Availability and Sustainability of Wood Resources for Energy Generation in the United States

Commissioned by:

American Forest & Paper Association
1111 Nineteenth Street, NW, Suite 800
Washington, DC 20036
www.afandpa.org

Conducted by:

FORISK CONSULTING
Forisk Consulting
PO Box 5070
Athens, GA 30604
www.forisk.com

Principal Investigators:
Brooks Mendell, Ph.D., bmendell@forisk.com
Amanda Hamsley Lang, ahlang@forisk.com
Tim Sydor, Ph.D., tsydor@forisk.com
Seth Freeman, sfreeman@forisk.com

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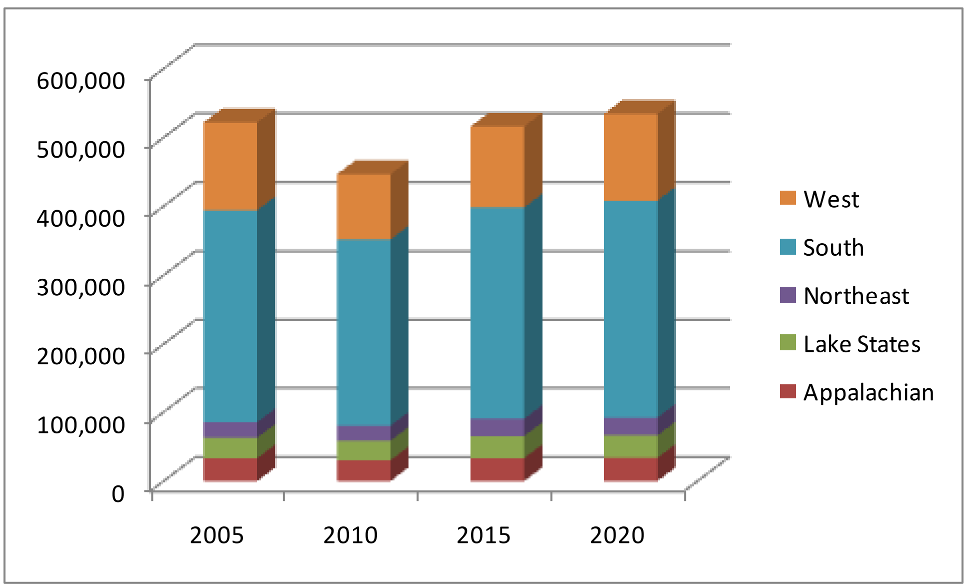
Executive Summary

This paper addresses the potential to define and quantify wood resources for energy generation that (1) exist independently of and in excess of those required as raw materials to manufacture forest products in the US and (2) can be harvested without jeopardizing the long-term sustainability of US forests. Key findings include:

- <u>Stable, overall wood demand outlook for the US forest industry</u>: through 2020, grade logs required by hardwood and softwood lumber mills are expected to increase and stabilize, while pulpwood volumes required by paper and paperboard manufacturers are expected to remain flat and decrease. Increasing demand from OSB manufacturers partly offsets reduced pulpwood demand. **In total, the US forest products industry, which consumed 522 million green tons in 2005, is returning to trend and expected to consume 516 million greens tons in 2015 and 534 million green tons in 2020 (figure below).**



US Forest Industry Wood Demand, 2005-2020,
green tons
(raw data in Figure 5)

- <u>Available forest and woody residues exist for emerging bioenergy projects</u>. **50 million dry tons of forest and wood-related supplies are estimated to be readily available for bioenergy users** (table below). Logging residues represent the single largest source (57%). Mill residues are the smallest source (3%).
    - Maximum available supplies total 88 million dry tons at $80 per ton.
    - Does not include 5 million dry tons of unused pulpwood-sized materials available at $25 - $60 per dry ton.

Type	Readily Available*	Summary Supply Curves						
		$20/dt	$25/dt	$30/dt	$35/dt	$40/dt	*$50/dt*	*$80/dt*
Logging Residues	28,442,631	36,681,589	36,681,589	36,681,589	48,708,693	54,727,763	*59,401,641*	*59,401,641*
Other Removals	11,083,030	0	0	0	0	11,083,030	*11,083,030*	*16,637,480*
Urban Wood Waste	8,328,051	3,094,301	3,847,302	6,091,148	7,959,082	8,328,051	*8,867,566*	*10,044,564*
Mill Residues	1,699,340	1,699,340	1,699,340	1,699,340	1,699,340	1,699,340	*1,699,340*	*1,699,340*
Total	***49,553,052***	***41,475,230***	***42,228,230***	***44,472,077***	***58,367,115***	***75,838,184***	***81,051,577***	***87,783,025***

*Defined as (1) unused by other wood raw material consumers and (2) directly accessible with proven logging configurations without major capital investment. Includes logging residues at lowest cost point ($13-15/dt), other removals (i.e. trees from land use changes) at $40/dry ton on board truck cost, urban wood waste available at $40/dry ton on board truck cost, all unused mill residues. Costs do not include stumpage or hauling off of the collection site.

- <u>Biomass incentive programs have unintended consequences</u>: a summary analysis of BCAP in the US highlights three issues. First, large portions of qualifying materials have existing markets, resulting from definitional ambiguities. Second, wood markets are interrelated, as proposed qualifying materials cannot be produced independently of traditional forest raw materials. Third, subsidies could cause wood suppliers and land owners to shift and divert wood flows in efforts to qualify for subsidies. **Ironically, these efforts could result in higher overall raw material prices and would defeat the intended purpose of BCAP**.
- <u>**Recommendation – incent reforestation**</u>: for policy efforts seeking to increase forest inventories and biomass supplies, we recommend simple, direct targeting and incenting of landowners to reforest. The success of previous federal programs such as CRP and the challenges of programs such as BCAP, emphasize the importance of targeting funds at that point in the forest supply chain that can most likely benefit all potential wood consumers.
- <u>**Recommendation – finance logging equipment**</u>: to materially shift the forest residuals supply curve and access volumes that may require cost supports, we recommend direct loans to forest logging contractors to invest in additional equipment needed to harvest and collect forest residues. The equipment could include larger chippers to handle growing stock residuals or additional skidders to aggregate additional harvest residuals at the landing. **We estimate that, starting at the "readily available" levels, 29% more logging residues could be collected with marginal, incremental support of $4-$7 per dry ton**.
- <u>**Recommendation – subsidize fuel treatments from public lands**</u>: the Billion Ton Study includes volumes from fuel treatments to reduce fire hazards as potential sources of biomass for energy uses. This study specifies research that highlights the operational challenges and costs associated with producing this material and did not include it as an available supply. However, targeting these materials for subsidies provide a potentially potent application of limited resources. Fuel treatments on public lands would simultaneously increase biomass volumes for bioenergy, directly reduce the threat of unexpected fires, and access trees dying from other factors such as beetle infestations.

Introduction

Intense investor interest in alternative energy sources and recent legislative activities[1] have corresponded with an increase in announced and under-construction wood-using bioenergy facilities. These forces and activities raise questions regarding the potential impacts of evolving biomass policies and markets on the sustainability of forest supplies and traditional forest products industries in the US today and in the future. This research aggregates and evaluates data and provides recommendations to support policy-making efforts focused on both developing wood-using markets for energy and reinforcing the long-term sustainability of the forest resource in the US for all users of wood raw materials.

In April 2005, the US Department of Energy (DOE) and US Department of Agriculture (USDA) jointly published the "Billion Ton Study" (Perlack et al. 2005), which assesses the feasibility of generating sufficient biomass in the US to displace 30% of current US petroleum consumption. Meeting this target requires over one billion dry tons of biomass feedstock annually. Of the 1.3 billion dry tons identified in the study, 368 million dry tons (28%) came from forestland and wood-based sources (Figure 1). As the 2005 study did not account for issues associated with costs, sustainability and availability, the DOE has been updating the 2005 research and recently began releasing results (Perlack and Stokes, 2010). These results indicate that approximately 37% of the materials identified in the 2005 study are "unexploited" today and not used elsewhere.

Figure 1: Estimated US Forest Biomass Supplies, million dry tons/year

Category	Billion Ton 2005	Billion Ton 2010 Update		Forisk 2010
	Supply	Supply*	"Unexploited" Supply	Readily Available**
Fuelwood	52	51	0	0
Manufacturing residues	145	144	8	2
Urban wood residues	47	47	28	8
Logging residues	64	47	32	28
Fuel treatments to reduce fire hazards	60	60	60	0
Other removal residues		17	9	11
TOTAL	**368**	**366**	**137**	**49**

*Does not sum to 368 as in 2005 due to rounding
**Does not include an estimated 5 million tons of available pulpwood-sized material

This study (Forisk 2010) revisited the forest biomass sources in the Billion Ton Study to assess which of the estimated volumes may in practice be "readily available." Readily available refers to biomass supplies that (1) are currently unused by other wood raw material consumers (consistent with "unexploited") and (2) directly, economically accessible with proven log harvesting configurations. For example, logging residues available through the addition of a small chipper to an integrated logging operation were considered "readily available." Logging residues that required a significant capital investment or negatively impacted normal logging production were not deemed "readily available." These results indicate that 13% of the volume

[1] Including the Energy Independence and Security Act of 2007 (EISA), the 2008 Farm Bill, the Biomass Crop Assistance Program (BCAP) in 2009, and state-based Renewable Portfolio Standards (RPS).

from the original 2005 Billion Ton Study and 36% of the "unexploited" supply identified in the 2010 Update is directly, readily available.

