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Abstract

There is growing interest in harvesting forest biomass to meet the needs of bioenergy and bioproducts facilities in the Northeast. This interest is accompanied by increased concern over the potential impacts of biomass removals on forest ecosystems. Debates over biomass proposals have revealed a considerable level of confusion over the term *biomass harvest*, much of which stems from ambiguity surrounding the term *forest biomass*. Indeed, all forest material removed during harvest is forest biomass, yet many view only a small portion of this—typically low-value chipped material—as biomass. Since much of this material is destined for use as energy, we feel that communication among the public, foresters, academics, and industry representatives would improve by referring to forest biomass of this nature as what it really is: *energy wood*. Once terms are clarified, it is easier to understand how concerns with market dynamics, soil productivity, water quality, and forest biodiversity can be addressed through forest policy development.

Keywords: bioenergy, bioproducts, energy wood, forest policy, timber harvesting

Growing energy demands and expectations of a return to escalating fossil fuel prices have spurred interest in a host of wood-to-energy proposals. At the national level, the Energy Independence and Security Act, passed in December 2007, mandates a fivefold increase in biofuel production over the next 15 years, with 60% (22 billion gallons/year) to be derived from cellulosic feedstocks such as trees and switchgrass. In the Northeast, interest in wood-to-energy proposals is particularly keen given the region's heavy reliance on home heating oil, abundant forests, and high population densities and associated energy demands (see, for example, Biomass Energy Resource Center 2007, Lilieholm 2007, Governor's Wood-to-Energy Task Force 2008, Benjamin et al. 2009).

Although feedstocks for new and emerging bioenergy technologies can be derived from a variety of sources (e.g., agricultural and municipal waste, algae, and logging and sawmill residues), it is likely that the proportion harvested directly from the forest will increase. Indeed, industry analysts expect global production of wood pellets for residential and commercial heating to increase 25–30% annually over the next decade (Wood Resources Quarterly 2009). Already, biomass chip harvests in Maine have increased nearly fourfold since 2000 (Maine Forest Service 2008b)—a trend that is expected to continue given plans for new and expanded capacity in the region. Given the prospects for increased bioenergy demands on Northeastern forests, ensuring an adequate wood supply is of growing concern to the region's forest products sector. These concerns arise from traditional wood processing sectors, as well as new and emerging industries such as wood pellet and bioproducts manufacturers that are considering important investments regarding mill location and expansion (Benjamin et al. 2009). Moreover, industry concerns over the adequacy of wood supplies have been joined by growing public interest regarding the long-term sustainability of biomass harvesting (Benjamin et al. 2009, Damery et al. 2009, Marciano et al. 2009). Nationwide, Perlack et al. (2005) estimated that 30% of US energy needs can be derived from renewable biomass energy sources and that 27% of that total can come from forest resources. This finding is particularly significant for the Northeast, with its average accessible forestland cover of 71%, which ranges from a low of 53% in Rhode Island to a high of 88% in Maine (Benjamin et al. 2009). Damery et al. (2009) further identify over 1.3 billion cubic meters of growing stock in New England forests composed of approximately 45% softwood and 55% hardwood species.

While increased attention over wood energy creates a host of exciting opportunities and challenges for the region and its forests, the growing debate has revealed considerable confusion regarding the terms *forest biomass* and *biomass harvest*—even among seasoned foresters and academicians. Given that energy demands on forestlands are likely to continue to grow, efforts are needed to forge a common terminology and understanding of the issues and tradeoffs likely to emerge. This report clarifies definitions of forest biomass and biomass harvesting with respect to the bioenergy and bioproducts industries, and discusses potential concerns and opportunities associated with these practices.

Terms

In the broadest sense, forest biomass can be described as the total mass of roots, stems, branches, bark, and leaves of all tree and shrub species—living and dead—found in the forest. For the bioenergy industry, forest biomass is often considered a byproduct of existing forest practices and is described as waste, which includes logging and processing residue, along with previously nonmerchantable stems due to poor form, species, or stem size. Many bioproduct technologies are still in development, so it is too early to determine what feedstock characteristics are preferred (e.g., species, size, and bark content), but a common source of raw material is likely to be the same as that for the bioenergy industry.

