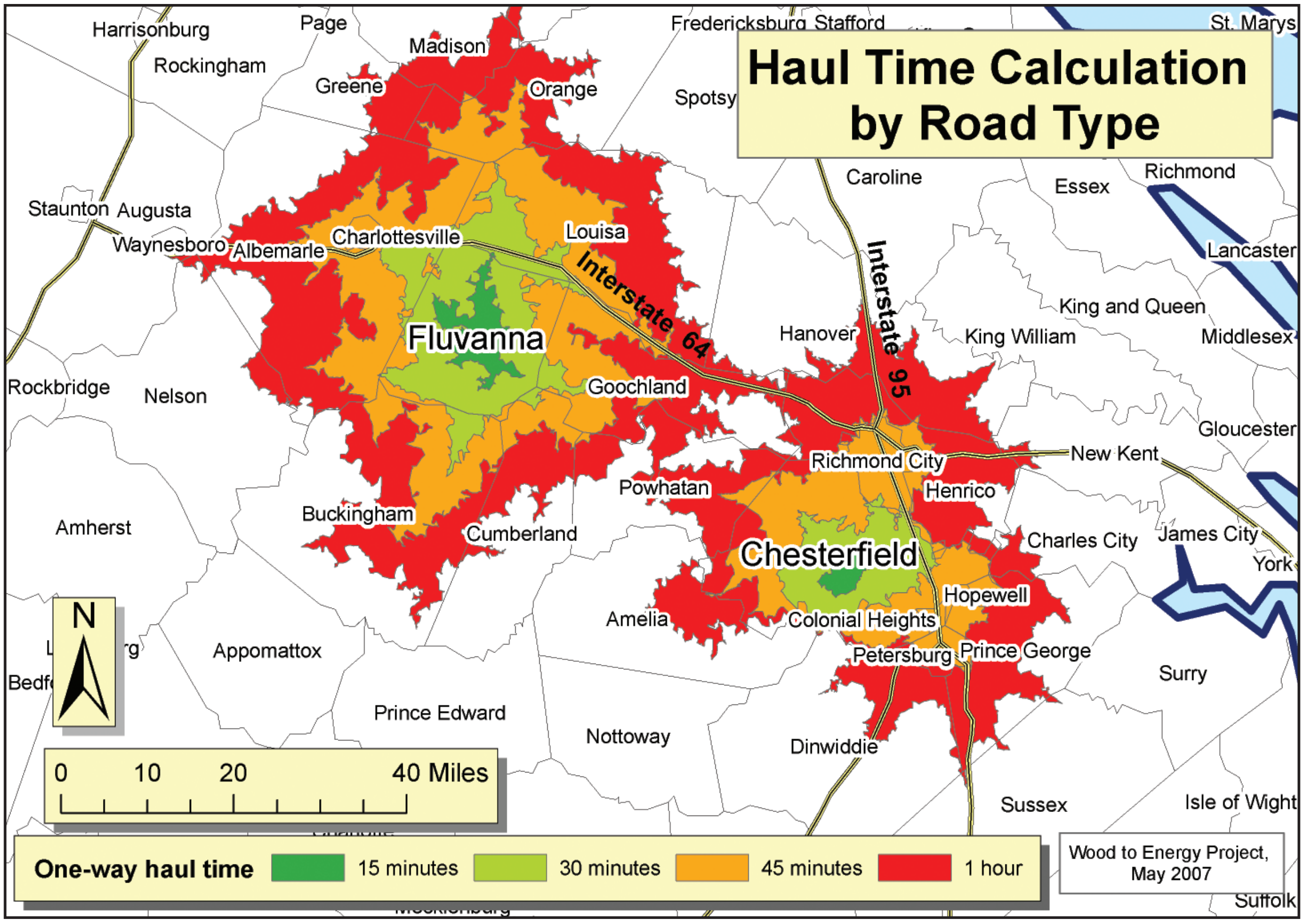

Figure 1. *Wood harvested within each colored band can be transported to the center of each county in 15-minute increments.*