In further researching the issue of currently unused forest-derived and wood-based biomass supplies that may be accessed sustainably for wood bioenergy applications, this study:

- Quantifies wood demand in the forest products industry, based on forecasted estimates through 2020, to better understand the volume of timber required to support traditional paper and wood products facilities in the US.
- Evaluates forest resource accessibility, by forest region in the US, while taking into account differences in regional forests and harvesting operations.
    - Includes an assessment of the forest-based residues that could be economically recovered, using current harvesting technologies, with and without subsidies.
    - Includes an assessment of the cost and availability of clean, woody municipal solid waste (MSW) by forest region.
- Highlights issues and drafts a recommendation for clarifying definitions for wood raw materials types and categories. The intent is to better distinguish and clarify for policy-makers those resources central to traditional forest industry manufacturers from those resources that could be viably and sustainably accessed for energy-related purposes.
- Assesses potential policy consequences and market effects resulting from biomass incentive programs such as BCAP. What can be observed today that may be instructive moving forward?
- Provides recommendations, based on this analysis, previous research and case studies, for policymakers to consider seeking to increase forest inventories and biomass supplies.

Methodology

This research relies on cross-disciplinary data and analysis from public and private sources including the US Forest Service, the Energy Information Administration, Forisk Consulting, the American Forest and Paper Association, the US Department of Energy, Oak Ridge National Laboratories, M&E Biomass, and university-based research and guidance from the University of Georgia, Oregon State University, North Carolina State University and others. In addition, assumptions were vetted via communications with forestry consultants and timberland managers. In cases where data, analysis or models from one US forest region are applied to another, all efforts are made to specify the relevant assumptions and potential implications from generalizing results in any way. Complete citations for specific studies and references used to support this research are provided at the end under "Data Sources and Literature Cited."

The general approach to conducting this research included the following considerations:

- Specify forest-derived and wood raw materials that are unused and currently available. The priority in this assessment is given to materials that, given what we know today, do not have a current market and can be accessed, aggregated and transported with existing, proven technology. This includes screening out forest volumes from areas such as steep slopes and wetlands.

- <u>Assess the supply and demand characteristics by US forest region.</u> Forest resources, forest industry facilities and the population are clustered, not evenly distributed, in pockets across the US. This research breaks down key measures across regions for purposes of comparison and for better targeting potential policy efforts.
- <u>Apply best available and published research associated with harvesting and biomass removal technology in estimating supply curves.</u> Biomass availability relies critically on assumptions associated with the economics – the costs – of biomass-related in-woods and processing operations. What can loggers and wood raw material suppliers do today as part of their current operations? What are the marginal costs, which could be addressed through policy or subsidy programs, associated with accessing additional volumes? In cases where peer-reviewed results were not available, conservative estimates were specified and applied.

Definitions

Understanding forest resources requires clarity and specificity when defining raw material types and how we assess their availability and accessibility. We highlight two areas of definitional ambiguity associated with forest operations and wood raw materials analysis: *forestry metrics* and *forest supply specifications*. Inconsistency in these two areas can, and have, resulted in incorrect assessments of available wood volumes and in apples-to-oranges comparisons of forest supply types.

<u>Forestry metrics</u> refer to the terms used to describe the size, volume and flows of forests and forest raw materials. The primary sources of confusion in this area are, first, the differences between stocks and supplies (flows) and, second, unit/volume conversions, including the differences associated with green and dry volumes of wood raw materials. These metrics apply to indicators of timber scarcity and wood raw material availability.

1. <u>Forest growing stock</u> refers to the ***inventory*** of stumpage – standing trees of merchantable size– in a forest. The US Forest Service defines "merchantable" as at least 5 inches diameter at breast height (dbh) from a 1-foot stump to a minimum 4-inch top diameter outside bark (dob). As an example, the state of Georgia has approximately 1.3 billion tons of forest growing stock (Mendell et al. 2007).[2] Participants new to forestry may ask, "Isn't all of that wood raw material available for use?" In theory, yes; in practice, no. The forest growing stock (inventory) is equivalent to the principal associated with capital investments. The forest is an endowment which produces annual wood flows for use.
2. <u>Forest supplies</u> refer to the annual flows associated with harvesting trees. The maximum, potential supplies are indicated by the annual growth of the forest since the previous year. Forest removals – the harvesting of trees to satisfy demand from wood-using mills – are the actual supplies generated. For example, Georgia produced net annual growth of 77 million tons of wood and removed (harvested) 63 million tons (Mendell et al. 2007). Figure 2 indicates that Georgia's forest growth exceeds removals by 14 million tons, implying excess supplies statewide. In practice, this fails to account for access and availability. The metrics

[2] Assumes 25 cubic feet per ton; based on US Forest Service FIA data indicating 33,065 million cubic feet.

say nothing about ownership – are these volumes on private lands or in public parks? – or access – are the trees in hard-to-reach mountains or wet lowlands? – or location – are the trees near relevant wood markets or hundreds of miles away?

Figure 2: Standard Forestry Metrics, Georgia Example

Term	Definition	Units	Example (Georgia)
Growing stock	Forest inventory	Tons	1,300,000,000
Net annual growth	Forest growth net mortality	Tons/year	77,000,000
Removals	Trees harvested	Tons/year	63,000,000
Metric	**Definition**	**Units**	**Example (Georgia)**
Growth to growing stock	Rate of forest growth	%/year	5.92%
Removals to growing stock	Rate of forest removals	%/year	4.85%
Growth/drain ratio	Growth to removals	Ratio	1.22

3. Unit conversions refer to the ratios used to convert measures of forests and wood raw materials to different measures such as volume to weight or green tons to dry tons.
    a. Volume to weight: Figure 2 used a volume-to-weight conversion of 25 cubic feet per ton of green wood. Industrial roundwood conversions vary, typically from 25 to 30, across geographies and species.
    b. Green tons to dry tons: Moisture content of wood affects every end use differently. Traditional forest industry users prefer, on balance, fresh wood. Potential users of wood for bioeonergy prefer dry wood. A common error in evaluating raw material supplies for announced bioenergy projects is confusion of green-versus-dry tons. A rule of thumb conversion is 2:1 green-to-dry. Therefore, the implied 14 million ton net between growth and supplies from Figure 2 equates to 7 million dry tons.

Forest supply specifications refer to the actual definitions applied to various wood raw material categories. While definitions for grade raw materials used by the forest industry are relatively clear as a category, definitions for lower-grade raw materials become ambiguous as they overlap definitions of biomass types and volumes purportedly available to new wood users.

1. Forest industry merchantable raw material types refer to the categories of raw materials consumed by facilities such as sawmills, pulp mills, OSB facilities and plywood plants.
    a. Grade logs: A catch-all category for logs – such as sawtimber, sawlogs and chip-n-saw – used to manufacture solid wood products such as lumber, plywood and poles. The US Forest Service defines a sawlog as a roundwood product, usually at least 8 feet in length, processed into a variety of sawn products such as lumber, pallets, railroad ties, and timbers. While the US Forest Service further defines the measurable specifications for each type of grade log, the broad category is clearly delineated by its size – large enough to saw – and value. The economics of grade logs effectively segregate them for use at grade consuming mills.
    b. Pulpwood-sized material: Pulpwood is a timber product from small diameter (6-9 in.) and/or low quality trees used for fuel, paper production, and oriented strand board (OSB). Pulpwood-sized material is a category of interest to bioenergy firms as

a source of raw material. When using US Forest Service FIA "merchantable" data, this analysis defines pulpwood-sized material as wood from trees that are 5 to 9 inches in dbh and ½ of the trees in the 9-11 dbh class. The ½ of the 9-11 dbh category is used to approximate all merchantable volume that is 9+ dbh that ultimately ends up classified as pulpwood due to reasons such as defect, cull and mis-sorting.

   c. Mill residues: wood and bark residues from all primary wood-using mills during the processing of roundwood. Over 90% of the mill residues that are currently produced are used by forest products manufacturing facilities as a source for raw materials or for fuel. This category is also of interest to bioenergy firms as a raw material source.

