Economics of forest biomass removal for bioenergy

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Summary. Removing low-value woody biomass from forest presents a difficult economic problem because of low economic value of biomass and its high volume. In many locations, woody biomass costs more to remove from the woods than it can be sold for. The cost of removing biomass is driven by so many site and operations variable that it is difficult to provide general estimates. For example forest type, density, age, slope, elevation, and stand size all affect the costs of harvesting biomass. Similarly the silvicultural prescription, type of harvesting machined used, products extracted, and distance to utilization all affect the efficiency and costs of biomass removal operations. New harvesting and transport systems designed for low-value material offer hope that the cost of biomass removal will become most efficient in the future. In addition, the forestry community is gaining needed experience with the removal of woody biomass from forests to meet increased bioenergy needs.

Keywords. *Wood Prices; Treatment Costs; Mechanization; Haul Distance*

Introduction

Woody biomass has long been a useful but underutilized byproduct of forest management activities. Now rising energy costs, concerns about carbon emissions from fossil fuels, and the threat of catastrophic wildfires have greatly increased interest in using woody biomass from forests. Even with all the interest in using woody biomass, getting it from the forest to the consumer presents economic challenges. In most cases, harvesting and transporting woody biomass is relatively costly because smaller stems have low value by volume and high handling costs, and most forest harvesting systems were originally designed for larger-diameter timber.

This paper presents a review of the existing literature on the costs of removing woody biomass from the forest, with an emphasis on case where the end use is bioenergy. In addition, examples are drawn from case studies of biomass removal projects around the county. The case studies were collected as part of the report *Synthesis of Knowledge from Woody Biomass Removal Case Studies* (Evans 2008) and are available on the website: http://biomass.forestguild.org.

Although some biomass removal projects are able to generate a profit or at least break even, many projects are subsidized. There are regional and forest type differences in the profitability of biomass removal. In addition contractors, mechanization, utilization markets, haul distances, and the mix of removed products all affect profitability.

Costs

Removing woody biomass can generate a profit or cost thousands of dollars per acre. In general there are better data on project costs than project profits. In case study project, the median cost for projects that did not generate income was $625 per acre (Evans 2008). Estimates for the cost of bringing woody biomass

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to the roadside in the western US ranged from $400 to $1,630 per acre depending on forest type and terrain. The median cost from this study was $680 for gentle slopes (USFS 2005). Costs for biomass removal in Colorado ranged from as low as $100 per acre where fuels could be left on site to $1,100 per acre where markets for biomass were weak (Lynch and Mackes 2003). Projects that face unusual constraints incur costs on the higher end of the spectrum. For example, a thinning project near Los Alamos National Laboratory in New Mexico cost $6,000 per acre to chip and removed 80 to 120 green tons per acre, in part because of the potential for radioactivity in the chipped material (Bill Armstrong, personal communication).

It is important to note that it is difficult to extract general biomass removal costs from the literature because there are critical gaps in the data and differing methods for predicting treatment costs. One of the central data gaps with estimating the cost of biomass removal is the use of machine rates for production and cost. Basic machine rates can exclude tax considerations, overhead costs, and risk (Rummer 2008). Similarly, broad estimates for repair and maintenance costs can be quite different from actual costs incurred at the project level. Because there is no standard methodology for estimating costs or even for drawing the boundaries of analysis it is difficult to compare between published studies. For example, studies differ in their treatment of indirect costs, fixed costs such as planning, profit, risk and overhead (Rummer 2008).

Site Variables that Influence Cost

A large part of the uncertainty about biomass removal costs comes from the specifics of each stand. The prescription, forest type, density, age, slope, and other site factors play a strong role in determining treatment costs (Lynch and Mackes 2003, USFS 2004, 2005). For example a study of mechanical fuel treatment costs identified the following factors that affect costs (USFS 2004):

- Size of area to be treated
- Fire regime
- Elevation
- Fuel load
- Management objectives
- Whether site is in wildland-urban interface (WUI)
- Forest Service Region

A study of costs in western forests shows that on average treatments on rolling terrain cost $170 more per acre to implement than those on gentle terrain (USFS 2005).