The amount of logging residue and pulpwood for all counties in the southeast U.S. was obtained from the USDA Forest Service (2003) Timber Product Output Reports. This database provides forest inventory and harvest information, including annual yields of forest residues and pulpwood. We reduced the figure for logging residues by 30 percent to exclude stumps. For example, in Fluvanna, there are 13,000 green tons (37 percent moisture) of logging residues available annually from existing forestry operations. There are also 56,500 green tons (50 percent moisture) of pulpwood harvested annually. Because the pulpwood harvest is currently used to produce pulp and paper products, not all of this resource is economically available for bioenergy. However, additional biomass is available from forest thinning, particularly those conducted for ecosystem restoration, which is not included in this assessment (Condon and Putz 2007).

Moisture content refers to the amount of moisture remaining in wood and is an important consideration in the quality of biomass resources. Moisture content is 0 percent in oven-dried biomass, about 20 percent for air-dried biomass, and about 50 percent for fresh or "green" biomass. As the moisture content of wood increases, the energy content per unit mass of wood decreases. Thus, wood with low moisture content will combust more efficiently than wood with high moisture content. Moisture content in this document is reported on a green-weight basis.

Table 2. *Three Sources of Available Wood*

County	Available urban wood waste	Available logging residues	Harvested pulpwood
Chesterfield	35,000	16,000	18,500
Fluvanna	3,000	13,000	56,500

Supply Curve Construction

Given information regarding cost, quantity, and distribution of all three types of woody biomass, supply curves can be generated for the two counties. Figure 2 shows the price of wood at different quantities needed. The y-axis represents price per MMBtu of energy and the x-axis represents the total amount of wood available in 15-minute increments. Several scales are provided to translate the quantity of wood into tons, energy content, and houses electrified. Biomass sources include urban wood waste, logging residues, and pulpwood within a one-hour haul radius of each county center.

Supply Analysis Results

Energy resources and costs for each resource-haul time category for the two counties are shown in Table 3 (resources are ranked from cheapest to most expensive based on delivered cost of energy). These values were used to construct the supply curves shown in Figure 2. The supply curves suggest that 1.7 and 1.9 trillion Btu, or 14 and 16 megawatts (MW) of electricity, which is enough to power 5,800 and 6,500 households (Bellemar 2003), are available for less than $2.60 per MMBtu in the Chesterfield and Fluvanna County woodsheds, respectively. Energy at this cost is competitive with current costs of coal. Within a one-hour haul radius, up 0.9 and 0.2 trillion Btu can be provided from urban wood waste alone in Chesterfield and Fluvanna county woodsheds, respectively. With the addition of logging residues, 1.7 and 1.9 trillion Btu can be produced in the Chesterfield and Fluvanna County woodsheds, respectively. Other types of wood may be available from thinnings to improve forest health, although estimates of this wood are not available. As the cost of oil increases, all price estimates increase (with petroleum inputs for harvesting and transportation), but so do the costs of coal and natural gas. In other words, as fossil fuels become more expensive, the delivered cost of wood will increase but will become increasingly competitive with nonrenewable fuels.

Economic Impact Analysis

The potential economic impacts of developing a wood-fueled power plant are an important consideration for both public and private interests in a community. In this economic analysis, two sizes of power plant were considered: 20 or 40 MW. The construction of the plant would be a one-time impact event that is assumed to occur within a year, while the impacts of plant operations

