

Recommended Methodology for Assessing Forestry Biomass for Bio-energy Utilization

Prepared for Services, Utilization, and Marketing Task Force
Southern Group of State Foresters
Prepared by: Nathan McClure

Part 1: Introduction

Recent concerns with energy security, energy costs, rural economies, and environmental concerns have increased interest in the use of *forest biomass* for energy. Forest biomass can be obtained directly from the forest in the forms of trees or portions of these trees. It can also be obtained from forest product manufacturing facilities in the form of by-products, such as bark, sawdust, shavings and other residues. For the purpose of this report, biomass from urban sources, such as tree trimmings and demolition wood, will not be considered.

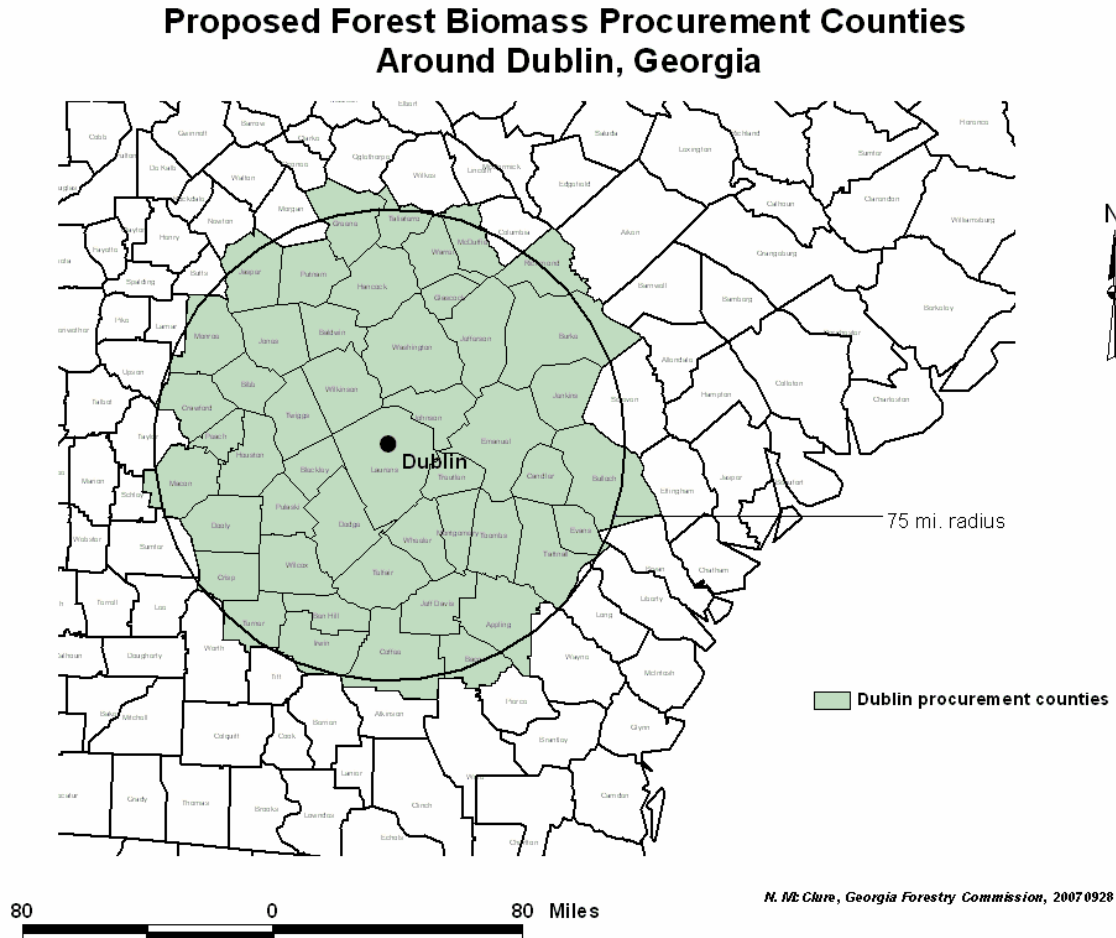
The U. S. Forest Service Forest Inventory and Analysis (FIA) program¹ is designed to collect information concerning forest resources and serves as the best source of data for forest biomass assessments. The FIA program collects data by fixed plot measurements throughout forests in the US, by conducting surveys, by performing logging utilization studies, and by conducting other research concerning forest resources. This report provides instructions on the use of various FIA data to perform forestry biomass assessments. Instructions are included in the Report text and sample tables are listed in Appendix B.

Part 2: Procurement Area Considerations

Energy facilities using forest biomass desire to assess the availability of biomass around a specific facility site. The cost of transporting biomass normally limits the analysis to a radius of 75 miles or less around a facility. Typical analyses use 50 and/or 75 miles for a radius. Foreign-based firms may prefer to use metric units, which makes 100 km (60 miles) a valid radius to use for a biomass analysis. It should be noted that the area of a circle increases in greater proportion than the radius. This effect yields approximately 5 million acres of land within a 50 mile radius of a given point and over 11 million acres within a 75 mile radius of that point.

The FIA plot data is analyzed using actual plot location and can be grouped by county. The forest product mill surveys are county-based. Any analysis that will compare or combine data from both these sources must use a county-based approach. Therefore, counties must be selected around the specific facility site that approximately fall within the desired radius. Figure 1 shows an example of how this might be done using maps or geographic information software. Once the counties are selected, online databases from the FIA website² (Mapmaker 3.0) at <http://www.ncrs2.fs.fed.us/4801/fiadb/fim30/wcfim30.asp> and the Timber Product Output (TPO) webpage at <http://srsfia2.fs.fed.us/php/tpo2/tpo.php> can be queried to produce tables of the appropriate needed data. It is useful to copy and paste Mapmaker data tables into an Excel spreadsheet for further calculations and to develop charts that reflect the biomass and other resource quantities that fall within the considered area.

