WEST VIRGINIA WOOD WASTE FROM UNCHARTED SOURCES: LOG LANDINGS AND ACTIVE SURFACE MINES

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Abstract.—Traditionally, biomass availability estimates from West Virginia have focused on primary and secondary mill byproducts and logging residues. Other sources of woody biomass are available that have not been surveyed. Through a series of field studies during 2010 and 2011, biomass availability estimates were developed for surface mine sites and log landings in West Virginia. Initial estimates indicated approximately 28 green tons of woody biomass were produced for each acre of surface mine cleared. Furthermore, approximately 2.1 tons of woody biomass per acre of forest harvested were found on log landings. Continued research will help to refine our understanding of biomass availability in West Virginia.

INTRODUCTION

Woody biomass availability has gained an increasing amount of attention over the last decade because of an increased desire to replace fossil-based fuels with renewable feedstocks. Most estimates of feedstock availability focus on either primary and secondary processing residues or logging residues. Several states, including Virginia (Parhizkar and Smith 2008), Tennessee (Anonymous 2007), and West Virginia (Spong et al. 2009), have developed reports detailing the availability of primary processing residues in recent years. While primary processing residues represent a significant source of unused material, increased use by wood pellet and engineered product facilities has reduced their availability. Other forms of biomass, such as logging residues, are also actively indexed. Logging residues commonly take the form of tree tops as well as cull and other felled trees remaining after harvest. In West Virginia, substantial amounts of logging residues remain after harvesting (Grushecky et al. 2006), and the relationship between market factors and location have been investigated (Grushecky et al. 2007). Two other potential sources of biomass that have not been quantified in the central Appalachians include biomass on active surface mine sites and residues remaining on log landings after timber harvesting.

West Virginia has an extensive history of coal extraction, especially in the central and southern counties. Many governmental and private groups pursue development opportunities for areas that have been surface mined. One new opportunity for these sites may be projects that produce energy from biomass. This is further warranted because of incentives based on the use of surface mine sites and biomass in the state's renewable energy plan. Because feedstock availability is often a limiting factor for the development of new energy projects, a better understanding of biomass inventories on and adjacent to surface mine sites is needed. Specifically, estimates of recoverable biomass that is produced during mine development are lacking.

During the first phase of mine development, readily marketable roundwood is removed. Following harvesting, contract crews clear the remaining woody vegetation during a second phase often referred

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to as “grubbing.” Fiber cleared during this stage is typically piled and disposed of. The cost for the secondary wood clearing is typically more than $1,000/acre.

Another source of biomass includes material remaining after traditional forest harvesting in West Virginia. Typical timber harvests consist of a centralized log landing that connects a series of skid and haul roads. Logs are often skidded to the log landing where sorting and additional processing takes place. As part of that processing, logs are cut to merchantable lengths, and areas of defect are removed. The result can be a substantial pile of cut-off chunks, unmarketable logs, and unusable branches. This material is often left behind at the end of the logging job and has potential to be utilized as woody biomass fuel, chips, mulch, and other products.

The objectives of this pilot project were to determine the amount of wood fiber that is available on surface mine sites and log landings in West Virginia. This research will help refine biomass availability estimates statewide and serve as an important component of energy-related development in West Virginia.

METHODS AND MATERIALS

Surface Mine Biomass

During 2009 and 2010, approximately 615 acres were harvested for merchantable timber on the research site in central West Virginia. A contiguous 481 acre section within the active mine development area was chosen for this project. Traditional harvesting was complete, and the mining operator was preparing the site for grubbing during the data collection period in the summer of 2010.

The area of the surface mine disturbance was mapped, and a 100 meter grid was established using a geographic information system (GIS). A negative buffer of 50 meters was used to reduce edge effects during sampling. A total of 107 one-fifth acre forest inventory plots were established in each of the grid intersections.

Both standing tree and logging residue information were collected on the site. Species and diameter at breast height (d.b.h.) of standing trees were collected on all plots. Species, d.b.h., and height to a 4-inch merchantable top were recorded on every third plot. Standard diameter tapes were used to measure d.b.h. to the nearest 0.1 inch. Merchantable height was obtained using a survey laser. To determine merchantable heights on those plots where only d.b.h. and species information was collected, a nonlinear model was used to estimate heights based on data from the 33 percent subsample.

Total tree weights were determined using the following nonlinear model that was developed from data collected by Wiant et al. (1977):

$$Green\ Weight = \beta_1 D^{\beta_2},$$

Where β_1 and β_2 are parameter estimates given by Wiant et al. (1977), and D is the diameter at breast height. Logging residue weights were estimated using the equation from Van Wagner (1968):

$$Weight = \frac{11.65\, S \sum D^2}{L},$$

Where weight is reported in tons/acre, S is the specific gravity of the logging residue, D is the diameter (in inches) of logging residue that intersects with the transect line, and L is the length (in feet) of the sampling transect line. A more thorough description of this equation can be found in Van Wagner (1968, 1982).