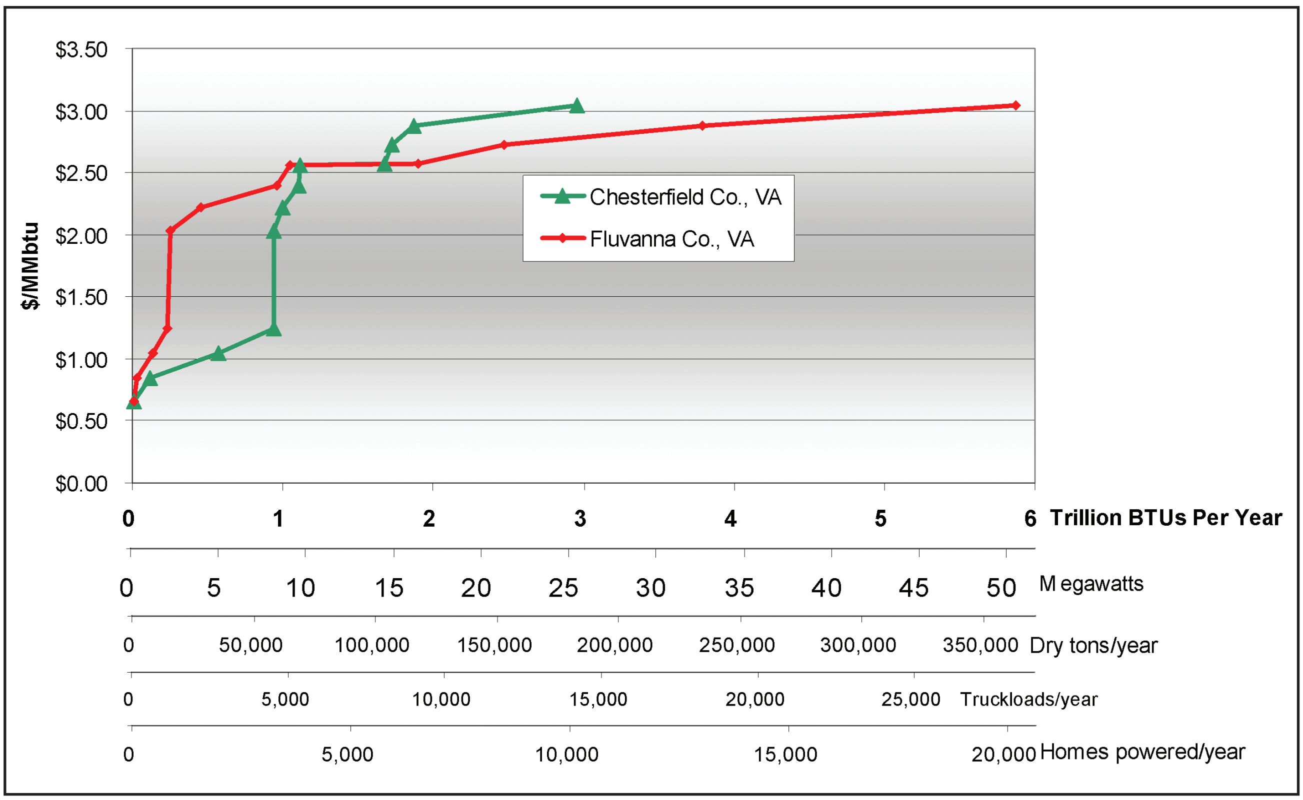

Figure 2. *Supply curves for woody biomass indicate the cost and quantity of wood at 15-minute hauling intervals.*

Table 3. *Delivered Cost of Available Wood*

		Trillion Btu available per year within a one-hour haul radius	
Delivered cost ($/MMBtu)	**Resource/Haul time category**	**Chesterfield County**	**Fluvanna County**
$0.65	Urban wood: 0-15 minutes	0.01	0.01
$0.85	Urban wood:15-30 minutes	0.11	0.03
$1.05	Urban wood: 30-45 minutes	0.45	0.10
$1.25	Urban wood: 45-60 minutes	0.37	0.09
$2.03	Logging residues: 0-15 minutes	0.01	0.02
$2.21	Logging residues: 15-30 minutes	0.05	0.20
$2.39	Logging residues: 30-45 minutes	0.11	0.51
$2.56	Pulpwood: 0-15 minutes	0.01	0.09
$2.57	Logging residues: 45-60 minutes	0.56	0.84
$2.72	Pulpwood: 15-30 minutes	0.05	0.58
$2.88	Pulpwood: 30-45 minutes	0.14	1.32
$3.04	Pulpwood: 45-60 minutes	1.09	2.08