2. Forest-based materials not used in the primary manufacture of forest products are materials that forest products facilities are not using to make pulp, plywood, lumber or OSB directly. Forest products facilities may use some portion of this material as fuel.
   a. Logging residues: Logging residues are defined by the US Forest Service as the unused portions of trees cut or destroyed during harvest and left in the woods. The US Forest Service Timber Product Output (TPO) database reports logging residue removals in two categories. Due to current harvesting and collection equipment limitations, some portion of this material may be inaccessible:
      i. Logging residues from growing stock include residues from the growing stock portion of the tree between a 1-foot stump to a 4-inch top diameter outside bark (dob). These residues are produced from material that is too short to meet a merchantable specification or has a quality defect.
      ii. Logging residues from non-growing stock are residues from limbs and tops above a 4 inch top dob, or from non-growing stock trees (less than 5 inches dbh) that are killed as a result of the logging operation.
   b. Other (non-roundwood) removals include tree volumes removed from timberlands due to land use changes to non-forest uses as well as trees killed during forest improvement activities. Due to current harvesting and collection equipment limitations, some portion of this material may be inaccessible.

Forest supply definition issues summarize areas of specific confusion and provide recommendations for defining raw material types of interest for biomass related policies.

1. Biomass studies use interchangeably product specifications, harvesting type and raw material source to define available raw materials. The Billion Ton Study, for example, includes raw materials as defined by use (i.e. fuelwood), as defined by source (i.e. urban wood residues, forest industry wastes), as defined by harvest operation (i.e. fuel treatments), and as defined by specification (i.e. logging residues). While sufficient for academic purposes, categorizing potential sources by multiple categories creates ambiguity and implementation complications. For example, fuel treatments to reduce fire hazards may produce merchantable roundwood that could be redefined and redirected based on policy and subsidy incentives. Another example includes the sliding scale associated with commercial and pre-commercial thinnings.
2. Logging residues, while relatively clear as a category in the current market, could morph into a gray-market raw material supply. By definition, harvested roundwood trees that are

cut into small pieces and left in the woods would qualify as logging residues. Would this be an unreasonable result in a market environment that combined low or modest pulpwood and chip-n-saw prices with strong and subsidized biomass for energy prices?

3. Forest supply specifications are uniquely local. A primary challenge with broad-based legislative descriptions is the reality of definitional variance across local markets. Specifications for chip-n-saw vary in Georgia versus Alabama versus Mississippi. A pulpwood log in a large-log market may be a grade log in a small-log market. These realities reinforce the difficulties of producing consistently applied definitions for forest raw material supplies.

Forest supply definition recommendation: for policy applications, focus on raw material sources. While biomass specifications and definitions vary, raw material sources remain constant. While raw material uses vary, raw material sources provide one means for establishing distinct lines for describing biomass supplies over the long-term. Sources of material include, for example, landfills, mills, public forests, private forests and developments.

Wood Demand Outlook

The economics of wood markets net demand and supplies based on costs and prices. To better understand the magnitudes and trends associated with wood raw material needs of the forest products industry, we quantify, by forest region in the US, the volume of timber required to support traditional paper and wood products facilities today and, based on forecasted estimates, through 2020.

The analysis focuses on core end markets for pulpwood (pulp and paperboard mills, OSB mills) and grade logs (sawmills, plywood plants). Specific assumptions were made in evaluating and generating outlooks across end product markets by region. Key assumptions included:

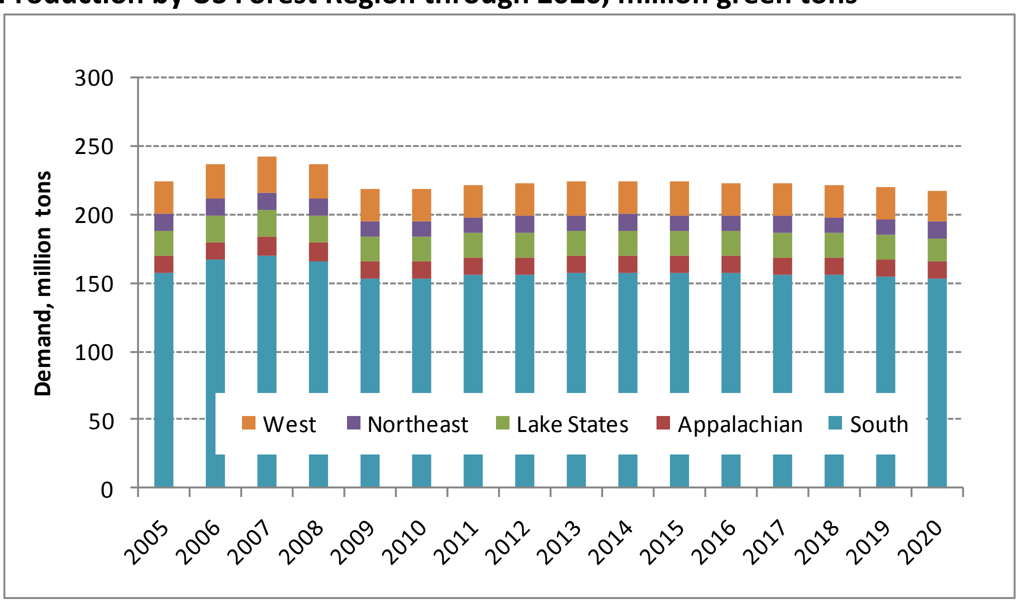
- Pulp and paperboard: baseline production by region was based on Forest Resources Association data through 2004, and on Forisk Wood Demand data from 2004 through 2009. Forecasts of pulpwood raw material needs for the South include softwood, hardwood and all required wood manufacturing residues/chips (ForiskForecast 2010). Annual changes and trends produced from the Southern-based econometric model are applied to all regions annually off of each region's historic pulpwood-consuming baseline. All regions are assumed to maintain constant US market shares through 2020 for this application.
- Oriented strand board (OSB): baseline production for the sector is based on panel capacity and production data from US Forest Service data published by Henry Spelter (Spelter et al. 2006). Southern wood demand for panel production is based on the Forisk Wood Demand database. Panel-to-wood raw material conversions for all regions are based on Forisk Wood Demand data at 1.174 tons of logs per cubic meter of panel capacity or production.
- Softwood lumber: Regional, baseline production is based on US Forest Service data from Henry Spelter (Spelter et al. 2009). This data was validated using state-by-state production data from the US Census. Southern wood demand was based on a three-year average (2006 through 2008) from the Forisk Wood Demand database. Annual changes and trends produced from a Southern-based econometric model for lumber consumption are applied

to all regions annually off of each region's baseline (ForiskForecast 2010). All regions are assumed to maintain constant market shares through 2020 for this application.

- Hardwood lumber: baseline, historic production was aggregated by state from US Census data. Hardwood grade consumption came from the Forisk Wood Demand database, based on a three-year average of 2006 through 2008. Hardwood lumber forecasts followed forecasted housing start trends, as assessed from the historic relationship between housing starts and hardwood lumber production in the US between 1985 and 2008. It was assumed that each region maintained constant hardwood lumber production market shares.
- Plywood: baseline production for the sector was based on panel capacity and production data from US Forest Service data (Spelter et al. 2006). Southern wood demand for panel production was based on the Forisk Wood Demand database. Panel-to-wood raw material conversions for all regions based on Forisk Wood Demand data at 2.02 tons of logs per cubic meter of panel capacity or production. All plywood production trends were based on softwood plywood production trends. The plywood forecast assumes that US plywood production continues its long-term market share decline relative to OSB through 2020. All regions are assumed to maintain constant market share through the outlook period.

Figures 3 and 4 provide historic and forecasted wood demand trends by US region paper and paperboard and softwood lumber. Since 2005, wood demand for paper and paperboard production peaked in 2007 at 241.7 million green tons of pulpwood and chips. While demand has fallen, it is expected to increase modestly with GDP growth through 2014 to 223.9 million tons, and decrease slightly to 217.7 million tons in 2020 as per capita use of paper and paperboard decreases in the US.

