INTEGRATING WOODY BIOMASS INTO THE U.S. SOUTH WOOD SUPPLY CHAIN

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ABSTRACT

The rapid growth in announced wood bioenergy plants in the US South has increased the potential annual demand for wood feedstock. Federal legislation creating a renewable electricity standard could significantly increase this projected demand. We examined the potential impacts on the wood supply chain in the US South of this large increased demand. Our research is based on surveys of the forest industry, interviews with biomass harvesting contractors from across the country, and a detailed analysis of data related to the supplies, availability and demand of wood biomass resources in the US South. This allows examination of how new markets could focus on different sources of wood feedstock and how they may compete with existing industry for raw material.

INTRODUCTION

Over the past five years significant interest has developed in replacing fossil energy with renewable energy in the US. This has been driven by higher market prices for petroleum and coal, concerns about impacts of carbon emissions from fossil fuels on climate change, and national security issues associated with importing nearly 70% of US oil from often unfriendly nations. As a result, interest in increasing use of renewable energy, including forest biomass, has grown markedly.

Renewable energy today provides about 7% of total US energy use and roughly half of that is biomass, 75% of which comes from forests. Today most forest biomass is burned to provide process heat and/or steam and in some cases to produce electricity for the forest products industry and the grid. Wood pellet markets have also increased significantly with the primary destination for these products being coal-fired electric plants in the European Union. In addition, most major US electric utilities and several independent electricity producers have announced plans to use wood to produce electricity from new wood-fired plants, co-firing coal with wood, or converting

older coal plants to wood feedstock. There is also an infant wood to liquid fuels industry with a handful of plants announced in the US. Collectively, these announcements and plants under construction in the US would consume over 123 million green tons per year by 2020 if successful, with half of this new capacity targeted for the US South (Forisk 2010).

Biomass feedstocks from forests are available in the form of logging residues, currently unmerchantable small stems, understory plants, and wood fiber currently used for other products (e.g., pulpwood). A globally competitive wood supply system is already in place producing traditional roundwood products such as pulpwood and sawtimber as well as clean pulp chips. Markets are developing for other products (wood pellets, electricity from wood, liquid fuels) that can use tree biomass not used by traditional markets. To harvest this additional biomass, we must modify our forest management regimes and forest harvesting systems to obtain the material productively and economically with minimal impacts to the harvested site. Cost-effective harvesting and transportation are the keys to delivering biomass feedstocks at a competitive market price (Aguilar and Garrett 2009). DOE recently identified $47 per dry ton (~$23.50 per green ton) as a target delivered feedstock price for 2012 to make biomass-based processes competitive (Wilkerson et al. 2008). Of this, they target $10/dry ton for the landowner ($5/green ton), leaving $37 per dry ton ($18.50/green ton) available for collection and transportation. These targets have recently been revised, but they represent ambitious goals given the scale of projected biomass demand. They also raise serious questions about the ability of traditional wood using industry to continue to source their facilities at a competitive cost.

We recently examined how the integration of biomass harvesting on a large-scale within a decade would impact the wood supply system in the US, including landowners, logging contractors, and wood using industries (pulp & paper, lumber, panels, and energy). This evaluation included how modifications of today's harvesting systems could increase the recovery of forest biomass and at what delivered or on-board cost per ton. We evaluated the potential supply of forest biomass from each major forested region of the country given the expected cost of harvesting, collecting, and delivering forest biomass. This analysis also examined likely responses of forest landowner base to price and demand signals in the marketplace prompted by the entry of bioenergy facilities and potential price increases associated with higher demand for biomass and pulpwood products. In this paper, we summarize the expected impacts of greater use of wood for bioenergy on the US South where the bulk of the America's pulp and paper and forest products industry is today concentrated.

BIOMASS HARVESTING TECHNOLOGY

Our assessment of wood biomass harvesting included a nationally-distributed survey of forest industry professionals and a series of in-depth regional site visits to biomass harvesting contractors. We divided the country into the five regions defined by the Forest Resources Association (FRA) and Wood Supply Research Institute (WSRI) using the approach of the USDA Forest Service Forest Inventory and Analysis (FIA) units (Figure 1). This assessment first examined the rapidly expanding published literature on ways to modify our current harvesting systems to include harvest of traditionally unmerchantable biomass components. We searched

both refereed, scientific journals as well as industry trade publications to find contractors and approaches that succeeded in each of the FRA regions. Using the review of literature and through contacts of industry foresters and logging contractors, we compiled a list of top biomass harvesting contractors in each region.