Log Landing Biomass

A subset of logging jobs within West Virginia were randomly selected from a database provided by the West Virginia Division of Forestry (WVDOF) containing all timber harvests that were completed during the 2010 fiscal year. WVDOF personnel familiar with the selected harvests in each county were asked to provide information that would aid in contacting landowners, avoiding landowner issues, describing relevant conditions, and ultimately finding the landings.

A total of 13 landings, primarily located in northern West Virginia, were visited for this preliminary study. A more intensive ongoing project will investigate biomass loadings at 45 landings throughout the state. Only primary landings, described as the main roadside area where timber was skidded to be merchandised and loaded on trucks to be hauled to primary markets, were included in this study. This study did not include any secondary landings that may have been located within the harvest site used for prebunching or staging activities.

Once a landing was located, each individual pile was numbered. Separate measurements were taken on each pile to characterize its volume. A total of three lengths, widths, and corresponding heights were taken for each pile using a survey laser and/or field tape. Although pile shapes were variable, volume for each pile was computed as a half-ellipsoid using the equation by Hardy (1996, 2011):

$$Volume = \frac{(\pi\,\bar{w}\,\bar{l}\,\bar{h})}{6},$$

Where volume is the pile volume, and w, l, and h are the average width, length, and height measurements recorded for each pile.

Following the collection of pile volume measurements, a transect was established using a surveyors tape along the centerline of the pile corresponding to its longest length. Sampling crews then followed the transect and recorded the starting point and ending point of each void (area where surveyors tape did not contact wood fiber) along the entire length of the pile. Likewise, for each piece that was at least 4 inches in diameter that contacted the transect line, the species, length, and small and large end diameters were recorded. Any defect that reduced the volume of a piece such as dote or hollow area was measured and recorded.

An estimate of actual wood volume as a percentage of the calculated pile volume was computed for each pile using a reduction factor based on the cumulative length of the voids as a percentage of the length of the transect line. The individual piece size data from the transects were used to calculate the total weight for the pile. The weight of each piece was calculated using piece volume (Smalians) and its associated density (species specific) (Panshin and de Zeeuw 1980). The total weight was then divided by the total volume for all pieces intersected by the transect to develop a weighted average density (green) for the landing pile. This density was then multiplied by the pile volume to determine the approximate weight.

RESULTS AND DISCUSSION

Surface Mine Biomass

Data were collected from a total of 84 plots of the 107 established plots. Information from 23 plots was not recorded because the plots were either not directly located in the surface mine permit area or were not in a harvested area.

The most commonly sampled tree was cucumbertree (*Magnolia acuminata*), followed by yellow-poplar (*Liriodendron tulipifera*), sugar maple (*Acer saccharum*), and red maple (*Acer rubrum*). For the purposes of analyses, all species were placed into one of two groups, hard-hardwoods and soft-hardwoods, based on their specific gravity. Hard-hardwoods included red maple, sugar maple, American beech (*Fagus grandifolia*), red oak (*Quercus rubra*), chestnut oak (*Quercus prinus*), white oak (*Quercus alba*), and black birch (*Betula lenta*). All other species were included in the soft-hardwood group. Average specific gravity (green) of 0.49 was used as the cutoff point.

The average diameter of all standing trees was 7.6 inches. Hard-hardwoods averaged 7.8 inches and soft-hardwoods averaged 7.5 inches at breast height. The average diameter at intersection for all species sampled on logging residue transects was 6.1 inches. Hard-hardwoods averaged 6.3 inches and soft-hardwoods averaged 5.8 inches.

Biomass availability per acre before grubbing operations took place was estimated to be 28.3 green tons/acre on this site (Table 1). This included 19.4 green tons/acre of standing trees and 8.9 green tons/acre of logging residues. The majority of this residue was in the soft-hardwood species group. When extrapolated to the entire surface mine permit area, the total amount of biomass resources available would be 17,404 green tons, or approximately 725 truckloads.

This availability reflects the expansion of the sampled surface mine during the 2010-2011 time frame. As the mine continues to operate, additional biomass resources will become available as the mine permit boundary expands. Although caution should be used when expanding this number to all active surface mines in West Virginia, a statewide estimate can be developed. As of September 30, 2010, approximately 11,255 surface mine acres were under “active, moving coal” status by the West Virginia Department of Environmental Protection (WVDEP) (see website at: http://gis.wvdep.org/data/omr.html). Using the estimates developed during this project, approximately 318,516 green tons of biomass would be available in West Virginia.