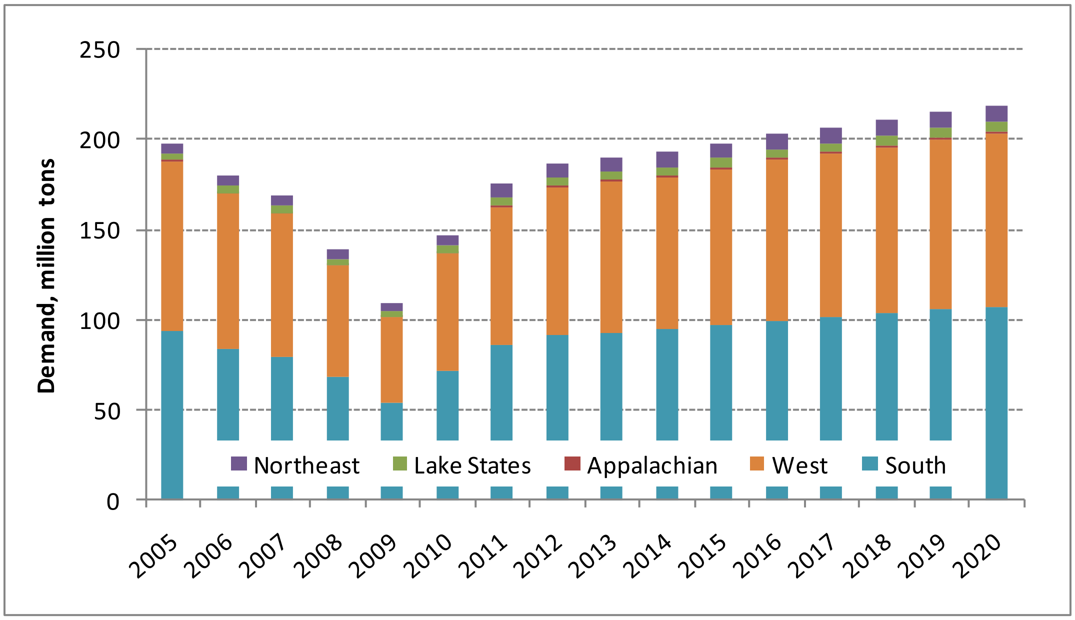
Figure 3: Demand of Pulpwood and Pulpwood-Equivalents for Paper and Paperboard Production by US Forest Region through 2020, million green tons



Source: ForiskForecast 2010-2020

Demand for softwood sawtimber for the production of softwood lumber by region is summarized in Figure 4. US softwood lumber production bottomed in 2009 and has begun to increase in 2010. Longer-term demand is expected to approach historic levels of nearly 200 million tons in 2015. A relationship exists between the increased production of lumber and the demand for pulpwood: as lumber production increases, so does the supply of residual chips, thereby decreasing pulpwood needs.

Figure 4: Demand of Sawtimber for Softwood Lumber Production by US Forest Region through 2020, million green tons



Source: ForiskForecast 2010-2020

Figure 5 summarizes total roundwood and wood chip raw material demand by region across five end markets: (1) paper and paperboard; (2) oriented strand board (OSB); (3) softwood lumber; (4) hardwood lumber; and (5) plywood. While recent market conditions represented a major decline in raw material consumption, housing market recovery, population growth and economic production in the US increase overall wood raw material demand to trend consistent with historic levels.

Figure 5: Total Forest Industry Wood Demand by US Forest Region through 2020, million green tons

Region	2005	2010	2015	2020
Appalachian	33,174	30,155	33,413	33,665
Lake States	29,681	28,237	31,770	32,468
Northeast	22,539	21,978	25,141	25,893
South	308,934	271,357	307,955	316,182
West	127,577	94,711	117,714	126,091
Total	521,904	446,438	515,993	534,299

Source: ForiskForecast 2010-2020

Resource Assessment

The forest resource assessment evaluates, by US forest region, forest and wood-based residues that could be economically recovered, using current harvesting technologies. The economic analysis estimates supply curves for each raw material type to assess what volumes could be accessed within current logging operations and fee structures, and what additional volumes could be available with additional financial support (i.e. subsidies). The analysis applies previous, published research on costs associated with collecting and aggregating residual materials.

Available supplies were evaluated by type and region. The forest resource raw material types of interest in this research include:

- <u>Logging residues from non-growing stock and from growing stock</u>. Per the Billion Ton Study, this research assumes 65% of total estimated logging residues are available, given unlimited budgets to access this material.
- <u>Other forest removals residues</u>. Residues associated with non-harvesting operations on timberlands, we assume a 50% accessibility factor.
- <u>Unutilized pulpwood-sized materials</u>. This measures historic pulpwood removals (as measured by TPO) relative to current pulpwood removals by region. In cases where pulpwood removals declined between 1996 and 2006, we assume that the volume that was removed historically would still be available today if sufficient demand existed from regional wood-using facilities. This analysis assumes 50% of the difference (if lower today) would be available in the form of pulpwood-sized supplies.
- <u>Manufacturing (mill) residues</u>. Few primary mill residues go unused. This analysis assumes that only un-used mill residues, as measured by TPO data, are available.
- <u>Urban wood residues (woody municipal solid waste, MSW)</u>. Analysis from Marie Walsh of M&E Biomass provided estimates of clean urban residues by region from municipal solid waste, yard trimmings, and construction and demolition. This analysis assumes 50% of the estimated volumes are recoverable and accessible. (Urban wood residue volumes are detailed in the supply curve analysis."

This research does not include fuelwood or fuel treatments to reduce fire hazards as available or currently viable sources of biomass. Fuelwood, as noted in the Billion Ton Study, is considered 100% utilized in existing markets. Therefore access to this volume would require diverting wood flows. Wood flows from fuel treatments are minimal and, based on existing research, costly and unproven to date. Fuel reduction treatments with mechanical treatments can exceed $1,000/acre, requiring significant financial commitments from harvesting contractors (Prestemon et al., 2008). Becker et al. evaluated the effectiveness of various policy incentives to reduce the cost of hazardous fuel reduction (2009). As transportation costs contributed 64-69% of total costs, the most beneficial strategy was co-locating lumber mills and bioenergy plants within 10 miles of harvest sites. This approach was the only option that made fuel reduction treatments profitable. Additional policy options, from most to least effective, included subsidies paid to the harvesting contractor, a 50% equipment cost share, and a transport tax credit of $10/green ton of biomass produced.

Figure 6 summarizes the total available supplies of logging residues (assuming 65% of generated supplies per the Billion Ton Study) and other removals residues (assuming 50% of generated supplies from non-forest harvesting operations).

Figure 6: Forest and Other Removals Residues by Region, dry tons

Region	Logging Residues	Other Removals	Total
Appalachian	6,556,000	2,647,380	9,203,380
Lake States	4,246,630	2,805,680	7,052,310
North East	4,199,170	101,390	4,300,560
South	22,273,490	11,083,030	33,356,520
West	8,418,280	0	8,418,280
Total U.S.	45,693,570	16,637,480	**62,331,050**

Data sources: US Forest Service TPO database

Figure 7 summarizes the total available supplies of pulpwood-sized materials based on declines, in some regions, of overall pulpwood demand by traditional industries. The estimated available dry tons represent 50% of the difference in removals, if lower, between 1996 and 2006 based on US Forest Service TPO data.

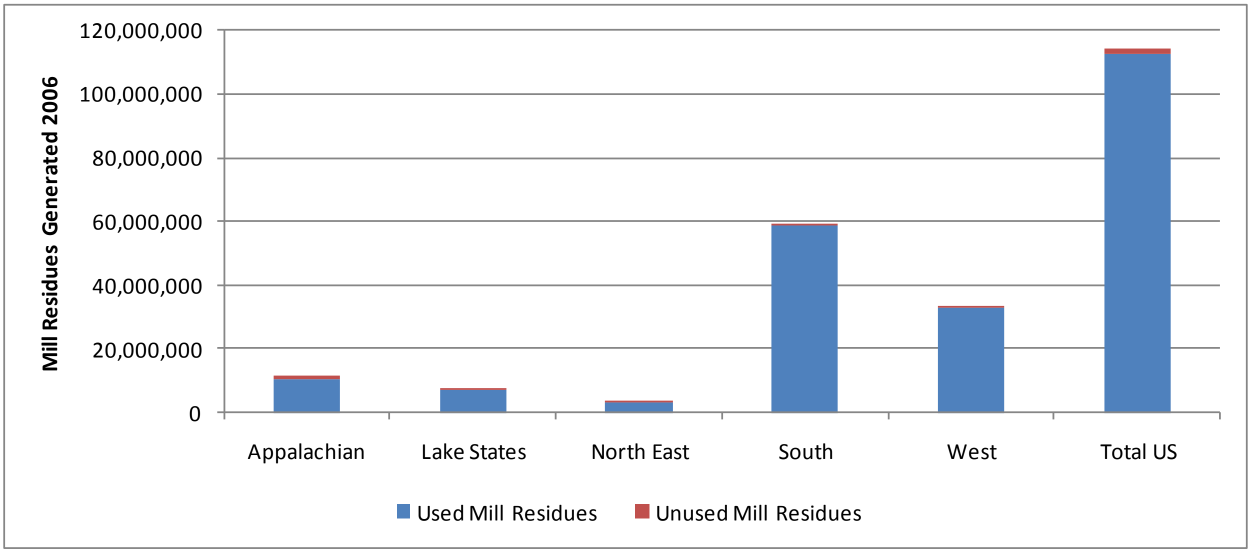
Figure 7: Available Pulpwood-Sized Material by Region, dry tons

Region	Pulpwood-Sized
Appalachian	40,980
Lake States	0
North East	660,570
South	4,466,510
West	0
Total U.S.	**5,168,060**

Data sources: US Forest Service TPO database

Figure 8 summarizes the total and available mill residues by region in the US. According to the US Forest Service, 114 million dry tons of mill residues are generated annually, but only 1.7 million dry tons (1.5%) are unused. The Appalachian region has the highest absolute available volume (880,000 dry tons) and highest available percentage of produced mill residues (7.8%) across regions.