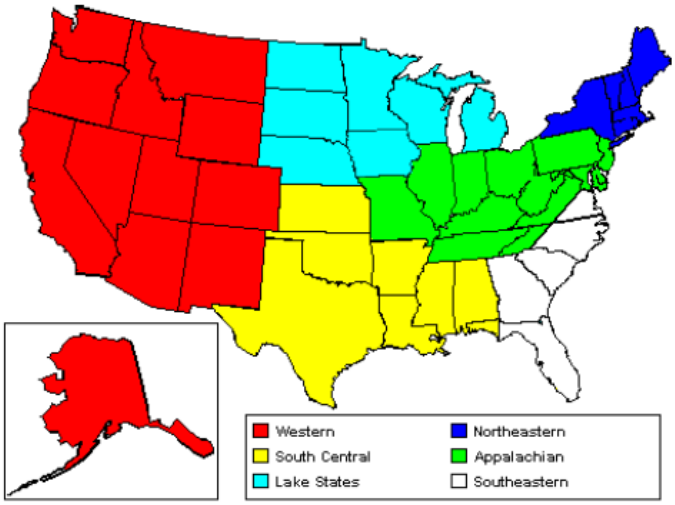

Figure 1: FRA Regions used in study.

Based on our literature review, we developed a short web-based survey that we distributed to each WSRI member company or association and logging associations across the country. Data collected during the survey allowed harvesting contractors to include contact information if they were willing to host an on-site visit. These contacts were combined with lists of high profile biomass contractors gathered from our literature search. We contacted the list of top performers to arrange on-site visits to as many high priority operations as possible during one-week trips to each region during May – August of 2010. Each trip involved at least two members of our forest operations research team. A standard interview form was used to collect common data from each of the operations visited. Information on harvesting system configuration and production were gathered as well as information on resource availability and market strength.

Findings from our web survey of biomass users has been reported by Enrich et al. (2010) and by Greene et al. (2010) and will not be directly summarized here. Instead we report on the findings of our field visits in the US South with comparisons to technology observed in use in other regions where appropriate.

- Pulp mills remain the major market for woody biomass in the South with 90% of those contacted delivering wood fuel to these facilities.
- Biomass is typically purchased on a green ton basis which creates disincentives for allowing feedstocks to dry in the field before delivery for both logging contractors and forest landowners.
- The size of residue material used for woody biomass markets appears to be directly related to the demand and competition for pulpwood by pulp mills in a region. South

Central and Southeast biomass residue markets are harvesting stems less than 4 inches with a significant portion of the material from tree crowns. This is in sharp contrast to other regions of the US where biomass residue material is larger in average diameter and at times may be interchangeable with pulpwood.

- Most operations chip or grind biomass in the field prior to transportation to improve product quality and maximize truck payloads. Grinders are becoming somewhat less common while chippers appear to be expanding in use in the South. Green basis payment encourages the use of chippers which are better with green material, while dry material is best handled by grinders. Reliance on tree-length systems using skidders with residues piled at roadside for grinders appears to introduce more soil contaminants into the residues than use of cut to length systems in other regions. This could be mitigated by piling material with loaders or fork attachments rather than pushing residues with solid blades on skidders.
- Transportation efficiency is critical to the success of biomass harvesting operations and maximizing truck payloads is a key. This is a particular challenge in the South where most state weight laws limit vehicle gross vehicle weight to 40 tons (often with 5-10% allowances) and the use of drop-belly trailers for in-woods use is rare due to the prevalent road building standards.

BIOMASS RESOURCE AVAILABILITY ASSESSMENT

The resource availability research focused on aggregating and analyzing data related to the supplies, availability, and demand of wood biomass resources in the United States. Specifically, this analysis included:

- Confirmation of wood basket regions and relevant raw material types.
- Product specifications for the following harvest types: pre-commercial, thinning and final harvest.
- Analysis of current and historic supply and demand for softwood and hardwood raw materials.
- Detail on current mills and competition for available pulpwood-sized material and woody biomass.
- Based on the estimated forest impacts, assessment of potential impacts on woody biomass supplies.