Figure 1: Display of Procurement Area for Forest Biomass



Part 3: Timberland Area

The area of *timberland* by ownership class, forest type, and age class should be determined. Particular emphasis should be made in separating pine plantations, natural pine areas, mixed pine/hardwood areas, and hardwood areas. This can be determined using a variety of procedures within the Mapmaker database. However, the “attribute of interest” should be “area of timberland”.

Part 4: Biomass in Standing Tree Inventory

Section A: FIA Program Forest Biomass Terminology

Forest biomass can be derived from portions of trees considered merchantable for use in traditional forest products manufacturing and forest biomass can be obtained from portions of trees considered non-merchantable. The FIA program also considers that forest biomass may be in *growing stock trees*, *rough (cull) trees*, and *rotten trees*. Furthermore, the term

growing stock wood volume is used for the amount of merchantable wood in *growing stock trees*. Reviewing the definitions of the following terms provides a better understanding of the terminology and a better interpretation of the FIA data as applied to forest biomass for energy. These definitions¹ are also included in Appendix A.

Growing stock trees: Living trees of commercial species classified as sawtimber, poletimber, saplings, and seedlings, which contain or have the potential to contain at least one 12-foot log.

Growing stock volume: The cubic-foot volume of sound wood in growing-stock trees that are at least 5.0 inches DBH, with volume being included from a 1-foot stump height to a minimum 4.0 –inch top diameter-outside-bark (DOB) of the central stem.

Rough trees: Live trees of commercial species not containing or without the potential of containing at least one 12-foot saw log because of roughness, poor form, splits, and cracks.

Rotten trees: Live trees of commercial species not containing or without the potential to contain at least one 12-foot saw log because of rot or missing sections.

Non-growing stock volume: The volume in the stumps, tops, branches, and cull sections of the central stem of any poletimber or sawtimber trees classified as growing stock plus any portion of a rough, rotten, sapling, or non-forest tree.

All live biomass: The total above ground biomass of trees 1.0 inch DBH and larger, including tops, limbs, and bark; but excluding foliage.

All live merchantable biomass: The biomass of trees 5.0 inches DBH and larger from a 1-foot stump to a 4-inch top DOB of the central stem including bark.

Section B: Merchantable Wood Volume in Standing Timber Inventory

Merchantable standing timber inventory is a common forest resource indicator. *Merchantable biomass* can also be used for certain bioenergy products, depending on the value of the energy product and biomass processing costs. Biomass within the standing timber inventory can be estimated with the Mapmaker database utilizing a variety of different “attributes of interest”. However, to promote ease of conversion from wood volume to weight; it is recommended that the attribute of interest be “*All live merchantable biomass on timberland*”. This attribute is available from the Mapmaker database in oven-dry tons and in green tons. The green ton estimate is made directly from volume using conversions that are specific to species and tree size. The oven-dry ton estimate is simply the green ton estimate divided by two, which assumes an average 50% moisture content for all tree biomass. If there are concerns about local differences in moisture content of trees, then the green ton estimate should be used followed by conversion to dry weight using local conversion factors. It is useful to gather more details concerning this resource, such as species, tree diameter and stand age class. Mapmaker can be used in a variety of ways to compile this information. The following section describes two methods of Mapmaker

database utility that are recommended for estimating merchantable standing timber inventory.

Method 1) After choosing the attribute “All live merchantable biomass on timberland – oven dry tons”, use “stand origin” as the page variable, “stand age 5 year classes” as the column variable and “species group – major group” as the row variable. This example would result in an estimate of the oven-dry weight of biomass in all live standing trees with DBH >5”, by planted or naturally regenerated stands, by species group and by stand age class. The resulting table(s) should be copied on to an Excel spreadsheet for further use and for creating charts. Table 1 provides an example of a portion of a data table derived in this manner for merchantable biomass.

Method 2) After choosing the attribute “All live merchantable biomass on timberland – oven dry tons”, use “species group - major” as the page variable, “stand age 5 yr classes” as the column variable and “current DBH in 2” classes” as the row variable. If no filter is used, this will provide an estimate of the oven-dry weight of biomass in all species of live standing trees with DBH >5”, by species group, by DBH class, and by stand age class. The resulting table(s) should be copied on to an Excel spreadsheet for further use and for creating charts. Table 2 provides an example of a portion of a data table derived in this manner for merchantable biomass. The merchantable biomass can also be displayed in 2 or more tables for further detail by using additional filter options. For example, the “stand origin” filter can be used followed by “species group-major” for the page variable, “current DBH in 2” classes” for the row variable, and “stand age 5 yr classes” for the column variable. This example would result in an estimate of merchantable biomass by planted or naturally regenerated stands, depending on your filter selection.

Section C: Non-merchantable Wood Volume in Standing Timber Inventory

Much of the biomass grown in forests is not considered merchantable for traditional forest products, such as lumber and paper. Sources of this *non-merchantable biomass* include the total amount of biomass in small non-crop trees (<5” DBH) and the tops and branches of larger trees (>5” DBH).

The FIA program classifies trees into 3 groups: 1) growing stock trees, 2) cull rough trees, and 3) cull rotten trees. These are described in the *FIA Program Forest Biomass Terminology* section above. For the purposes of this report, the lower and upper stems of the rough and rotten culls will be considered merchantable and are included in the *Merchantable Wood Volume in Standing Timber Inventory* section above. An argument can be made that all the biomass in cull rough and cull rotten trees is available for bioenergy uses. However, the *Harvest and Utilization Studies* performed by the US Forest Service Southern Research Station do not support this argument. For example, the Georgia study for 2004³ indicated that 3.6% of the utilized softwood was from cull trees and 6.9% of the utilized hardwood was from cull trees. Considering these studies and the recent improvements in harvest utilization throughout the industry, it would be unreasonable to include the major stem portions of the cull rough and cull rotten trees as “non-merchantable” and available for energy at a much lower cost than for other products. However, the tops

and branches of these trees are not currently used and should be considered as “non-merchantable” and available for bioenergy.