Figure 8: Mill Residues by Region, dry tons



Data sources: US Forest Service TPO database

Supply curves of the available supplies for key categories provide an assessment of what portion of the estimated supplies are available with existing cost structures and logging approaches, and what portions may require additional investment or subsidies to access, aggregate and deliver to potential wood-consuming energy facilities.

Figure 9 summarizes all of the supply curves by raw material type. According to our research and analysis, available forest supplies exist for emerging bioenergy projects net current forest industry demand. Of the total, 49.6 million tons are defined as "readily available" supplies for bioenergy users. Logging residues comprise the largest portion (57%); mill residues the smallest (3%).

Figure 9: Summary Supply Curve and Raw Material Availability by Type, US, dry tons

Type	Readily Available*	Summary Supply Curves						
		$20/dt	$25/dt	$30/dt	$35/dt	$40/dt	*$50/dt*	*$80/dt*
Logging Residues	28,442,631	36,681,589	36,681,589	36,681,589	48,708,693	54,727,763	*59,401,641*	*59,401,641*
Other Removals	11,083,030	0	0	0	0	11,083,030	*11,083,030*	*16,637,480*
Urban Wood Waste	8,328,051	3,094,301	3,847,302	6,091,148	7,959,082	8,328,051	*8,867,566*	*10,044,564*
Mill Residues	1,699,340	1,699,340	1,699,340	1,699,340	1,699,340	1,699,340	*1,699,340*	*1,699,340*
Total	***49,553,052***	***41,475,230***	***42,228,230***	***44,472,077***	***58,367,115***	***75,838,184***	***81,051,577***	***87,783,025***

*Defined as (1) unused by other wood raw material consumers and (2) directly accessible with proven logging configurations without major capital investment. Includes logging residues at lowest cost point ($13-15/dt), other removals (i.e. trees from land use changes) at $40/dry ton on board truck cost, urban wood waste available at $40/dry ton on board truck cost, all unused mill residues. Costs do not include stumpage or hauling off of the collection site.

Figure 10 summarizes the pulpwood-sized materials estimated to be available due to declines over time in pulpwood use in the US by traditional users. We estimate 50% of the total decline as available. Of this– 5.2 million dry tons - we classify the entire estimate as readily, directly available. Including the readily available figures from Figure 9, **we estimate total readily available wood resources volumes of 54.7 million dry tons.**

Figure 10: Readily Available Pulpwood-Sized Materials, US, dry tons

$20/dt	$30/dt	$40/dt	$50/dt	$60/dt
0	4,466,510	4,466,510	4,466,510	5,168,060

The methodology for the supply curves associated with logging residues leveraged multiple studies and included county-level analysis of roundwood-to-logging residual ratios. Starting assumptions for logging residuals included:

- 65% of logging residues produced will be available/accessible for use (Perlack et al. 2005).
- Harvest operations that produce logging residues would (could) be integrated operations that produce roundwood products and chip logging residues at the landing.

Our objective was to segregate logging residues that are readily available with an integrated harvesting operation (typical roundwood operation with the addition of a chipper on the landing to process residues) without additional cost, other than the cost of operating a supporting chipper on the landing. Baker et al. (2010) estimated that integrated harvesting operations using a small chipper at the landing could produce biomass chips from logging residues without incurring additional cost to the roundwood operation at roundwood-to-chip ratios between 3:1 and 6:1 in pine stands in the US South. Our analysis applies this range as the baseline criteria to estimate logging residues at the lowest cost point (the cost of chipping and of loading the chipper on a landing without negatively impacting roundwood operations).

This analysis accounts for the differences in logging residue volumes produced relative to roundwood volumes at the regional and county levels across the US. In analyzing roundwood-to-logging residues by region, the following methodology was applied:

1. Applied the 65% recovery factor to the logging residues produced by county from the USFS TPO database.
2. Calculated the roundwood-to-logging residue ratio for each county in each region of the US. Counties that had roundwood volumes but no residue volumes were removed from the dataset.
3. Calculated the percentage of counties that had roundwood-to-residue ratios between 3:1 and 6:1, the percentage of counties that had ratios less than 3:1, and the percentage of counties that had ratios greater than 6:1.
4. Applied these percentages to the available logging residue volumes to determine the volume of available residues in each of these three categories by region.

For each of the three categories, we estimated the collection and processing cost to get the logging residue material in a chip van based on assumptions in Figure 11. The core insights relevant to this analysis include:

- Operations with too few chips to run the chipper efficiently must allocate additional resources to aggregate additional residuals from the woods, and will produce chips at a higher per-unit cost because the chipper will not run near capacity.
- Operations with too many chips will be forced to allocate additional loader time to handle logging residues, which can decrease the efficiency of the roundwood operation.

Figure 11: Cost and Assumptions for Chipping Residues in an Integrated Harvest Operation

Roundwood-to-Chip Ratio	Impact on Operation	Cost Assumption
Between 3:1 - 6:1	No impact to roundwood operation; optimal ratio for integrated operations.	Chipping + 18% (1/5.5) of loading cost. System produces on average one load of chips for each 4.5 loads of roundwood.
< 3:1	More residues than optimal ratio; increases costs to roundwood operation as increased residues divert harvesting resources to residues; increased loading time for chipping.	Full loading cost as a proxy for the impact of processing residues on loading and the penalty to the roundwood operation.
> 6:1	Fewer residues than optimal ratio; increases skidding costs to pick-up additional material; increases chipping cost because chipper productivity declines.	Full skidding cost + 50% increase in chipping cost.

We used the USFS Fuel Reduction Cost Simulator (FRCS; Dykstra 2010) model to determine the component costs of logging residues. The following assumptions were made:

- Appalachian, Lake States, and Northeast costs generated from FRCS North model.
    - Assumed ground-based mechanical whole tree system in Vermont.
    - Fuel price is 12-month average from June 2009-May 2010 for New England from EIA: $2.87/gallon.
    - Model inputs were 131 trees per acre and 18.8 cubic feet per tree, from Manager's Handbook for Oaks in the North Central States. GenTech Rep. NC-37.
- West harvesting costs generated from the FRCS West model.
    - Assumed ground-based mechanical whole tree system in Oregon.
    - Fuel price is 12 month average from June 2009-May 2010 for West from EIA: $2.88/gallon.
    - Model inputs were 190 trees per acre and 25 cubic feet per tree. Inputs qualified via personal communication with Tom Hanson, International Forestry Consultants, Inc.
- South assumed baseline $12.00 per ton stump-to-truck logging costs.
    - Used FRCS South model and assumed 150 TPA at 15.39 cubic feet per tree to determine chipping costs, skidding costs, loading costs.
    - Assumed ground-based mechanical whole tree system in Georgia.
    - Fuel price is 12 month average from June 2009-May 2010 for Gulf Coast from EIA: $2.73/gallon.

In short, logging residues that required a significant capital investment, such as an additional skidder, or negatively impacted normal logging production, such as by reducing volume or increasing longwood variable costs, were not deemed “readily available.” Figure 12 shows the cost inputs for the supply curves on a green ton basis, as they are applied in forest operations.

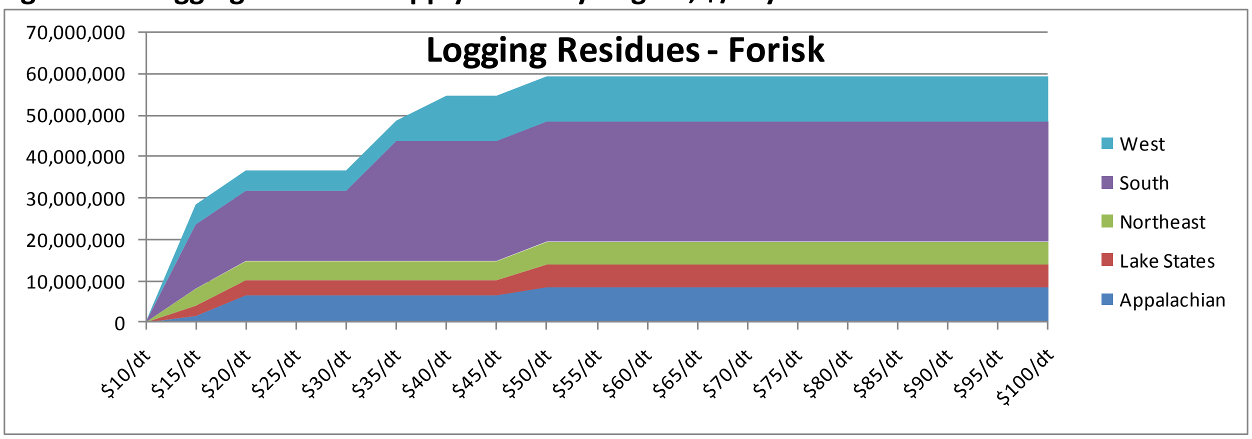
Figure 12: Supply Curve Cost Inputs, per green ton

	On board truck costs $/green ton				
Region	LR with RW:Residue Ratios between 3:1 - 6:1	LR with RW: Residue Ratios < 3:1	LR with RW: Residue Ratios > 6:1	Pulpwood-Sized Materials	Other Removals
Appalachian	$6.73	$9.46	$23.16	$27.94	$34.06
Lake States	$6.73	$9.46	$23.16	$27.94	$34.06
North East	$6.73	$9.46	$23.16	$27.94	$34.06
South	$6.83	$8.54	$16.35	$12.00	$18.45
West	$7.40	$9.56	$17.95	$20.09	$27.01

LR with RW = Logging Residues with Roundwood

Figure 13 summarizes the supply curves for all regions for logging residues.