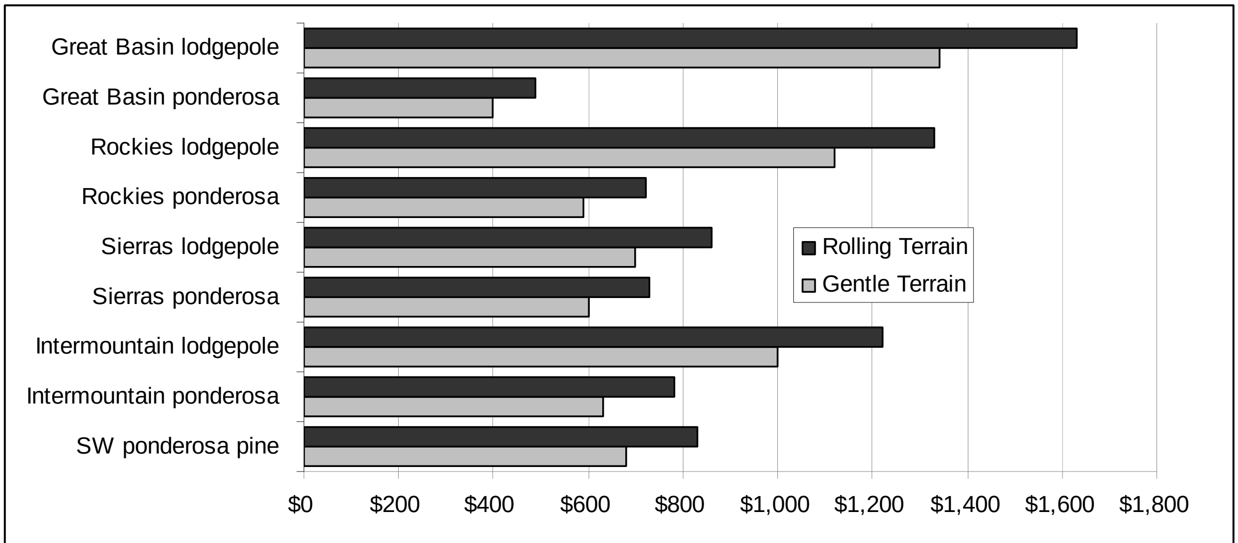

Figure 1 Data from USFS 2005

Woody Biomass Prices

Prices for low grade wood products vary greatly over time and across the country. The case studies demonstrate a range from $0.10 to $40 per ton for chips (Evans 2008). Nationally the prices per million BTUs for wood ranged from $1.40 in Florida to nearly $9 in Alaska during 2005 (Energy Information Administration 2007).

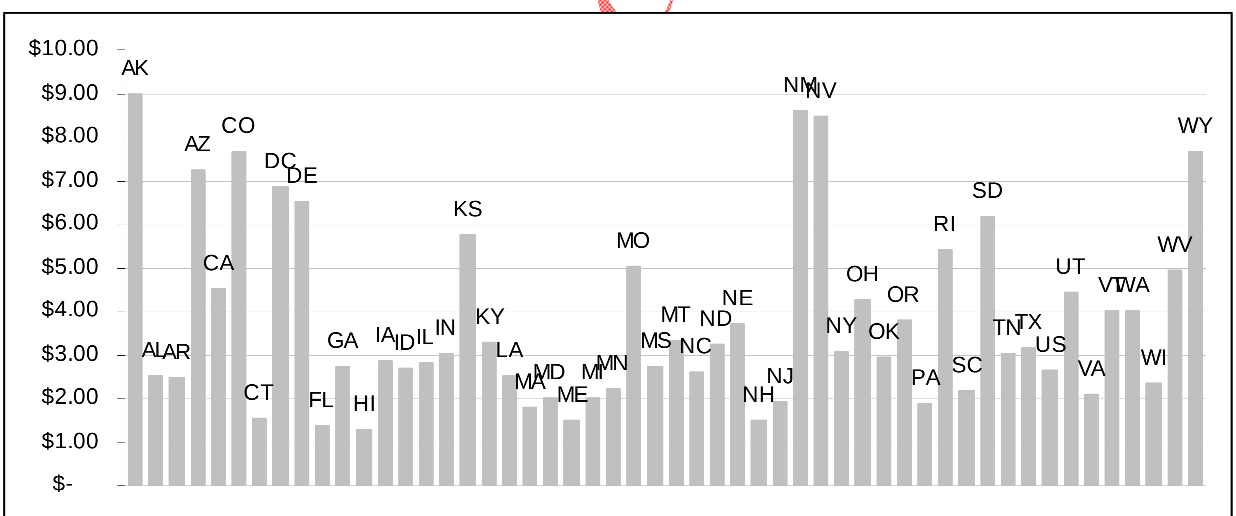

Figure 2 Data from the Energy Information Administration

Over time the average price for wood for bioenergy per million BTUs has increased from $1.27 to $3.75 in nominal terms (Energy Information Administration 2007).