The perception that forest biomass is waste is misleading on two fronts. First, any woody material can be used by bioenergy and bioproduct industries. It is economics and political issues that drive those industries to use “waste” wood for biomass. Second, forest biomass has market value as a wood product and, as with most other forest products such as sawtimber or pulpwood, is more appropriately described by its primary use: *energy*. In fact, Nordic countries already use the term *energy wood* to describe woody material used in electricity generation plants (Asikainen 2004, Jylha 2004, Karha et al. 2005). In the United States, energy wood has also been used to describe forest understory biomass (Miller et al. 1987). Energy wood can be expanded to describe any woody material that is de- rived directly from the forest for electricity, firewood, pellets, and liquid fuels such as cellulosic ethanol. As such, an *energy wood harvest* is simply the extraction of wood from the forest to derive energy.

Market Dynamics

The terms *energy wood* and *energy wood harvest* should assist the public in understanding the context for this product, but a change in name does not remove all confusion or concern. An understanding of stumpage markets, processing technologies, and final products is critical to understanding the likely impact of a growing market for forest-based energy wood. During any forest operation, the distribution of various products typically follows a downward gradient in value from veneer logs to biomass chips (Maine Forest Service 2008a), but the prospect of new wood users and technologies has the potential to displace existing feedstock flows. As a result, increased demand for energy wood may affect resource flows based on the relative price that can be paid in comparison to other competing uses and the cost of production and transportation.

Cost of production is highly variable and dependent on harvest method, harvest system, terrain, stem size, stand density, and species composition. For example, it is often assumed in whole-tree operations (Figure 1) that logging residue is delivered to roadside at no cost. As a coproduct, however, energy wood bears a portion of the total harvest cost in addition to subsequent processing and transport costs. For cut-to-length operations, logging residue used for energy wood must be accumulated in a separate operation, such as the slash bundling unit shown in Figure 2. Active energy wood markets create opportunities to conduct silvicultural treatments on areas that might otherwise be uneconomical (Han et al. 2004, Kärhä et al. 2005, Eriksson 2006, Polagye et al. 2007), but this could require, or result in, changes to both harvesting methods and harvesting systems.

Environmental Impacts

A growing energy wood market could result in increased processing of logging residues; harvest of previously unmerchantable material, such as snags and small diameter stems; shorter rotations for natural stands; and, potentially, the establishment of dedicated short-rotation energy wood plantations. As a result, increased demand for energy wood has the potential to affect a host of ecosystem services, including soil productivity, water quality, and forest biodiversity. For example, a standing dead tree can remain in place for wildlife habitat, felled and placed in skid trails to reduce soil compaction and erosion, or harvested as energy wood. All values cannot be realized in each case, and tradeoffs may be necessary.

Soil Productivity

The forest science community has been researching the environmental effects of timber harvesting for decades. Although extracting any resource from the forest will inevitably remove some nutrients from the site, the level of nutrients removed during whole-tree operations are much greater than that of conventional stem-only harvests because a significantly larger portion of total biomass nutrients resides within branches and leaves (Pierce et al. 1993, Hakkila 2002). As a result, there have been longstanding concerns that intensive use of energy wood over and above conventional stem-only harvesting may result in long-term nutrient depletion (Napier 1972, Wells and Jorgensen 1979, Freedman et al. 1981, Hornbeck and Kropelin 1982, Smith et al. 1986). Many studies of soil quality specific to the Northeastern United States have been conducted related to biomass harvesting and soil quality (Young et al. 1964, 1979, 1980, Young and Carpenter 1967, Hornbeck 1986, Smith et al. 1986, Pierce et al. 1993, Briggs et al. 2000, McLaughlin and Phillips 2006, Meyer et al. 2006). Unless energy wood harvests maintain the long-term productivity of forest soils, the system could lead to unwanted declines in forest health and site productivity.

Water Quality

Water pollution and water quality in the United States is regulated by the US Environmental Protection Agency, primarily through the 1972 Clean Water Act and its reauthorization in 1993. Forestry has a silvicultural exemption from permitting, and as such all states have developed their own best management practices (BMPs) to protect water resources and water quality during harvest activities (Shepard 2006).