Figure 13: Logging Residues Supply Curve by Region, $/dry ton



The logging residues supply curve shows 28.4 million tons of logging residues at a cost of $15 per dry ton or less. Per Figure 12, these are volumes that fall in the 3:1 to 6:1 roundwood to logging residues ratios and cost from $6.73 to $7.40 per green ton to process (in dry ton terms, this equates to $13.46 to $14.80). An additional 8.2 million dry tons are on logging operations where the roundwood to logging residues fall below 3:1. In these cases, more loading time is required and, possibly, a larger chipper. To act as a proxy for handling these additional tons, we assume full per ton loading costs for the 8.2 million dry tons. These loading costs, as well as the other component costs assumed for the supply curves, are summarized by region in Figure 14.

Figure 14: Assumed Per Dry Ton Component Costs by Region to Access Additional Residues

Region	Chipping Cost	Full Skidding	Full Loading	% of Loading Cost for integrated operations
Appalachian	$12.24	$27.96	$6.68	18%
Lake States	$12.24	$27.96	$6.68	18%
North East	$12.24	$27.96	$6.68	18%
South	$12.90	$13.34	$4.18	18%
West	$13.84	$15.14	$5.28	18%

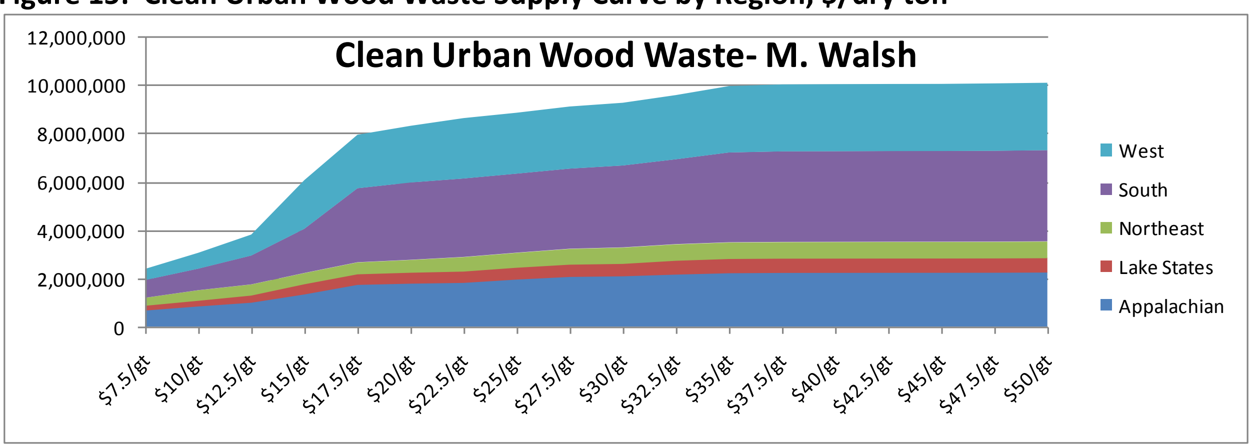
Marie Walsh, a researcher with M&E Biomass, has done extensive work in the area of urban wood waste supplies and pricing. Forisk used Walsh's supply curve data to obtain urban wood supply estimates for the regions in this study. She has developed models unique to each urban supply type based on macrofactors such as population and housing starts for each region.

Regional supply data is allocated to the state based on published state waste generation statistics. Walsh creates supply curves at the state and county level based on costs to produce the urban wood supply types and the volume of urban wood available. The costs include the cost to sort and process the wood waste material at a landfill or recycling center net of revenues from recovered products and tip fees. The costs equation is:

Price of Unused Wood = Net Tip Fee + Value of Other Recovered Products + Value of Landfill Cover – Wood Sort/Process Costs

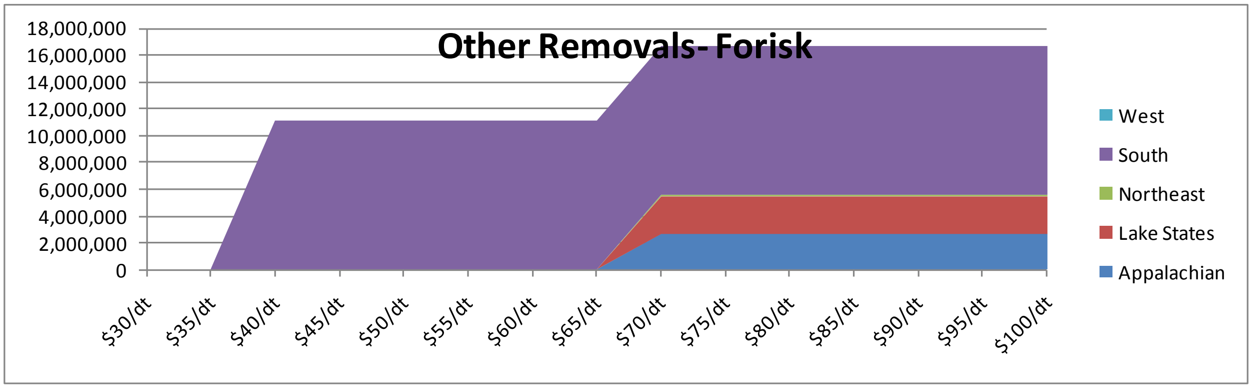
Note that the prices represent the breakeven costs to produce the urban wood raw material. Transportation cost and profit for the supplier are not included. We report Walsh's supply curves for clean urban wood waste and applied a 50% availability or recoverability factor to the volumes in her curves. We also converted the volumes to green tons. Figure 15 summarizes the supply curves for all regions for urban wood wastes.

Figure 15: Clean Urban Wood Waste Supply Curve by Region, $/dry ton



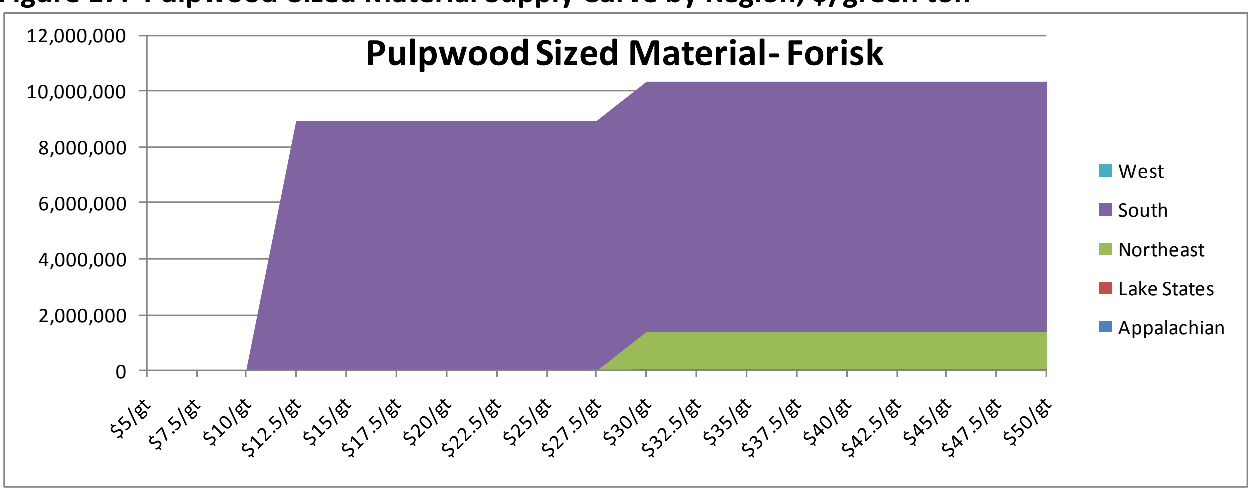
We assume that the cost to produce other removals is the cost to chip material plus the baseline cost to produce pulpwood in each region. Figure 16 summarizes the supply curves for all regions for this category of material.

Figure 16: Other Removals Chipped Supply Curve by Region, $/dry ton



We used the USFS Fuel Reduction Cost Simulator (FRCS) model to estimate the cost to produce pulpwood in each region. Figure 17 summarizes the supply curves for all regions for pulpwood-sized material on a green ton basis, as used and reported in normal forest harvesting and wood supply operations.