Table 1.—Total estimated biomass resources available on a surface mining site in central West Virginia

	Biomass resource (tons/acre)		
	Standing trees	Logging residues	Total
Hard-hardwood	6.7	5.1	11.8
Soft-hardwood	12.7	3.8	16.5
Total	19.4	8.9	28.3

Chunk Pile Biomass at Landings

Data collected on the 13 sites included information from both industrial and private landowners. Harvesting information gleaned from WVDOF timbering notifications and observational data on site showed a mixture of harvest types including both even-aged and uneven-aged management strategies. Other activities included a site cleared for a housing development, a site cleared for coal mining activity, one site cleared for a utility right-of-way, and two sites cleared for oil/gas well drilling activity. Reported acreage for the harvest activities ranged from 2 acres up to 180 acres. Average site size was 57 acres.

Obvious signs of firewood "harvesting," either ongoing or in the recent past, were observed on 6 of 13 sites where large chunk piles remained. At some sites this was performed by or for the landowner, but at other sites it could only be attributed to unknown individuals. Discussions with the landowner or neighbors revealed the presence of other inaccessible chunk piles that had been buried, bulldozed over hillsides, or that had been utilized by firewood and mulch harvesters. It was not possible to estimate how much additional biomass material had been present in these chunk piles, but at several larger sites, indications suggested that substantially more biomass remained at the landing than was currently visible to the site crew.

For the 19 chunk piles measured on 13 sites, pile volume ranged from a minimum of 382 ft^3 to a maximum of 23,196 ft^3, with an average size of 3250 ft^3. Computed estimates of the amount of residue in piles ranged from a minimum of 9.5 tons to a maximum of 577 tons, with an average of 72.6 tons of residue.

Total estimated residue on the thirteen sites was 1307.9 tons, from a total of 626 harvested acres combined for all the logging sites. Hard-hardwoods made up 40.5 percent (529.3 tons) of the total weight, and 59.5 percent (777.7 tons) were soft-hardwoods. Computed average residue available at the landing was 2.1 tons/acre of forest harvested. This value will change as more sites are examined.

The average small end diameter of pieces found in the chunk piles ranged from 7.5 inches for chestnut oak to 14.6 inches for red oak (Table 2). The average small end diameter for all species sampled was 10.5 inches. Average piece length ranged from 4.5 feet for blackgum (*Nyssa sylvatica*) to 13.8 feet for black cherry (*Prunus serotina*). The overall average piece length was 10.0 feet (Table 2).

Using these numbers, a statewide total for biomass availability on log landings can be estimated. In 2010, there were approximately 1950 logging sites involving 128,000 acres within West Virginia. Harvested areas ranged from 1 acre to a maximum of 1500 acres. These preliminary results suggest that even after losses due to firewood harvesting, as much as 256,000 tons of woody residue might still be present on the landings from 2010 that might be recovered and utilized. More would be available if it was recovered during logging activities or immediately after the logging job was completed.

Table 2.—Piece size distribution (±standard deviation) for roundwood sampled in landing chunk piles in West Virginia, sorted by descending volume

Species	Small end diameter (inches)	Large end diameter (inches)	Length (ft)	Volume (ft^3)
Sugar maple (*Acer saccharum*)	9.7 (--)[a]	20.6 (--)	13.5 (--)	19.1 (--)
White oak (*Quercus alba*)	11.2 (10.6)	14.6 (10.8)	12.9 (15.0)	10.1 (13.4)
Black cherry (*Prunus serotina*)	8.8 (4.1)	10.0 (4.4)	13.8 (6.4)	8.1 (8.1)
Red oak (*Quercus rubra*)	14.6 (4.8)	16.9 (5.7)	5.0 (3.0)	7.3 (5.8)
Hickory spp. (*Carya spp*.)	8.9 (1.3)	12.6 (0.8)	11.2 (10.1)	7.3 (6.6)
Yellow-poplar (*Liriodendron tulipifera*)	10.9 (3.1)	13.0 (4.0)	9.1 (8.3)	7.2 (8.2)
Red maple (*Acer rubrum*)	8.4 (4.2)	11.1 (5.0)	11.3 (8.5)	5.8 (4.9)
Chestnut oak (*Quercus prinus*)	7.5 (2.1)	9.4 (1.1)	13.5 (5.0)	5.1 (0.1)
Blackgum (*Nyssa sylvatica*)	9.0 (4.2)	11.3 (3.2)	4.5 (0.7)	2.9 (2.2)
Overall Average	10.5 (5.1)	12.9 (5.7)	10.0 (8.5)	7.3 (7.6)

[a]Single measurement

CONCLUSIONS

Significant amounts of woody biomass are generated during surface mining operations in West Virginia. Additional residual woody biomass is left behind at the landings of logging sites related to forest harvesting, property development, and other land clearing activities. Total estimated woody biomass that was potentially available in 2010 from surface mining and log landings combined was 574,000 tons. These new sources of biomass increase earlier estimates of 2.4 million green tons (Wang et al. 2006) by more than 20 percent. Many options are available to capture this waste-stream and use it in value-added opportunities. These estimates can be used to inform both mining operators and surface landowners about the potential biomass resources that become available during these operations.

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