The recommended method for obtaining estimates of “non-merchantable” forest biomass in standing timber inventory using the FIA Mapmaker database is to use the difference in “all live biomass” and “merchantable biomass”. The operation can be described as:

$$B_E = B_T - B_M$$

B_E is biomass for energy

B_T is all live biomass

B_M is all live merchantable biomass

Non-merchantable biomass estimates are obtained using Mapmaker and Excel spreadsheet functions using the following process:

Step 1) Select “custom tables” and the appropriate counties within the assessment area. Choose the attribute “All live biomass on timberland – oven dry tons”. Afterwards, use the same procedures as described in Section B above.

Step 2) Transfer the tabular results to worksheets within the same spreadsheet file as used in Section B. When displaying biomass in a table with DBH class as a row variable, the “all live biomass on timberland” table will include rows for the 1” – 4.9” DBH classes, as well as those greater than 5”. An example is displayed in Table 3. It should be noted that the data can be most easily obtained using Mapmaker for “merchantable” and “all live” biomass in one session. This eliminates repetition of choosing the geographic area of interest and reduces error.

Step 3) The spreadsheet functions should be used to subtract the two tables within the spreadsheet file to produce the estimate of non-merchantable biomass. It should be noted that since the “all live” table has additional rows for small diameter trees the operation will require a copy of the first two rows of this table and a subtraction of the “merchantable biomass” table from the remaining portions of the “all live” table. Rows representing the larger DBH classes may also be missing in some tables because of the lack of FIA samples in those classes. Tables 4 and 5 are examples of the resulting “Non-merchantable biomass”.

The non-merchantable biomass estimates include biomass in stumps between the cut-height and ground level. It is not practical to utilize this stump biomass. Therefore a reduction in the non-merchantable biomass table must be done. The Forest Service Harvest and Utilization Studies provide the best information on stump utilization. Table 6 lists the recommended reduction percentage for each southern state where harvest studies have been performed. The percentage is derived by determining the proportion of “non-growing stock” biomass that is contained in stumps, as listed in Column B of the table.

Table 6: Recommended Reductions in Non-merchantable Biomass Estimates by Percent as a Result of Stumps⁴

State	Column A Un-utilized Stump Volume as a % of Total Non-growing Stock Volume		Column B Stump Volume as % of Total Non-growing Stock Volume	
	Softwood	Hardwood	Softwood	Hardwood
Alabama*	17%	21%	31%	21%
Arkansas	20%	23%	34%	29%
Florida	16%	22%	34%	35%
Georgia	16%	22%	33%	30%
Kentucky*	19%	22%	31%	27%
Louisiana	21%	27%	34%	31%
Mississippi	18%	20%	32%	28%
North Carolina*	19%	22%	31%	27%
Oklahoma	17%	20%	30%	30%
South Carolina	15%	21%	32%	28%
Tennessee*	19%	22%	33%	22%
Texas	17%	19%	30%	30%
Virginia*	17%	21%	32%	25%
* Updated % coming in the near future.				

The reductions should be made to the Non-merchantable table by reducing each category of biomass assessment by the reduction for the appropriate species group. Table 7 shows an example of the final table of non-merchantable biomass estimates. Any table showing a combination of species groups should also be adjusted by using a weighted average of reduction for stump biomass obtained by applying the reduction to species groups first. For the example given in the attached tables for the Dublin, Georgia area; a weighted average of reduction is obtained by the following operation:

$59.5 \text{ mil odt non-merchantable biomass after reduction} / 86.9 \text{ million odt (total non-merchantable biomass)} = 0.685$ (31.5% reduction overall). Table 8 shows how this can be applied. The totals may not exactly match due to rounding.

An additional consideration must be made for young forest stands of small trees, such as young pine plantations. Trees from these stands will be included in the non-merchantable biomass estimate because of their small diameter. The tables of non-merchantable biomass derived using the above described method can be used to separate young stands from older stands (by 5-year age classes) and to separate small trees from large trees (DBH classes). Typically trees within a planted softwood, or pine stand, younger than 15 years will be unavailable for harvest; unless a *pre-commercial thinning* is performed. Naturally regenerated forest stands of softwood (pine) and hardwood would not be available for commercial harvest prior to age 20 or

greater. Results from the analysis of non-merchantable biomass could be combined to have a total amount in stands older than a merchantable harvest age and a total in stands younger than the merchantable harvest age. The author has chosen to use 15 years as the merchantable harvest age. The detail of Table 8 would likely be the most desirable product from this analysis.

The opportunity to capture biomass in the younger forest stands through pre-commercial thinning should also be recognized. Naturally regenerated stands and densely planted stands of southern pine species would likely have the most potential to produce biomass for energy using pre-commercial thinning. The development of a strategy to reasonably estimate available biomass from pre-commercial thinning would be a difficult and complicated task, considering that young forest stands have differences in species, stocking levels, topography and other variables. Therefore, this paper will not attempt to make recommendations on methods to estimate biomass from pre-commercial thinning.

Part 5: Logging Residue Annual Production Estimates

Logging residues are recognized as an important source of potential forest biomass. The annual production of logging residues can be estimated using the historically reported levels of logging residue production from the Forest Service Southern Research Station Timber Product Output⁵ studies. These studies report logging residue amounts by county through the SRS FIA website at <http://srsfia2.fs.fed.us/php/tpo2/tpo.php>. The same counties should be selected as chosen when determining standing timber biomass.

It is recommended that the table listed as “Average annual timber removals by removals class, species group, and source” (last table in the third block) be used for analysis of logging residues. A range of years should be selected for an average annual estimate to be made. The table will be produced similar to Table 9. It should be noted that if a procurement area includes counties in more than one state, separate database queries will be required for each state. The data collected from each state can be combined into a single table.