Figure 17: Pulpwood-Sized Material Supply Curve by Region, $/green ton



Policy Assessment: BCAP

A recent legislative effort with direct implications for wood raw material supplies is the Biomass Crop Assistance Program (BCAP), which was authorized as part of the Food, Conservation, and Energy Act of 2008. The stated purpose of the program is to "assist agricultural and forest land owners and operators with the establishment and production of eligible crops including wood biomass…for conversion to bioenergy, and the collection, harvest, storage, and transportation of eligible materials for use in a biomass conversion facility" (USDA 2010). In addition, the program seeks to simultaneously "avoid diverting any materials potentially eligible for BCAP matching payments from existing value added production processes already occurring in the marketplace" (USDA 2010).

Successful implementation of BCAP depends on navigating at least three practical challenges that, unaddressed, could directly distort local wood markets and divert wood from existing markets. First, large portions of qualifying materials – such as in-woods chips, residual chips and bark – have existing markets. Therefore, the program has definitional challenges. Second, wood markets are interrelated. Logging residuals are by-products of standard logging operations and cannot be produced independently of pulpwood and grade logs. Third, the application of a subsidy could cause wood suppliers to shift wood from one category (i.e. pulpwood) to another (i.e. fuelwood or logging residuals) to qualify. Rodger Sedjo (2010), in a recent assessment of BCAP, succinctly addresses these issues:

> *Today, many materials potentially eligible for matching subsidy payments are already used in the market place. This suggests that avoiding the diversion of materials from existing production processes already occurring in the market will be difficult. The conflict is likely to be greatest between traditional wood processors like pulp and composite mills, with the program creating winners and losers.*

BCAP introduces other complicating issues specific to forestry. Abt et al. (2010) identified issues in reviewing the rule proposed in February 2010, several of which are highlighted here. First, while BCAP was developed as part of and falls under existing farm programs, over 90% of the payments are expected to be forestry and wood-related. Potential disconnects between development and implementation raises concerns about whether BCAP would be more effectively managed as a forestry program, rather than a farm program. Second, statistical and actual measures associated with estimating green and dry tons appear problematic. Third, costs estimates and demand assumptions were developed without including the role of pulp and paper mills (which represent 70% of Biomass Consuming Facilities in the South), without including the role of pellet production, and assuming that there will be no impact on demand of eligible materials by Biomass Consuming Facilities.

In his BCAP assessment, Sedjo cites a US Forest Service study (Connor et al. 2009), which evaluates potential biomass supplies in South Carolina, as indicative of definitional and accessibility issues. The 2009 study updates a 2001 study from the South Carolina Forestry Commission which treated commercial thinnings as a viable feedstock for bioenergy, while the 2009 update sets aside commercial thinnings because they have existing higher-value uses. Whether BCAP defines commercial thinnings as eligible for subsidies or not, the potential exists for diverting wood flows. If eligible for BCAP subsidies, thinnings and other pulpwood-sized materials could immediately, in part, flow to alternate markets. If ineligible for BCAP subsidies, forest owners and suppliers may alter management plans or harvesting practices to become eligible. This could result in higher raw material prices and, ironically, would defeat the intended purpose of the program.

Recommendations and Conclusions

This research confirms both the robust wood raw material demand from traditional forest industry manufacturers and the potential to sustainably produce specified woody raw material flows for bioenergy applications. During normal market conditions, the US forest industry consumes in excess of 500 million tons of wood raw materials per year. Looking forward, the industry returns to trend by 2015 and will exceed 530 million green tons of consumption by 2020. As part of this forest industry supply chain, the forest industry generates over 90 million dry tons per year of logging residuals. This research indicates that of the total available supplies, 54.7 million dry tons of forest and wood-related supplies are estimated to be readily, immediately available for bioenergy users. Logging residues represent the single largest source.

In concluding this research, we offer three recommendations. The recommendations come from recognizing the challenge and difficulty of subsidizing raw materials that flow through functioning markets without affecting current market participants or diverting wood flows. First, to support ongoing, responsible forest management while supporting the US forest industry, we recommend simple, direct targeting and incenting of landowners to reforest. The success of previous federal programs such as CRP and the challenges of programs such as BCAP, which target the middle of the supply chain, emphasize the importance of targeting funds at that point in the forest supply chain that can most likely benefit all potential wood consumers.

Second, to materially shift the forest residuals supply curve and access volumes that may require modest cost supports, we recommend direct loans to forest logging contractors to invest in additional equipment needed to harvest and collect forest residues. The equipment could include larger chippers to handle growing stock residuals or additional skidders to aggregate additional harvest residuals at the landing. We estimate that, starting at the "readily available" levels, 29% more logging residues could be collected with marginal, incremental support of \$4-\$7 per dry ton to the logger.

Another area highlighted in this research is the importance associated with volumes from fuel treatments to reduce fire hazards as potential sources of biomass for energy uses. This study specifies research that highlights the operational challenges and costs associated with accessing and producing this material and, as such, did not include it as an available supply source. However, targeting these materials for subsidies provide a narrow and potentially potent application of limited resources. Supporting efforts to increase volumes from fuel treatments could satisfy multiple objectives: develop an untapped source of raw material supplies, improve forest health, and limit the impact and ability of subsidies to produce unintended consequences on traditional forest industry raw material markets. Additionally, these fuel treatments have the added benefit of capturing dead or dying material on public lands associated with beetle infestations.

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Appendix 1: Forest Resource Sustainability

Forest sustainability by region is assessed through aggregating FIA data from the US Forest Service to evaluate total growth of merchantable volumes relative to wood demand from forest industry manufacturers within these regions. The analysis excludes forest inventories located on steep slopes (>80%), narrow flood plains and beaver ponds. The analysis is conducted across forest ownership types, and then for private forests alone. Additionally, **the analysis is conducted in green tons as it includes green ton measures of forest industry demand**.

The analysis includes adjustments to inventory and growth number for the West region. Why? Historical inventory data and growth data was unavailable from the US Forest Service FIA database and from the US Forest Service directly for the states of California, Oregon, and Washington. Forisk adjusted the West estimates for total merchantable growth, pulpwood merchantable growth, and sawtimber merchantable growth to include a reasonable estimate of growth from the missing states.[3]

Figure A summarizes the regional growing stocks and growth rates by region. Nation-wide, merchantable forest inventories grow 2.74%, adding nearly 900 million tons annually. When netted against wood demand, US forests add over 440 million tons more volume than is harvested with nearly a 2:1 growth-to-demand ratio (1.96), increasing at a net annual rate of 1.35%. All US regions have positive growth net demand. In absolute terms, the US South has the highest net growth volumes, but the second lowest growth-to-demand ratio. The hardwood-heavy Appalachian region has the highest growth-to-demand rations, second highest net growth, and highest net growth rate.

Figure A: Forest Sustainability Metrics by Region, green tons[4]

	Growing Stock		Growth Rate	Growth/Drain	
Region	**Pulpwood, green tons**	**Sawtimber, green tons**	**Total, annual %**	**Growth / Demand**	**Growth - Demand**
Appalachian	1,390,336,011	5,390,732,819	2.57%	5.58	142,822,631
Lake States	873,049,750	1,747,658,243	2.89%	2.76	48,366,714
North East	898,487,316	2,359,102,430	2.35%	3.49	54,648,879
South	2,852,450,299	6,907,543,836	4.60%	1.59	167,119,405
West adjusted	1,662,634,924	8,703,498,695	1.46%	1.30	28,567,247
Total US	**7,676,958,300**	**25,108,536,023**	**2.74%**	**1.96**	**441,524,877**

Data sources: US Forest Service, Forisk Consulting

[3] Methodology: merchantable pulpwood and sawtimber growth rates were calculated for all other states in the West region. These growth rates were applied to the current forest inventories of California, Oregon and Washington to estimate annual growth by product type. As a result, we view the West growth numbers conservatively because the other states in the West region may not suitably reflect the growth rates and potential of the forest inventories in California, Oregon and Washington.

[4] Includes growing stock from public and private lands, hardwoods and softwood, natural and plantations.

Figure B summarizes the regional growing stocks and growth rates by region for private forests only. Nation-wide, merchantable forest inventories grow 3.54% annually. The higher growth rate on private lands is expected; private forests, on average, are more intensively managed and include most of the US plantations. When netted against wood demand, US private forests add 318 million tons more volume than is harvested with a 1.75 growth-to-demand ratio.[5] All US regions have positive growth net demand except the West, which showed a net deficit of 3.9 million tons per year. The deficit occurs because pulpwood demand as measured in roundwood tons exceed pulpwood removals as measured by harvest volume. In practice, a high percentage of the pulpwood demand in the West is satisfied by residual chips from manufacturing facilities, negating the deficit. Regardless, the close-to-one growth/demand ratio in the West highlights the critical dependence on private forests as removals have decreased from public lands over the past twenty-five years.