This research relied on cross-disciplinary data and analysis from public and private sources including the US Forest Service, Forisk Consulting, the Forest Resources Association, and research and guidance from the University of Georgia. In cases where data, analysis, or models from one US forest region were applied to another, all efforts were made to specify the relevant assumptions and potential implications from generalizing results in any way.

Supply Results

Analysis of current wood supplies, as measured by removals (harvested materials), provides a baseline for establishing (1) the magnitude of relevant wood volumes flowing through the system

and (2) which of the relevant categories may be more volatile or unreliable as long-term sources of woody biomass. Table 1 includes total current wood removals across five pulpwood and residual categories across the five US regions. We highlight the following from the data:

- The US South is the dominant producer of pulpwood. This finding is wholly consistent with historic research generated by the Forest Resources Association (2005).
- Harvesting activities generate over two times more volume of non-growing stock logging residuals than growing stocking residuals. This is consistent with practice, as harvesting activities generate greater volumes of limbs and tops than cut-offs.
- Mill residues, which flow primarily from primary grade-consuming forest industry facilities, represent a significant volume of raw material for pulp facilities, on-site energy generation and other miscellaneous uses such as animal bedding.

Table 1: Current removals (total green tons), total species, total ownership, 2006.

Region	Pulpwood *	Other Removals	Logging Residues (GS)	Logging Residues (NGS)	Mill Residues (All)
Appalachian	21,075,400	10,589,520	7,288,000	18,936,000	22,630,000
Lake States	33,352,000	11,222,720	2,636,520	14,350,000	14,949,240
Northeast	24,429,880	405,560	2,900,720	13,895,960	6,246,880
South	152,549,200	44,332,120	31,007,400	58,086,560	117,726,080
West	23,352,240	0	6,569,840	27,103,280	66,561,160
Total	*254,758,720*	*66,549,920*	*50,402,480*	*132,371,800*	*228,113,360*

**Includes pulpwood, composite, and fuelwood*

Table 2 details the total, estimated volume by type and region of wood biomass that would be available on an annual basis for consumption by alternative wood users such as bioenergy facilities. The key categories are the two logging residue volumes, growing stock (GS) and non-growing stock (NGS), which together represent 65.6% of the total estimated volume of available materials. The table includes the following assumptions for each type of material:

- Other removals: 50% of total estimated volumes are available.
- Logging residues (GS and NGS): 65% of total estimated volumes are available.
- Mill residues: only unused volumes, as estimated by the US Forest Service TPO data, are available.
- Pre-merchantable materials: following the methods of Conner et al. (2009), 75% of the 1 to 4" dbh class volume on $1/10^{th}$ of the overstocked acres is available. (This translates to approximately 7.5% of the volume in this specific age class.)

Overall, the South leads all regions with over 90 million green tons of estimated biomass, which represents 50% of all estimated materials nationwide.

Table 2: Current available volume of non-traditional materials.

Region	Other Removals	Logging Residues (GS)	Logging Residues (NGS)	Mill Residues	Pre-merchantable	Total
Appalachian	5,294,760	4,737,200	12,308,400	1,758,560	2,660,988	26,759,908
Lake States	5,611,360	1,713,738	9,327,500	298,000	4,680,492	21,631,090
Northeast	202,780	1,885,468	9,032,374	214,400	5,247,540	16,582,562
South	22,166,060	20,154,810	37,756,264	599,760	9,661,266	90,338,160
West	0	4,270,396	17,617,132	527,960	3,332,083	25,747,571
Total	*33,274,960*	*32,761,612*	*86,041,670*	*3,398,680*	*25,582,368*	*181,059,290*

The composition of biomass materials vary. Overall, two-thirds of the respondents to the UGA biomass user survey noted that at least some portion of the biomass supplied derives from non-merchantable tree species. The balance is primarily a mix of out-of-spec materials, cut-offs, and limbs and tops (Table 3). These results are largely driven by responses from loggers in the US South, the US West and the Lake States.

Table 3: Excluding conventional materials, what is used as biomass (check all that apply)?