Reductions for stumps should be applied to softwood and hardwood non-growing stock portion of logging residues. The Column A reductions listed in Table 6 should be used. For example, the 28.6 mcf of softwood logging residues from non-growing stock in Table 9 would be reduced by 16% and the 24.4 mcf hardwood logging residues from non-growing stock would be reduced 22%. A weight/volume conversion should then be applied to the result to determine the oven dry ton amounts of logging residues produced each year. Table 10 lists several weight/volume conversions from a variety of references^{6,7,8,9} for poletimber-sized trees. Other conversions can be used as determined by the analyst to apply to the local situation. Of particular note is the increased weight per volume for biomass in non-growing stock resulting from higher percentages of bark in tops, branches, and smaller trees. Table 11 shows this procedure for the Dublin example and would be the desired product from the logging residue analysis.

Table 10: Weight/Volume Conversions for Forest Biomass in Green Pounds of Wood and Bark per Cubic Foot of Wood in Poletimber-Sized Trees

Biomass Type	Area	Southern Pine Species		Soft Hardwood Species	Hard Hardwood Species
		Planted	Natural		
Growing stock (Butt – 4” top)	Piedmont	67	69	69	76
Non-growing stock (4”top - tip)	Piedmont	67	69	74	81
Growing stock (Butt – 4” top)	Upland South	na	na	63	73
Non-growing stock (4”top - tip)	Upland South	na	na	70	77
Growing stock (Butt – 4” top)	Coastal Plain	68	73	65	77
Non-growing stock (4”top - tip)	Coastal Plain	68	73	77	84

Part 6: Mill Residues

Estimated quantities of *mill residues* are obtained through the TPO survey and database system⁵. These residues are in high demand for a variety of alternative uses. According to the 2005 Timber Product Output database, 99.1% of the forest product mill residues in the South are used in some manner. Therefore, the cost of transportation and relative value of the residues to competing uses will determine the amount available for bio-energy. The real availability of mill residues will be determined by individual contact with mill managers.

The Timber Product Output reports¹⁰ and online data published by the Forest Service Southern Research Station also contain estimates of forest product mill residues. The TPO online database can be used to collect estimates of mill residue production by type for one year by using “Table x12 Weight of Bark and Wood Residue by Type of Residue, Softwood, Hardwood, and Use”. If an average is desired, multiple queries of the database for each year in the time period will need to be performed and an average taken manually. Table 12 provides data for the Dublin example.

Part 7: Timber Growth and Removals as an Indicator of Sustainability

The growth and removals of timber is an indicator of the ability of a forest to supply additional resources as a feedstock for industry. The FIA program only compiles growth and removals data for *growing stock* volume of wood. Therefore, “Net growth of growing stock on timberland” and “Removals of growing stock on timberland” are the two “attributes of interest” which should be used in Mapmaker to provide these estimates for the identified

group of counties. “Net growth of growing stock on timberland” incorporates growth and mortality. It follows that the data obtained from “Removals of growing stock on timberland” can be subtracted from the “Net growth of growing stock” to determine if there is a positive gain or a loss in timber inventory each year. This data can be displayed in a variety of ways including tables, charts, and growth-to-drain ratios.

Part 8: Discussion and Summary

The relationship between the forest biomass attributes described above and their level of actual recovery should be considered.

This report has listed several methods of estimating the availability of biomass from forest sources. The timberland area indicates the area of commercial forestland that can support forest resource-based industries. Past timber growth and timber removals estimates provide the amount of increased utilization of biomass that might be sustainable. The inventory of merchantable and non-merchantable biomass in standing timber gives a snapshot of the total resource base that can be drawn upon. The past estimates of logging residues and mill residues are very useful in determining the residues already being handled in some manner each year. It is important to understand that these estimates of particular forest resource attributes are not necessarily additive, with the exception of mill residues. For example, the logging residues are a component of the standing inventory of both merchantable and non-merchantable biomass. The standing inventory of non-merchantable biomass is an estimate of the total at one point in time, while the logging residue estimate is an annual production estimate. Also, the amount of timberland acres by type is an indication of the resource base, but does not predict a specific yield of biomass. Furthermore, the timber growth-to-removals ratio gives an indication of sustainability, but does not provide available quantities of non-merchantable biomass. Although not additive, all of these estimates together provide a substantial quantitative description of biomass availability for a particular area. They can also be very useful in comparisons between areas.

Bioenergy project developers desire to obtain estimates of quantities of biomass with the lowest cost and appropriate for their application. This usually means mill residues, tops and branches of sawtimber-sized trees, all of pulpwood sized trees, and trees with smaller than 5” diameter. Therefore, the analysis should focus on “non-merchantable biomass”, logging residues, mill residues, and merchantable biomass in pulpwood-sized trees (<9” dbh). This report includes methods for obtaining all of this related data.

The level at which forest biomass can be economically recovered for a bio-energy use has the same importance as the actual existence of the biomass. The various types of biomass sources listed in this report (standing forest biomass, logging residues, mill residues) have varying degrees of recoverability. Standing forest biomass availability depends on its size, distribution, ownership objectives and the existence of supporting activities; such as timber harvests for traditional products. Traditional forest industry has established the recovery costs of larger trees, while less is known about the true cost of harvesting smaller trees in a variety of growing conditions. Several research projects are underway across the South to determine the most efficient methods and the cost of each method of harvest of standing biomass and logging residues. As more knowledge is gained, better estimates of recovery rates can be made and incorporated into revisions of this and other reports.