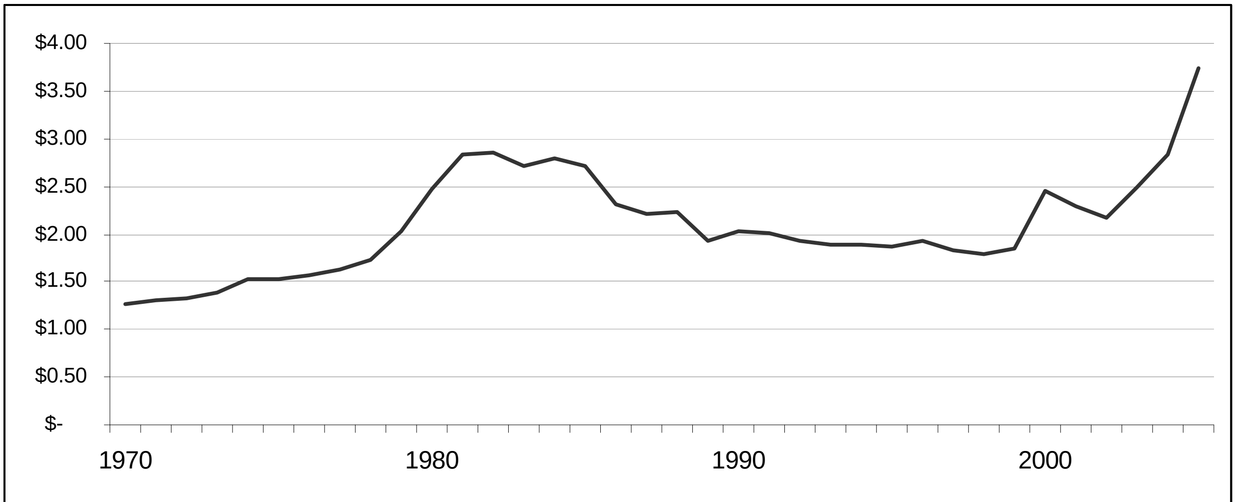

Figure 3 Data from the Energy Information Administration

In comparing prices it is important to identify the product specifically as hog fuel (dirty chips) are not a substitute for clean chips. Some prices and costs are obscured by separating treatment costs from product sales revenue. For example, on a BLM Klamath Falls Resource Area project in Oregon, the nominal per-acre cost was $345, but the sale of chips generated approximately $64 per acre (Evans 2008).

Another element in the pricing of biomass removal is the cost of not removing biomass. For some fuels reduction projects, lower firefighting costs may be an appropriate comparison. One study calculated the avoided future cost of fire suppression to be between $238 and $601 per acre in the Southwest (Snider et al. 2006). The value of avoided fire suppression is just one of a number of potential non-monetary co-benefits from biomass. Other co-benefits include reduction of smoke emissions, reduction or offsets of carbon emissions, creation of local jobs and industry expansion, and habitat improvement. A report from the National Renewable Energy Laboratory estimated that biomass power plants created 4.9 full-time jobs for each megawatt of generating capacity (Morris 1999). Where biomass removal is linked to forest-stand improvement, co-benefits include the future growth of crop trees, regeneration harvests, natural regeneration, and avoided costs of planting.

Combining Multiple Forest Products in Biomass Removal Projects

In many cases biomass is removed at the same time as more valuable forest products such as sawtimber. For example, a technical release from the Forest Resource Association supports this idea: “Income from this type of biomass volume alone is not enough to sustain a logging operation. Biomass is a low-value product or by-product that can add to the bottom line for loggers and increase utilization and return for landowners” (FRA 2007b). By combining biomass harvests with the removal of higher value products the fixed costs of the harvest such as planning and sale administration can be spread over all products. In fire-adapted forests, “the ability to separate and market larger-diameter logs for higher-value products is critical to the net revenues or costs of fuel treatments” (USFS 2005). The combination of low-grade material and high value material is important in fuel reduction treatments because across the Western U.S. over the next five years more than half of the volume removed is likely to be sawtimber (Barbour et al. 2008).

While combining multiple products can help make biomass projects successful, dividing the harvesting and handling of those products may also increase efficiency. Involving more than one contractor to take advantage of each contractor's expertise can help make biomass removal efficient (Evans 2008). The machines, planning, and implementation of biomass removals can be sufficiently different from traditional timber harvest that the biomass portion of a harvest should be left to contractors who specialize in such operations. In addition, it may be more efficient to schedule biomass and timber removal at different times (FRA 2007a).

Markets

Markets for biomass can determine whether or not it is removed from the woods at all (Bowe and Bumgardner 2006). Managers must be aware of existing markets, how markets and prices change over time, emerging markets, and product requirements. Biomass markets fluctuate, so timing sales can be important (Lynch et al. 2000).