	Appalachian	Lake States	Northeast	South Central	Southeast	West	*Total*
Cutoffs	0%	18%	0%	0%	4%	20%	*6%*
Limbs and tops	0%	9%	0%	5%	2%	13%	*5%*
Nonmerch species	100%	45%	75%	66%	77%	47%	*66%*
Out-of-Spec material	0%	18%	0%	21%	13%	7%	*15%*
Premerch material	0%	0%	0%	8%	2%	7%	*4%*
Bark/Fines/Overs	0%	9%	0%	0%	2%	7%	*3%*
Dead wood	0%	0%	25%	0%	0%	0%	*1%*
# Responses	*1*	*11*	*4*	*38*	*47*	*15*	*116*

In practice, the economics and costs of logging operations dictate the feasibility of allocating time and equipment to aggregating and processing wood biomass. Survey results from 53 forestry professionals including loggers, wood dealers, forest managers, and procurement foresters across the US responded that the minimum necessary volume of wood biomass required on a per acre basis to justify recovery ranged from 15 to 25 green tons per acre with minimum total volumes of 250 to 500 green tons and higher (Table 4). Southern operators were looking for at least 15 tons per acre for chipper crews and at least 350 tons on the site for chipper or grinder crews to be feasible. However, the supply data suggested that typical amounts remaining were on the order of 7-8 tons per acre of logging residues with another 10 tons of pre-commercial material that could be added to this (Table 5). This suggests that logging residues as a source of biomass is a marginal opportunity in the South, likely as a result of high wood utilization driven by historically competitive pulpwood markets.

Table 4: Minimum necessary volume that justifies recovery.

	Median (sample size in parantheses)					
	Appalachian	Lake States	Northeastern	South Central	Southeastern	Western
Biomass per Acre	25 (1)	15 (3)	15 (3)	15 (21)	20 (21)	25 (4)
Biomass per Site	250 (1)	480 (4)	n/a	350 (21)	500 (26)	550 (4)

Table 5: South available supplies per acre.

Harvest Type	Biomass Supply (Non-merch) in green tons per acre			
	Logging residue		Pre-merch	Total
	Slash, limbs, tops	Cut-offs and Out-of-spec		
Pre-commercial	0	0	10	10
Thinning	5	3	0	7
Final Harvest	5	3	0	7

Wood Demand Results

Analysis of pulpwood demand by US region since 2005 highlights two findings (Table 6):

- Most pulpwood, hardwood and softwood, is consumed in the US South.
- Pulpwood consumption, nation-wide, has remained relatively static, declining 4% (or 0.9% annually), between 2005 and 2009. The drivers behind this are (1) pulp markets declined less in the economic downturn than did lumber and building products and (2) pulp mills purchased additional volumes of pulpwood roundwood as a percentage of their total raw material consumption to offset decreases in residual chip production from sawmills.

Table 6: Pulpwood and chip demand by region, green tons, hardwood and softwood*

Market	2005	2006	2007	2008	2009	% change 05-09
Appalachian	13,609,122	14,356,732	14,612,528	14,398,514	13,456,867	-1%
Lake States	21,307,377	22,428,337	22,150,448	21,809,114	20,505,674	-4%
Northeast	12,668,714	13,277,815	13,521,970	13,284,641	12,352,791	-2%
South	172,890,369	185,123,690	189,312,002	183,259,000	165,600,752	-4%
West	24,087,152	25,520,406	26,010,797	25,459,840	23,513,924	-2%
Total	*244,562,734*	*260,706,979*	*265,607,745*	*258,211,110*	*235,430,008*	*-4%*

Source: Forisk Consulting, Forest Resources Association (FRA)
**Includes in-woods and mill residue chip receipts. According to FRA, residue chips made up 29% of total pulpwood receipts in Northeast in 2004, 19% of receipts in Lake States in 2004, 25% of receipts in the South, and 66% of receipts in the West in 2004.*

Grade (sawtimber and plywood) consumption has also declined over the past five years. Taken together, total wood demand of grade and pulpwood products declined by 23% for the entire US (Table 7). The largest percentage declines were in the West (39%) and the South (19%).

Table 7: Total hardwood and softwood demand (all products), 2005-2009, green tons.