continue annually over the life of the plant, for 20 years or more. Wood fuel costs were calculated from the regional supply curves discussed previously in this report. Economic impacts were estimated using IMPLAN software and databases for each county. These estimates included not only the direct impacts of plant construction and operation but also the indirect impacts from local purchases and local spending by employee households. Further information on the methods of analysis and interpretation of economic impact results is available in the fact sheet, *Economic Impacts of Generating Electricity*.

Economic impacts were evaluated for Chesterfield and Fluvanna counties in Virginia. Fuel typically represented the largest operating cost for a wood-fired power plant. Fuel costs were very similar for these counties, reflecting comparable resources and transportation infrastructure. Annual fuel costs averaged $3.9 and $10.1 million annually for the 20 or 40 MW plants, respectively (Table 4).

In contrast, the economic impacts of plant construction and operations varied widely between these counties. This was due to differences in the makeup of these local economies. The total annual operating impacts (first year) for a 20 MW plant ranged from $9.5 to $13.1 million in output (revenue), 187 to 218 jobs, and $5.5 to $7.8 million in value added (income). Total operating impacts for a 40 MW plant ranged from $20.4 to $28.5 million in output, 437 to 501 jobs, and $11.9 to $17.1 million in value added. The first year impacts for plant operations are representative of the ongoing annual impacts; however, future impacts could change due to prices of inputs such as fuel, unexpected maintenance activities, and general economic inflation.

Total construction costs were valued at $48.7 million for the 20 MW plant and $86.8 million for the 40 MW plant, including land, site work, construction, plant equipment, and engineering fees. Local construction impacts for a 20 MW plant ranged from $3.9 to $43.8 million in output, 40 to 222 jobs, and $2.1 to $22.1 million in value added. Construction impacts for the 40 MW plant ranged from $4.7 to $76.2 million in output, 50 to 372 jobs, and $2.5 to $38.2 million in value added. The construction impacts were significantly higher in Chesterfield County due to the presence of manufacturing industries for boilers and turbines. These are key components for a power plant and resulted in more of the capital spending being retained within the local economy.

Often it is helpful to predict the distribution of economic impacts across various sectors of the local economy. More than 60 percent of all jobs would occur in the agriculture and forestry sector, which supplies wood fuel to these facilities. However, there would also be significant employment impacts in the sectors for professional services, retail trade, and government, reflecting the indirect effects on the local economy associated with purchased supplies and employee household spending.

Table 4. *Economic Impacts of 20 and 40 MW Power Plants*

Virginia County	Wood Fuel Cost ($Mn)	Annual Operations Impacts (first year)			Plant Construction Impacts		
		Output ($Mn)	Employment (Jobs)	Value Added ($Mn)	Output ($Mn)	Employment (Jobs)	Value Added ($Mn)
20 MW							
Chesterfield	3.81	13.08	187	7.84	43.83	222	22.14
Fluvanna	4.06	9.56	218	5.51	3.93	40	2.14
Average	**3.94**	**11.32**	**202**	**6.67**	**23.88**	**131**	**12.14**
40 MW							
Chesterfield	10.22	28.46	437	17.07	76.22	372	38.24
Fluvanna	10.04	20.42	501	11.89	4.72	50	2.51
Average	**10.13**	**24.44**	**469**	**14.48**	**40.47**	**211**	**20.38**

Conclusions

Economic concerns are important to discussions of using wood for energy in the South. For many communities, the conversation begins with the recognition that there might be enough wood at an affordable cost. Our supply analysis suggests that, indeed, enough wood at a reasonable cost is available in Chesterfield and Fluvanna counties to make a continued conversation possible. 1.7 and 1.9 trillion Btu (i.e., 14 and 16 MW or energy to power 5,800 and 6,500 homes annually) of woody biomass are available at less than $2.60 per MMBtu in Chesterfield and Fluvanna counties, respectively. These general estimates could be improved with more site-specific analysis and information.