Part 9: References

- ¹ Southern Research Station Inventory and Analysis website. 2007. <http://srsfia2.fs.fed.us/>
- ² Forest Inventory and Analysis Data as listed on the Mapmaker database. Southern Research Station, US Forest Service. 2007.
<http://www.ncrs2.fs.fed.us/4801/fiadb/fim30/wcfim30.asp>
- ³ Bentley, James, Harper, Richard. Georgia Harvest and Utilization Study, 2004. Southern Research Station, US Forest Service. SRS-117. 2006
- ⁴ Bentley, James. Email communication. Southern Research Station, US Forest Service. 2008
- ⁵ Timber Product Output database as published on the Southern Research Station website. US Forest Service. 2007. <http://srsfia2.fs.fed.us/php/tpo2/tpo.php>
- ⁶ Clark, Alexander, III; Daniels, Richard F.; Borders, Bruce E. 2006. Effect of rotation age and physiographic region on weight per cubic foot of planted loblolly pine Gen. Tech. Rep. SRS-92. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. pp. 344-346.
- ⁷ Clark, Alexander, III; Phillips, Douglas R.; Frederick, Douglas J. 1986. Weight, Volume, and Physical Properties of Major Hardwood Species in the Piedmont Res. Pap. SE-255. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 84 p..
- ⁸ Clark, Alexander, III; Phillips, Douglas R.; Frederick, Douglas J. 1986. Weight, Volume, and Physical Properties of Major Hardwood Species in the Upland-South Res. Pap. SE-257. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 61 p..
- ⁹ Clark, Alexander, III; Phillips, Douglas R.; Frederick, Douglas J. 1985. Weight, Volume, and Physical Properties of Major Hardwood Species in the Gulf and Atlantic Coastal Plains Res. Pap. SE-250. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 72 p..
- ¹⁰ Johnson, Tony, Wells, John. Georgia's Timber Industry – An Assessment of Timber Product Output and Use, [1995-2005]. Southern Forest Research Station. US Forest Service

Appendix A: Definitions

All live biomass: The total above ground biomass of trees 1.0 inch DBH and larger, including tops, limbs, and bark; but excluding foliage.

All live merchantable biomass: The biomass of trees 5.0 inches DBH and larger from a 1-foot stump to a 4-inch top DOB of the central stem including bark.

Forest Biomass: For the purposes of this report forest biomass includes wood and bark contained in live trees within commercial forest areas and wood and bark residues from primary forest manufacturing facilities. Waste wood from construction, demolition, secondary processing, and urban area tree trimmings are excluded.

Growing stock trees: Living trees of commercial species classified as sawtimber, poletimber, saplings, and seedlings, which contain or have the potential to contain at least one 12-foot log.

Growing stock volume: The cubic-foot volume of sound wood in growing-stock trees that are at least 5.0 inches DBH, with volume being included from a 1-foot stump height to a minimum 4.0 –inch top diameter-outside-bark (DOB) of the central stem.

Logging residues: The unused portions of trees cut during logging operations and left in the forest stand.

Mill Residues: Wood and bark materials generated in the process of producing other higher-value products at primary manufacturing facilities.

Coarse residues: Chips and other materials, such as slabs, edgings, trim, and log ends; which are suitable for chipping.

Fine residues: Material, such as sawdust and shavings, which are not suitable for chipping.

Non-growing stock volume: The volume in the stumps, tops, branches, and cull sections of the central stem of any poletimber or sawtimber trees classified as growing stock plus any portion of a rough, rotten, sapling, or non-forest tree.

Non-merchantable biomass: The total amount of biomass (wood and bark) in small non-crop trees (<5" DBH) and the biomass (wood and bark) in tops and branches of larger trees (>5" DBH). Foliage and stumps are excluded.

Pre-commercial thinning: The removal of a portion of the trees within a young forest stand that contains small trees, with the purpose of increasing growth rates of selected crop trees. The removed trees are too small for traditional commercial uses.

Primary manufacturing facility: A manufacturing facility that converts roundwood, such as saw logs, pulpwood, and veneer logs; directly into wood products such as lumber, paper, and plywood.

Rotten trees: Live trees of commercial species not containing or without the potential to contain at least one 12-foot saw log because of rot or missing sections.

Rough trees: Live trees of commercial species not containing or without the potential of containing at least one 12-foot saw log because of roughness, poor form, splits, and cracks.

Timberland: Forestland capable of producing 20 cubic feet of industrial wood per acre per year and not withdrawn from timber utilization.

Appendix B: Sample Tables

Table 1: Merchantable Biomass (oven dry tons) in Standing Timber within Dublin, GA 75 mi. Procurement Area

Stand origin: Total							
Stand age 5 yr classes							
Species group - MajorGroup	Total	0-5 years	6-10 years	11-15 years	16-20 years	21-25 years	26-30 years
Pines	115,847,826	1,222,820	1,989,532	12,072,444	24,847,920	18,359,284	7,067,046
Other softwoods	5,416,437	29,504	262,303	158,657	42,471	54,510	52,128
Soft hardwoods	55,472,837	820,149	1,261,396	1,734,973	1,804,797	1,721,277	1,627,719
Hard hardwoods	47,143,486	1,186,162	1,630,239	1,776,524	2,319,092	1,853,090	2,125,573
Unassigned hardwoods	2,810	1,202	0	1,608	0	0	0
Total	223,883,396	3,259,838	5,143,471	15,744,206	29,014,280	21,988,162	10,872,466
Stand origin: Natural stands							
Stand age 5 yr classes							
Species group - MajorGroup	Total	0-5 years	6-10 years	11-15 years	16-20 years	21-25 years	26-30 years
Pines	61,926,686	1,117,350	1,006,412	2,911,421	3,736,687	3,921,466	3,205,869
Other softwoods	5,326,230	24,734	212,824	156,127	9,043	54,510	52,128
Soft hardwoods	54,206,501	676,250	1,036,829	1,638,921	1,517,168	1,462,139	1,562,782
Hard hardwoods	45,276,631	1,079,062	1,386,425	1,577,102	1,895,750	1,416,100	1,826,395
Unassigned hardwoods	2,810	1,202	0	1,608	0	0	0
Total	166,738,858	2,898,598	3,642,490	6,285,178	7,158,647	6,854,215	6,647,175
Stand origin: Clear evidence of artificial regeneration							
Stand age 5 yr classes							
Species group - MajorGroup	Total	0-5 years	6-10 years	11-15 years	16-20 years	21-25 years	26-30 years
Pines	53,921,140	105,470	983,120	9,161,023	21,111,233	14,437,818	3,861,177
Other softwoods	90,207	4,770	49,479	2,530	33,428	0	0
Soft hardwoods	1,266,336	143,899	224,567	96,052	287,629	259,138	64,937
Hard hardwoods	1,866,855	107,101	243,814	199,422	423,342	436,991	299,178
Total	57,144,539	361,240	1,500,980	9,459,027	21,855,632	15,133,947	4,225,291