The market for wood bioenergy has increased dramatically with 65 new major wood energy projects across North America in 2008 alone (RISI Inc 2008).The U.S. as a nation and individual states have set goals to increase the use of renewable energy, which leads to an increased use of woody biomass (DOE 2006, PA DCNR 2008). Using wood for heat and power is attractive because it is renewable, can reduce carbon and other emissions, is less expensive than fossil fuels in some cases, and can be produced domestically as a substitute for imported fossil fuels. However the market for wood energy is by no means certain. Some wood energy projects have realized their potential to provide a market for low-grade wood, while others have not materialized. One of the key factors to encourage new markets as well as to ensure the survival of existing markets is consistent supply (GAO 2006).

As biomass markets grow and mature competition for biomass from forests may affect prices. In Vermont, for example, biomass prices have been relatively stable until recently, but high diesel prices have increased demand for low-grade wood. Part of the increase in demand comes from the 27 schools that have converted to woodchip heating over the last 20 years. An analysis of expanded biomass removal in the Western U.S. shows large potential market impacts, but impacts vary by silvicultural practice (i.e., thinning from below or thinning based on stand density index) (Ince et al. 2008).

In addition to demand effects on biomass pricing, oil prices have a dual effect on low-grade wood prices. On one hand, price increases in oil products such as heating oil and diesel is an incentive to switch to lower-cost wood heating or power generation. On the other hand, increases in diesel prices add to the cost of cutting, hauling, and processing woody biomass. The net effect of rising oil prices remains unclear.

All markets have product requirements, and managers should be aware of the specifications of each potential buyer. For example, heating and electrical facilities may require a high-grade, clean fuel from sawmill residue or be willing to accept a low-quality hog fuel from miscellaneous woody material (BERC 2006). The price of biomass is directly tied to product specifications. In Minnesota, for instance, bundled biomass has a lower price than an equivalent amount of loose material (Arnosti et al. 2008).

Haul Distances

While a short-haul distance from forest to utilization lowers project costs, but long-haul distances do not necessarily doom a project to failure (Evans 2008). Of course, as diesel costs rise, the shorter the haul distance the better for project profitability. A 2008 Minnesota analysis recommends a maximum haul distance of 100 miles (Arnosti et al. 2008). A study in West Virginia found the average haul distance for low-grade wood was 123 miles and the distance to market did not effect the amount of biomass left on site (Grushecky et al. 2007). However, in southwestern Wisconsin long distances to markets meant biomass was left in the woods (Bowe and Bumgardner 2006). An analysis of Western forests used a price of $30 per dry ton delivered to the mill for chips and chip transport costs of $0.35 per dry-ton-mile to estimate a maximum of 86 miles to break even on hauling cost, exclusive of treatment costs (USFS 2005). A national estimate of hauling costs identified a range of $0.2 to $0.60 per dry-ton-mile (Perlack et al. 2005). Opportunities to minimize hauling costs such as roll-on containers and low-cost back-hauls may also be available (Livingston 2008).

Mechanization

The effects of mechanized harvesting that employing feller-bunchers, forwarders, and other large equipment vary with forest type, site factors, and the specifics of the mechanization. In some cases more mechanized harvesting operations are more efficient, but mechanization is no guarantee of profitability. When harvesting machines are not well suited for small-diameter trees, the cost of mechanized felling is inversely proportional to tree size. For example, a study comparing harvesting costs in a lodgepole pine stand showed a harvester to be $4 per ton more expensive to operate than manual felling (Rummer and Klepac 2002). The same study points out that labor costs are likely to be the largest cost component, so assumptions about and changes in wages are central to overall cost estimates. Another consideration is health and safety of forest workers, which is usually improved by mechanization (NIOSH 2005).

Mechanization must be matched to the stand and well integrated into the rest of the harvesting operation. For example, a full-sized chipper may require significant harvesting capacity, such as multiple cut-to-length teams, to avoid idle time (Bolding and Lanford 2005). Decision support tools that help operators adjust the degree and type of mechanization to the distribution and type of material to be harvested can increase efficiency (e.g., the harvest cost-revenue estimator for the Southwest (Becker et al. 2008) or *My Fuel Treatment Planner* (USFS 2004)).

New forest harvesting technologies that are designed specifically for biomass removal may reduce the costs of cutting and processing small-diameter material. For example, densification of biomass from forests through bundling systems (Arnosti et al. 2008). Other publications have focused entirely on harvesting technologies (Windell and Bradshaw 2000, RE Consulting and Innovative Natural Resource Solutions LLC 2007).

Conclusions

Removing woody biomass from forests in an efficient and economic way may be the biggest forest management challenge of the next decade. The industry needs new equipment that is designate for a product that is high-volume, low-value, and has a small average size. More research is needed to better understand how the costs of biomass removal vary across the country and across forests. Research is also

needed to more fully explore the impact of biomass removals on wildlife habitat, soil nutrients, and long term soil productivity.

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