Additional assessments of local conditions, population density, distribution of wood, competition from pulp mills, restoration activities, and other factors would improve the accuracy of these biomass resource assessments. The following caveats should be considered when interpreting the results presented in this profile:

- The supply considered in this profile includes only urban wood waste, logging residues, and pulpwood. It excludes stumps and waste from wood industries.
- Because only county-level data were available, homogeneous distribution of resources within counties is assumed. Resource distribution within counties and location of bioenergy generating facilities will influence the actual economic availability of woody biomass suitable for energy generation. More detailed local analysis might consider the distribution of biomass resources within counties, especially for site selection of bioenergy facilities.
- The inclusion of other resources such as mill wastes or thinnings from forest management and habitat restoration would increase available resources.
- This analysis is not intended to be a definitive resource assessment but is rather meant to provide a starting point for discussions about the feasibility of using wood for energy. Resources can be excluded or added as more information becomes available, and prices can be modified to reflect local conditions.
- A rise in the price of petroleum would increase the cost of the resources shown here, as well as costs of conventional energy sources like coal.
- Some assumptions made in this analysis are subject to change. For example, large-scale bioenergy development in the area could increase competing demand for wood resources.
- Rail transportation, which could reduce transportation costs and make biomass resources from other areas more available, was not considered in this analysis.
- Construction and operation of wood-fueled power plants may have significant local economic impacts. These impacts vary widely among selected counties, depending upon the makeup of the local economy.

- Wood fuel represents one of the largest expenditures for a power plant and gives rise to large impacts in the local forestry and forestry services sectors. Other sectors of the local economy are also impacted through the indirect effects associated with purchased supplies and employee household spending.
- Economic impacts of a 40 MW power plant are greater than for a 20 MW plant, although not in proportion to the power output, due to economies of scale.

For more information about using wood to produce energy, visit http://www.interfacesouth.org/woodybiomass and read other fact sheets, community economic profiles, and case studies from this program, or http://www.forestbioenergy.net/ to access a number of other resources.

References

Bellemar, D. 2003. What Is a Megawatt? http://www.utilipoint.com/issuealert/article.asp?id=1728 (accessed July 13, 2006).

Condon, B. and F. E. Putz. 2007. Countering the Broadleaf Invasion: Financial and Carbon Consequences of Removing Hardwoods During Longleaf Pine Savanna Restoration. Restoration Ecology 5:2. In press.

U.S. Census Bureau. 2007. http://www.census.gov/ (accessed March 29, 2007).

USDA Forest Service. 2006. Forest Inventory and Analysis Factsheet Virginia 2001. Asheville NC: USDA Forest Service, Southern Research Station. http://srsfia2.fs.fed.us/states/va/VA2001~1.PDF (accessed April 23, 2007).

USDA Forest Service. 2003. Forest Inventory and Analysis. Timber Product Output (TPO) Reports. Asheville, NC: USDA Forest Service, Southern Research Station. http://srsfia2.fs.fed.us/php/tpo2/tpo.php (accessed November 15, 2006).

Virginia Department of Forestry. 2006. Economic Impact of the Forest Industry in Virginia. http://www.dof.virginia.gov/resinfo/economic-impact.shtml (accessed April 23, 2007).

Wiltsee, G. 1998. Urban wood waste resource assessment. National Renewable Energy Laboratory, Golden, CO.

Authors

Matthew Langholtz, Postdoctoral Research Associate and Douglas R. Carter, Associate Professor, School of Forest Resources and Conservation; Alan W. Hodges, Associate In Food and Resource Economics; and Annie Oxarart, Outreach Research Associate, School of Forest Resources and Conservation, University of Florida, Gainesville FL; and Richard Schroeder, President, BioResource Management, Inc., Gainesville FL.

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