Table 2: Detail of Merchantable Biomass (oven dry tons) in Standing Timber within Dublin, GA 75 mi. Procurement Area

Species group - MajorGroup: Total							
Stand age 5 yr classes							
Current dbh 2 inch classes to 40 inches	Total	0-5 years	6-10 years	11-15 years	16-20 years	21-25 years	26-30 years
5.0-6.9	25,107,113	425,159	1,219,424	5,344,783	6,680,191	2,987,020	1,067,039
7.0-8.9	37,396,329	414,208	920,071	5,018,082	10,906,619	6,252,867	2,048,664
9.0-10.9	35,122,036	455,627	650,288	1,877,302	6,598,776	6,190,982	2,905,381
11.0-12.9	30,766,092	407,579	541,630	798,426	2,324,489	3,650,470	2,210,482
13.0-14.9	26,539,300	361,447	562,798	676,322	996,679	1,115,912	1,182,956
15.0-16.9	20,749,782	345,193	319,587	480,066	526,540	478,277	618,888
17.0-18.9	15,193,258	277,944	270,682	542,391	492,661	147,043	295,163
19.0-20.9	11,057,189	83,365	214,530	463,056	224,516	210,830	85,076
21.0-22.9	7,721,803	125,518	60,855	220,052	27,260	320,092	84,389
23.0-24.9	5,580,285	264,119	165,214	126,708	45,960	182,389	115,560
25.0-26.9	2,852,593	0	156,269	197,017	60,191	58,169	0
27.0-28.9	2,224,076	0	62,122	0	0	0	0
29.0-30.9	1,281,756	99,679	0	0	0	0	0
31.0-32.9	832,046	0	0	0	0	149,767	0
33.0-34.9	486,995	0	0	0	0	0	92,289
35.0-36.9	335,399	0	0	0	0	146,344	0
37.0-38.9	402,929	0	0	0	130,396	0	166,578
39.0-40.9	136,416	0	0	0	0	0	0
41.0+	98,000	0	0	0	0	98,000	0
Total	223,883,396	3,259,838	5,143,471	15,744,206	29,014,280	21,988,162	10,872,466
Species group - MajorGroup: Pines							

Current dbh 2 inch classes to 40 inches	Stand age 5 yr classes						
	Total	0-5 years	6-10 years	11-15 years	16-20 years	21-25 years	26-30 years
5.0-6.9	16,012,741	82,968	765,176	4,830,535	5,952,172	2,316,448	459,185
7.0-8.9	25,739,396	79,221	440,429	4,455,249	10,300,626	5,636,152	1,389,863
9.0-10.9	21,303,298	143,999	212,144	1,418,716	6,016,148	5,511,926	2,288,071
11.0-12.9	16,659,309	239,357	218,931	387,668	1,773,808	3,264,701	1,662,801
13.0-14.9	11,601,179	117,020	194,852	259,856	500,595	872,044	876,093
15.0-16.9	9,013,611	289,459	78,417	194,097	234,564	290,278	253,141
17.0-18.9	5,654,618	67,741	35,307	272,517	70,006	77,424	87,564

Table 3: Detail of All Live Biomass (oven dry tons) in Standing Timber within Dublin, GA 75 mi. Procurement Area

Species group - MajorGroup: Total							
Current dbh 2 inch classes to 40 inches	Stand age 5 yr classes						
	Total	0-5 years	6-10 years	11-15 years	16-20 years	21-25 years	26-30 years
1.0-2.9	13,095,480	578,275	2,137,207	2,374,672	1,960,160	1,165,060	643,862
3.0-4.9	22,022,780	434,371	2,801,291	4,173,744	3,884,793	1,912,159	1,064,064
5.0-6.9	35,741,478	634,893	1,777,121	7,523,412	9,339,989	4,193,357	1,547,064
7.0-8.9	46,374,290	539,675	1,167,959	6,188,368	13,317,763	7,641,380	2,527,874
9.0-10.9	42,050,938	557,667	798,610	2,238,395	7,753,927	7,261,265	3,435,984
11.0-12.9	36,503,053	491,703	660,131	954,034	2,699,689	4,210,310	2,592,309
13.0-14.9	31,491,790	435,524	697,935	810,341	1,185,618	1,306,714	1,381,118
15.0-16.9	24,733,600	399,766	381,892	571,502	627,865	563,660	744,554
17.0-18.9	18,156,004	332,908	339,745	650,964	590,173	189,987	360,904
19.0-20.9	13,320,341	93,470	265,191	541,338	273,602	244,958	100,394
21.0-22.9	9,495,536	193,451	97,900	283,447	30,953	385,660	109,481
23.0-24.9	6,800,216	305,241	205,781	160,876	56,585	215,440	144,610

25.0-26.9	3,515,473	0	186,387	249,059	74,017	71,562	0
27.0-28.9	2,726,669	0	77,354	0	0	0	0
29.0-30.9	1,739,554	209,852	0	0	0	0	0
31.0-32.9	1,028,655	0	0	0	0	166,939	0
33.0-34.9	641,084	0	0	0	0	0	148,333
35.0-36.9	422,590	0	0	0	0	193,864	0
37.0-38.9	499,184	0	0	0	168,441	0	201,488
39.0-40.9	172,547	0	0	0	0	0	0
41.0+	273,507	0	0	0	0	273,507	0
Total	310,804,768	5,206,795	11,594,504	26,720,151	41,963,577	29,995,821	15,002,040