Market	2005	2006	2007	2008	2009	% change 05-09
Appalachian	33,173,922	33,599,732	33,000,888	31,071,234	29,469,572	-11%
Lake States	29,680,797	30,910,214	29,988,786	26,881,469	25,349,818	-15%
Northeast	22,538,554	23,485,055	23,712,610	21,891,961	20,119,415	-11%
South	308,933,549	308,838,908	308,498,297	285,953,743	250,317,268	-19%
West	127,576,692	120,366,731	115,007,289	94,819,628	77,812,833	-39%
Total	*521,903,514*	*517,200,640*	*510,207,870*	*460,618,036*	*403,068,906*	-23%

Wood Bioenergy Results

In 2008, Forisk began tracking bioenergy projects in the US using a bioenergy screening methodology that relies on two criteria for wood-consuming projects (Mendell and Lang 2010):

- Technology: projects that employ currently viable technology pass the technology screen. These include pelletizing technology and wood-to-electricity projects. Cellulosic ethanol from wood feedstock is still a developing technology and is currently not operational.
- Status: projects that are operational, under construction, or have received or secured two or more necessary elements for advancing towards operations pass the status screen.

We applied the screening methodology to all 432 known operating and announced wood-using bioenergy facilities in Forisk's *Wood Bioenergy US* database as of November 10, 2010 (Table 18). This does not include all cogeneration plants operating at pulp and paper facilities. By count, electricity and pellet projects comprise 91% of all projects, with cellulosic ethanol-oriented liquid fuel projects representing most of the balance. Regionally, the US South has the largest number of projects in total and by technology type, the highest potential wood use from operating and announced projects, and the highest volume of wood associated with projects that pass the basic viability screening.

Table 8: Announced and operating wood bioenergy project count.

	Type				
Region	Electricity	Liquid Fuel	Pellet	Total	*Total that pass screens*
Appalachian	24	6	37	67	48
Lake States	17	4	25	46	35
Northeast	55	4	27	86	58
South	81	17	45	143	79
West	55	7	28	90	57
Total	232	38	162	432	277

The screen was applied individually to all operating and announced wood bioenergy projects in each US region. As of November 2010, the projects accounted for in Table 8 represent potential, incremental wood use of 123 million green tons per year by 2020.[1] Projects representing 68.4 million tons per year passed the basic screening described for the entire US. This represents less than 56% of the potential, announced wood demand from bioenergy projects and provides an indication of how much actual, incremental wood demand we might expect given what's known today about these projects.

The US South region includes 143 announced and operating wood bioenergy projects, of which 79 pass the viability screens (55.2% pass rate). Table 9 summarizes the estimated wood consumption by year for these projects through 2020. These projects represent potential, incremental wood use of 59.2 million greens tons per year by 2020, of which 25.2 million (42.6%) pass basic screening.

Table 9: Wood demand from bioenergy in South region, all feedstocks, million green tons/year.

South	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
All Electricity	3.71	4.87	8.18	17.10	28.07	29.93	32.85	33.91	33.96	35.02	35.08	35.14
All Liquid Fuels	0.50	0.61	1.15	1.35	4.05	4.38	5.98	9.70	9.70	10.51	10.51	10.51
All Pellet	4.03	5.84	10.20	13.11	13.57	13.57	13.57	13.57	13.57	13.57	13.57	13.57
Total	**8.24**	**11.31**	**19.53**	**31.56**	**45.69**	**47.87**	**52.39**	**57.18**	**57.23**	**59.10**	**59.16**	**59.21**
Total that pass screens	**7.74**	**9.75**	**15.79**	**22.03**	**24.08**	**24.58**	**24.88**	**24.93**	**24.99**	**25.05**	**25.11**	**25.17**

Table 10 and Figure 2 summarize the sustainability results for the South. Non-traditional material supplies of 90.3 million tons per year exceed projected bioenergy demand through 2020. Industry demand for pulpwood can be satisfied with growth and does not impact the pulpwood stock's ability to grow. Net growth increases each year through 2020. If we remove the other removals category from the non-traditional material supply the total annual supply drops to 68.2 million tons per year. Logging residues, mill residues, and pre-merchantable material satisfy bioenergy demand until 2020. If we remove pre-merchantable materials from the non-traditional supply, the non-traditional supply drops to 58.5 million tons per year. At the reduced level of logging residues and mill residues alone, non-traditional materials can satisfy bioenergy demand until 2018. By 2020 the surplus bioenergy demand exceeds 700,000 tons per year excluding other removals and pre-merchantable material.

[1] These estimates focus on "green" tons, which measures wood raw material as it leaves the forest with moisture content of 40-50%. Specifically, green tons refer to 2,000 pounds of undried biomass material. Since bioenergy facilities consume raw material on a "dry" ton basis, moisture content must be specified if green tons are used as a measure of fuel energy. The "rule of thumb" applied in this study is a 2:1 ratio of green to dry tons (two tons of green wood equates to one ton of dry wood raw material).