The major influences of forest operations on water quality are soil erosion and sedimentation, vegetation removal influencing watershed hydrology, and the management of riparian areas. According to Maine’s BMPs, water quality is most affected by roads, skid trails, landings, and drainage systems—all of which may alter the natural flow of water through a watershed (Maine Forest Service 2004). Few studies directly relate to the impact of energy wood harvesting on water quality. This may in part be because energy wood in the Northeastern United States is often harvested in conjunction with other roundwood forest products. As Shepard (2006) indicates, existing BMPs to protect water quality for conventional operations should be applicable to “bioenergy systems,” even if such systems involve increased use of fertilizers and/or shorter rotations.

Forest Biodiversity

One of the greatest concerns among researchers is that by creating a market for currently unmarketable trees, energy wood removals and intensive management will have a negative impact on species habitat, thereby further reducing diversity. Forest biodiversity research from the last 20 years provides the foundation on which to investigate effects of energy wood harvests with respect to harvesting impacts on coarse woody debris and snags (Duvall and Grigal 1999, Fraver et al. 2002), importance and benefits of coarse woody debris to saproxylic and nonsaproxylic species (Harmon et al. 1986, Hunter 1990, Hagan and Grove 1999, Hammond et al. 2004), postharvest stand condition (Hunter 1990, Flatebo et al. 1999, Elliot 2008), selection of appropriate biological indicators (Hagan and Boone 1997, Hagan and Grove 1999, Hagan and Whitman 2006, 2007), and the influence of plantations and conventional forest management on biodiversity (Angelstam et al. 2002, Jonsell 2007, Stephens and Wagner 2007). The biodiversity impacts of energy wood harvests will be largely determined by the extent to which these concerns are realized.

Conclusion

Under current market conditions, feedstock derived directly from the forest for bioenergy and bioproducts industries in the Northeast will be composed primarily of logging residue and other traditionally nonmerchantable stems. Although that material falls under the broad definition of forest biomass, the focus, and hence the definition, should be on end use—i.e., energy. It is important to note, however, that energy wood can be derived from any woody material—even material typically reserved for higher value products such as pulpwood, sawtimber, and veneer logs. Energy wood harvests in the Northeast are also typically integrated with traditional forest operations, which makes it difficult to differentiate site-level impacts directly attributable to the energy wood harvest component. Therefore, the development of new regulations, BMPs, or guidelines to address energy wood harvests should focus on postharvest conditions as opposed to specific harvest levels or products.

The Northeast's existing framework of guidelines and regulations regarding timber harvest activities already addresses many of the environmental impacts described above (Cubbage and Newman 2006), but increased use of logging residue and other nonmerchantable stems does raise legitimate environmental concerns. These issues may be more prominent in areas with emerging bioenergy industries, but all areas are well served to review current practices and policies with respect to energy wood harvests—even states such as Maine and Vermont, where there has been an active energy wood market since the 1980s. As such, energy wood harvesting can be considered a *special-needs* operation, especially if the feedstock is composed of material with competing value to soil productivity, water quality, and forest biodiversity. Indeed, those environmental issues are overarching concerns that span all aspects of forest operations and must therefore be addressed and monitored at both the landscape and site levels.

Finally, foresters should embrace the public's growing interest in renewable energy to identify opportunities to improve perceptions of forestry in general and the bioenergy and bioproducts industries in particular. It is only through public acceptance of forestry that rising markets for energy wood can be fully harnessed to improve forest conditions while fostering the transition to a sustainable and renewable energy future.

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Figure 1. Roadside landing site for whole-tree harvest operation with an integrated energy wood component composed of logging residue piles set aside from tree-length merchantable logs. (Photo courtesy of Spencer Meyer, Cooperative Forestry Research Unit.)

Figure 2. An example of specially designed logging equipment for logging residue accumulation. The John Deere 1490D Slash Bundler collects and compresses logging residues on-site to produce composite residue bundles that can be transported to the roadside with conventional forwarders.