Species group - MajorGroup: Pines

Current dbh 2 inch classes to 40 inches	Total	0-5 years	6-10 years	11-15 years	16-20 years	21-25 years	26-30 years
1.0-2.9	2,593,934	247,313	788,129	668,762	414,681	125,869	74,628
3.0-4.9	8,600,716	85,584	1,917,300	2,648,110	2,183,853	635,950	203,611
5.0-6.9	22,244,630	115,878	1,100,871	6,749,231	8,239,566	3,188,253	631,951
7.0-8.9	31,275,827	97,091	538,998	5,442,738	12,520,354	6,837,681	1,680,801
9.0-10.9	24,805,164	167,034	246,683	1,655,752	7,016,111	6,417,247	2,662,589
11.0-12.9	19,057,898	273,461	255,701	448,831	2,028,318	3,737,676	1,900,765
13.0-14.9	13,144,504	132,581	220,604	293,864	567,718	989,633	991,914
15.0-16.9	10,178,546	326,083	88,290	218,649	265,803	330,338	284,983
17.0-18.9	6,358,479	76,695	39,658	305,953	78,514	86,913	98,344

Table 4: Non-Merchantable Biomass (oven dry tons) in Standing Timber by Species Group within Dublin, GA 75 mi. Procurement Area

Stand origin: Total							
Species group - MajorGroup	Stand age 5 yr classes						
	Total	0-5 years	6-10 years	11-15 years	16-20 years	21-25 years	26-30 years
Pines	33,530,952	526,120	3,256,293	6,657,964	8,466,999	4,429,974	1,520,053

Other softwoods	1,538,570	17,858	72,414	77,377	22,893	18,014	29,614
Soft hardwoods	26,212,770	586,851	1,579,973	2,041,147	2,082,590	1,809,273	1,296,871
Hard hardwoods	25,632,670	815,539	1,542,354	2,197,787	2,375,998	1,749,568	1,281,795
Unassigned hardwoods	6,410	589	0	1,670	817	832	1,241
Total	86,921,372	1,946,957	6,451,033	10,975,945	12,949,297	8,007,659	4,129,574

Table 5: : Detail of Non-Merchantable Biomass of Combined Species in Standing Timber within Dublin, GA 75 mi. Procurement Area

Species group - MajorGroup: Total							
Stand age 5 yr classes							
Current dbh 2 inch classes to 40 inches	Total	0-5 years	6-10 years	11-15 years	16-20 years	21-25 years	26-30 years
1.0-2.9	13,095,480	578,275	2,137,207	2,374,672	1,960,160	1,165,060	643,862
3.0-4.9	22,022,780	434,371	2,801,291	4,173,744	3,884,793	1,912,159	1,064,064
5.0-6.9	10,634,365	209,734	557,697	2,178,629	2,659,798	1,206,337	480,025
7.0-8.9	8,977,961	125,467	247,888	1,170,286	2,411,144	1,388,513	479,210
9.0-10.9	6,928,902	102,040	148,322	361,093	1,155,151	1,070,283	530,603
11.0-12.9	5,736,961	84,124	118,501	155,608	375,200	559,840	381,827
13.0-14.9	4,952,490	74,077	135,137	134,019	188,939	190,802	198,162
15.0-16.9	3,983,818	54,573	62,305	91,436	101,325	85,383	125,666
17.0-18.9	2,962,746	54,964	69,063	108,573	97,512	42,944	65,741
19.0-20.9	2,263,152	10,105	50,661	78,282	49,086	34,128	15,318
21.0-22.9	1,773,733	67,933	37,045	63,395	3,693	65,568	25,092
23.0-24.9	1,219,931	41,122	40,567	34,168	10,625	33,051	29,050
25.0-26.9	662,880	0	30,118	52,042	13,826	13,393	0
27.0-28.9	502,593	0	15,232	0	0	0	0
29.0-30.9	457,798	110,173	0	0	0	0	0
31.0-32.9	196,609	0	0	0	0	17,172	0
33.0-34.9	154,089	0	0	0	0	0	56,044
35.0-36.9	87,191	0	0	0	0	47,520	0
37.0-38.9	96,255	0	0	0	38,045	0	34,910
39.0-40.9	36,131	0	0	0	0	0	0
41.0+	175,507	0	0	0	0	175,507	0
Total	86,921,372	1,946,957	6,451,033	10,975,945	12,949,297	8,007,659	4,129,574

Table 6: Recommended Reductions in Non-merchantable Biomass Estimates by Percent as a Result of Stumps

State	Column A Un-utilized Stump Volume as a % of Total Non-growing Stock Volume		Column B Stump Volume as % of Total Non-growing Stock Volume	
	Softwood	Hardwood	Softwood	Hardwood
Alabama*	17%	21%	31%	21%
Arkansas	20%	23%	34%	29%
Florida	16%	22%	34%	35%
Georgia	16%	22%	33%	30%
Kentucky*	19%	22%	31%	27%
Louisiana	21%	27%	34%	31%
Mississippi	18%	20%	32%	28%
North Carolina*	19%	22%	31%	27%
Oklahoma	17%	20%	30%	30%
South Carolina	15%	21%	32%	28%
Tennessee*	19%	22%	33%	22%
Texas	17%	19%	30%	30%
Virginia*	17%	21%	32%	25%
* Updated % coming in the near future.				