Table 10: Sustainability results for US South pulpwood supplies.

Category	2009	2010	2015	2020
Growing stock*	2,852,450,299	2,897,541,193	3,182,149,395	3,597,817,132
Growth	224,481,479	228,030,032	250,428,063	283,140,187
"Non-traditional" materials***	90,338,160	90,338,160	90,338,160	90,338,160
Demand: Industry**	179,390,585	179,390,585	179,390,585	179,390,585
Demand: Bioenergy total	8,241,500	11,314,170	52,391,776	59,214,102
Bio demand not met by non-trad	0	0	0	0
Implied Net Growth	45,090,894	48,639,447	71,037,478	103,749,602
Annual % Growth	7.87%	7.87%	7.87%	7.87%

**Assume current merchantable inventory number as base*
*** Average 2007-2009*
****Assume same as 2006 or current estimate*

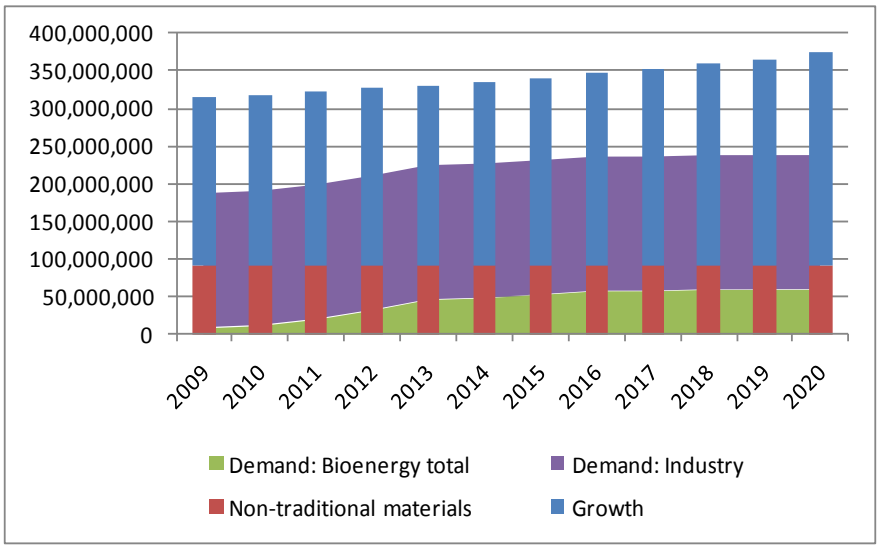

Figure 2: Pulpwood growth and sustainability in the South

SUMMARY

- Biomass supplies: US forests and mills generate ~181 million available green tons of non-traditional, unused woody biomass. These include "other" removals, logging residues, unused mill residues and pre-merchantable materials. The key categories are two types of logging residues, which together represent 65.6% of these materials. Overall, the South accounts for 90 million green tons, or 49.9% of all estimated materials nation-wide.
- US forest harvesting: The US harvests 2.1% of its timberlands annually. Nationally, this has been relatively stable for the past 20 years. Regionally, harvesting has increased in the South and Northeast and decreased in the West and Lake States. Approximately 60% of all harvesting activities today are partial cuts or thinnings. For biomass harvests

associated with standard logging operations, operational viability requires 15 to 25 tons per acre minimum, while most available biomass volumes across US regions fall below 15 tons per acre on average. Alternately, grinder operations that follow logging operations require minimum volumes per site, rather than per acre volumes, that range from 250 tons to 550 tons per site.

- Wood demand: In 2009, the US forest products industry consumed 235.4 million tons of pulpwood and chips, 4% less than in 2005. The South accounts for 70% of this demand.
- Wood bioenergy projects: Of the 143 announced and operating wood bioenergy projects in the US South, 79 pass basic viability screening. These "viable" projects represent 25.2 million tons of incremental wood biomass demand by 2020.
- Sustainability: Two sets of sustainability metrics indicate that, on both national and regional bases, the US South grows more than enough wood biomass from traditional sources to supply both known wood bioenergy projects that are likely to succeed and the current forest industry. While heartening for long-term planning, this same assessment tells us nothing regarding the operational, economic and political viability of sustainably supplying wood raw materials for a given wood bioenergy project in a given local wood basket.

ACKNOWLEDGEMENTS

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