Figure B: Forest Sustainability Metrics by Region on Private Forests, green tons[6]

	Growing Stock		Growth Rate	Growth/Drain	
Region	**Pulpwood, green tons**	**Sawtimber, green tons**	**Total, annual %**	**Growth / Demand**	**Growth - Demand**
Appalachian	1,147,956,280	4,356,094,341	2.71%	5.11	119,875,367
Lake States	536,270,474	1,172,059,288	2.93%	2.65	31,163,127
North East	779,047,529	1,973,015,855	2.36%	3.06	43,738,001
South	2,468,546,279	5,589,448,471	4.97%	1.46	127,160,648
West adjusted	541,150,435	2,403,901,516	2.87%	0.95	-3,932,116
Total US, private	**5,472,970,998**	**15,494,519,471**	**3.54%**	**1.75**	**318,005,027**

Data sources: US Forest Service, Forisk Consulting

[5] In the growth/drain ratios, demand was allocated across public and private ownership proportional to the percentage of forest removals that occurred on public versus private forests by region.
[6] Includes growing stock from public and private lands, hardwoods and softwood, natural and plantations.

Appendix 2: Wood Bioenergy Demand and Outlook for the US

Given the actual and potential growth in wood demand for bioenergy, a key challenge becomes how to track and evaluate the progress of wood bioenergy markets and projects over time to make better investment decisions. How can investors assess the actual, likely demand on local and regional wood raw material from new and announced projects? In 2008, Forisk initiated a research effort into tracking bioenergy projects in the US. The basic methodology for the screen relies on two criteria for wood-consuming projects:

- 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 received or secured two or more necessary elements for advancing towards operations pass the status screen.

Further details of the Technology criteria and Status elements incorporated in Forisk's methodology are detailed below.

Technology

Projects that employ currently viable technology pass the technology screen. The term "viable" refers to commercial scalability: a company can economically build a commercial-scale plant using available technology today. Examples include pelletizing technology and wood-to-electricity projects. Cellulosic ethanol from wood feedstock is still a developing technology and is currently not operational. While the technology screen applies to three broad categories (pellets, electricity, liquid fuels), each of these technology types have sub-categories of various applications.

Status

If a project is not already under construction or operating, it must have two or more of the following to pass the status screen:

- Secured site: The project has purchased a site or signed an agreement to lease a site. The project has secured the option to use the site.
- Financing: The project has secured some portion of the financing required to develop the project. This can include federal, state, and/or local grants, or the use of bonds or equity. To pass the financing category, a project must have received the grant, actually issued equity, or actually sold bonds.
- Air quality permit: State environmental agencies grant air quality permits or exclusions to new sources of air pollution and to existing facilities that make upgrades that increase levels of air emissions to comply with the Clean Air Act. According to the EPA, state agencies or the permitting authority go through a five step process to issue an air permit: 1) Determine if the permit application is complete; 2) Issue a draft permit; 3) Publish a public notice to inform the public of the comment period, usually 30 days, and the deadline to request a public hearing; 4) Make a decision to revise the draft permit based on comments received; 5) Issue the final air permit (EPA 2010). We only consider the final air quality permit to count as sufficient for passing the status screen.

- <u>Engineering Procurement and Construction (EPC) contract</u>: The project has a signed agreement with an engineer to design and construct the facility.
- <u>Power purchase agreement or off-take agreement</u>: The project has a signed contract with a customer to purchase power, wood pellets, or liquid fuel from the project.
- <u>Public Service Commission approval</u>: While regulated utilities do not have to secure power purchase agreements to sell power, they must gain the approval of the state's public service commission to implement a renewable energy project. State public service commissions, or public utility commissions, regulate utilities that are franchised monopolies and required to serve all customers (Schnapp 2007). Utilities must gain approval of actions that will affect the rate base to protect energy customers (C. Wirman, pers. comm.).
- <u>Interconnection agreement</u>: Interconnection agreements apply only to electricity projects. The project has a signed agreement and has obtained approval to connect power lines to the grid to distribute electricity.
- <u>Wood supply agreement</u>: The project has one or more signed agreements with wood or feedstock suppliers for a contracted volume of feedstock for a specified period of time.

We applied the screening methodology to all known operating and announced wood-using bioenergy in Forisk's wood bioenergy database. As of June 15, 2010, Forisk indentified 351 wood-consuming, announced or operating bioenergy projects in the US (Figure C). By count, electricity and pellet projects comprise over 92% of all projects, with cellulosic ethanol-oriented liquid fuel projects representing most of the balance.

Figure C: Number of Announced Wood-Using Bioenergy Facilities by Type and Region, US[7]

	Type			
Region	**Electricity**	**Liquid Fuel**	**Pellet**	***Total***
Appalachian	19	4	30	***53***
Lake States	13	2	29	***44***
Northeast	35	2	22	***59***
South	76	12	43	***131***
West	31	8	25	***64***
Total	**174**	**28**	**149**	***351***

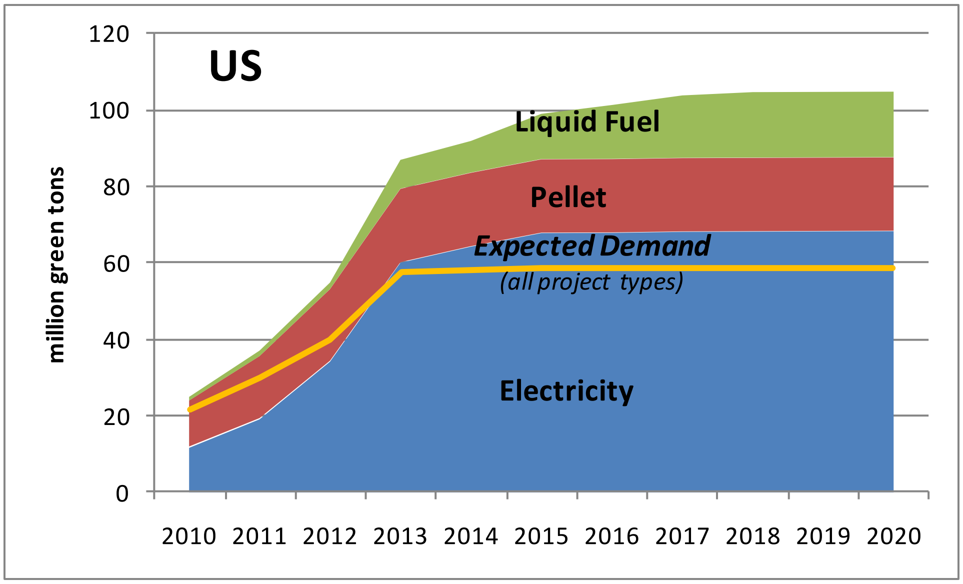
Source: Forisk Consulting

As of June 15, 2010, these projects represent potential, incremental wood use of 104.8 million green tons per year by 2020 (Figure D). The figure shows the wood use of announced projects in the US through time and by type as they come online from 2010 to 2020. The "expected demand" line on the figure indicates demand by projects that passed the technology and status screens and includes all project types. Based on Forisk analysis, projects representing 58.7 million tons per year pass the basic screening described. This represents less than 56% of the potential, announced wood demand from bioenergy projects. The US South is the region with the largest number of projects, the highest potential wood use from operating and announced projects, and the highest volume of wood associated with projects that pass the basic viability

[7] Does not include two projects, one each in Alaska and in Hawaii.

screening. Per the screening methods, no cellulosic ethanol projects pass the screen for any US region.

Figure D: Estimated Wood Use by Announced Bioenergy Facilities, US, green tons[8]



Source: Forisk Consulting

Figure E provides the year-by-year wood raw material consumption associated with current, announced and, per Forisk analysis, viability of wood-using bioenergy projects by type.

Figure E: Estimated Wood Use by Announced Bioenergy Facilities by Year, US, green tons[9]

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
All Electricity	11.63	19.09	34.18	60.08	64.29	67.83	67.89	68.16	68.22	68.27	68.33
All Pellet	12.08	16.29	18.81	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26
All Liquid Fuel	0.98	1.45	1.70	7.54	8.29	11.87	14.12	16.37	17.17	17.17	17.17
Total	**24.69**	**36.83**	**54.69**	**86.89**	**91.84**	**98.96**	**101.27**	**103.79**	**104.65**	**104.71**	**104.77**
Total that pass screens	**21.71**	**29.89**	**39.58**	**57.29**	**58.06**	**58.35**	**58.41**	**58.47**	**58.53**	**58.59**	**58.65**

[8] Based on actual, estimated and claimed production volumes for 262 (75%) of the announced and operating projects in Forisk's Wood Bionergy database. Of the 89 projects not accounted for in the volume numbers, 39 are small-scale pellet facilities.

[9] Based on actual, estimated and claimed production volumes for 262 (75%) of the announced and operating projects in Forisk's Wood Bionergy database.