Table 7: Non-Merchantable Biomass (oven dry tons) in Standing Timber by Species Group after Reductions for Stump (33% softwood and 30.5% hardwood) within Dublin, GA 75 mi. Procurement Area

Stand origin: Total							
Species group - Major Group	Stand age 5 yr classes						
	Total	0-5 years	6-10 years	11-15 years	16-20 years	21-25 years	26-30 years
Pines	22,465,738	352,500	2,181,716	4,460,836	5,672,889	2,968,083	1,018,436
Other softwoods	1,030,842	11,965	48,517	51,843	15,338	12,069	19,841
Soft hardwoods	18,217,875	407,861	1,098,081	1,418,597	1,447,400	1,257,445	901,325
Hard hardwoods	17,814,706	566,800	1,071,936	1,527,462	1,651,319	1,215,950	890,848
Unassigned hardwoods	4,455	409	0	1,161	567.815	578.24	862

Total	59,533,615	1,339,536	4,400,251	7,459,898	8,787,514	5,454,125	2,831,312
-------	------------	-----------	-----------	-----------	-----------	-----------	-----------

Table 8: Detail of Non-Merchantable Biomass (oven dry tons) of Combined Species in Standing Timber after Reductions for Stump (20% overall) within Dublin, GA 75 mi. Procurement Area

Species group - MajorGroup: Total							
Stand age 5 yr classes							
Current dbh 2 inch classes to 40 inches	Total	0-5 years	6-10 years	11-15 years	16-20 years	21-25 years	26-30 years
1.0-2.9	8,957,308	395,540	1,461,850	1,624,276	1,340,749	796,901	440,402
3.0-4.9	15,063,582	297,110	1,916,083	2,854,841	2,657,198	1,307,917	727,820
5.0-6.9	7,273,906	143,458	381,465	1,490,182	1,819,302	825,135	328,337
7.0-8.9	6,140,925	85,819	169,555	800,476	1,649,222	949,743	327,780
9.0-10.9	4,739,369	69,795	101,452	246,988	790,123	732,074	362,932
11.0-12.9	3,924,081	57,541	81,055	106,436	256,637	382,931	261,170
13.0-14.9	3,387,503	50,669	92,434	91,669	129,234	130,509	135,543
15.0-16.9	2,724,932	37,328	42,617	62,542	69,306	58,402	85,956
17.0-18.9	2,026,518	37,595	47,239	74,264	66,698	29,374	44,967
19.0-20.9	1,547,996	6,912	34,652	53,545	33,575	23,344	10,478
21.0-22.9	1,213,233	46,466	25,339	43,362	2,526	44,849	17,163
23.0-24.9	834,433	28,127	27,748	23,371	7,268	22,607	19,870
25.0-26.9	453,410	0	20,601	35,597	9,457	9,161	0
27.0-28.9	343,774	0	10,419	0	0	0	0
29.0-30.9	313,134	75,358	0	0	0	0	0
31.0-32.9	134,481	0	0	0	0	11,746	0
33.0-34.9	105,397	0	0	0	0	0	38,334
35.0-36.9	59,639	0	0	0	0	32,504	0
37.0-38.9	65,838	0	0	0	26,023	0	23,878
39.0-40.9	24,714	0	0	0	0	0	0

41.0+	120,047	0	0	0	0	120,047	0
Total	59,454,218	1,331,719	4,412,507	7,507,546	8,857,319	5,477,239	2,824,629

Table 9: Average Annual Timber Removals 1995-2005 by Removals Class, and Species Group and Source, Dublin 75 mi

Item	All	Growing	Nongrowing
		Stock	Stock
<i>Million cubic feet</i>			
Roundwood products			
Softwood	339.1	323.9	15.2
Hardwood	129.3	108.8	20.5
Total	468.5	432.7	35.7
Logging residues			
Softwood	50	21.3	28.6
Hardwood	48.6	24.2	24.4
Total	98.6	45.5	53
Other removals			
Softwood	27.9	19.4	8.6
Hardwood	35.1	24.5	10.5
Total	63	43.9	19.1

Table 10: Weight/Volume Conversions for Forest Biomass in Green Pounds of Wood and Bark per Cubic Foot of Wood in Poletimber Sized Trees

Biomass Type	Area	Southern Pine Species		Soft Hardwood Species	Hard Hardwood Species
		Planted	Natural		
Growing stock (Butt – 4" top)	Piedmont	67	69	69	76
Non-growing stock (4" top - tip)	Piedmont	67	69	74	81
Growing stock (Butt – 4" top)	Upland South	Na	Na	63	73
Non-growing stock (4" top - tip)	Upland South	Na	na	70	77
Growing stock (Butt – 4" top)	Coastal Plain	68	73	65	77

Non-growing stock (4"top - tip)	Coastal Plain	68	73	77	84
---------------------------------	---------------	----	----	----	----

Table 11: Annual Logging Residue Estimates after Reductions for Stump – Dublin 75 mi Average Production 1995-2005

Logging residues	million cubic feet		Growing Stock gr lbs/cf	Non-grow st Gr lbs/cf	oven dry tons	Non-growing Stock - Stump Excluded	Total
	Growing Stock	Non-growing Stock - Stump Excluded			Growing Stock		
Softwood	21.30	24.02	68	68	362,100	408,408	770,508
Hardwood	24.20	19.03	65	77	393,250	366,366	759,616
Total	45.50	43.06			755,350	774,774	1,530,124

Table 12: Weight of Bark and Wood Residue by Type of Residue, Species Group, and Use for 75 Mi. Dublin Area

Source	Species group	Fiber	Fuelwood	Misc.	Not Used	All
		by-product	by-product	by-product		by-products
<i>Thousand dry tons</i>						
Bark Residue	Softwood	0	534	173	0	707
Bark Residue	Hardwood	0	178	19	0	197
Bark Residue	Total	0	712	192	0	904
Wood Residue (coarse)	Softwood	983	9	83	0	1,075
Wood Residue (coarse)	Hardwood	178	55	6	0	239
Wood Residue (coarse)	Total	1,161	64	89	0	1,314
Wood Residue (fine)	Softwood	346	397	111	58	913
Wood Residue (fine)	Hardwood	0	164	28	2	195
Wood Residue (fine)	Total	347	561	139	61	1,107

Wood Residue (All)	Softwood	1,329	406	194	59	1,988
Wood Residue (All)	Hardwood	178	219	35	3	434
Wood Residue (All)	Total	1,507	624	229	61	2,421
All Residues	Softwood	1,329	940	367	59	2,695
All Residues	Hardwood	178	396	54	3	630
All Residues	Total	1,507	1,336	421	61	3,326