

Stump Harvesting

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Abstract

Increased use of forest fuel requires larger and larger procurement areas. Inclusion of stump material within the shorter distances could make this unusual source of biomass more economical to harvest. Land clearing activities are also helping to raise interest in stump harvesting. Processing stump material for biomass is an alternative to other, more costly, woody waste disposal alternatives. This paper reviews some of the existing research regarding harvesting equipment and systems, feedstock quality, and identifies environmental considerations related to the practice of stump harvesting.

Introduction

Stumps are a source of woody biomass, but stump harvesting is not a common practice in the United States. Stumps are often lifted, or pushed over, in land clearing operations prior to new residential or commercial construction. The cost associated with pushing up stumps, piling stumps and debris, and burning is often regarded as normal pre-construction activity. However, due to burning restrictions, some construction contractors are forced to find alternative means for removing stumps from work sites. Some are sub-contracting to logging contractors for stump removal services. In addition to receiving service contract payments for removals, the logging contractors may also comminute and sell the biomass that is produced.

Stump and root mass harvesting may seem like a very strange and costly way to obtain biomass. Transportation costs would be high because the odd-shaped pieces, with main root masses attached, would not compact well. Some type of comminution in the woods is needed to reduce the size of the pieces, thus increasing payloads for transport. Splitting may help in breaking the material up to facilitate larger payloads for in-woods transport.

Different comminution equipment may be needed based on the physical characteristics of the root masses. Oversized root masses may be too large to fit into the throat of a horizontal grinder without pre-processing. Disc chippers would be difficult to use because most do not have a horizontal conveyor in-feed. Tub grinders have historically been used to process stumps. Some stump harvesting systems may require stump splitting as a pre-processing step prior to comminution with a traditional grinder or horizontal-feed chipper.

The delivered value of the biomass material from stumps must be high enough to pay for the cost of processing and transport. In addition, the comminuted material may have high levels of contaminants such as soil and rocks. The feedstock quality can impact the delivered price and it can also limit the biomass delivery locations to those purchasers who can accept some impurities in their handling systems and conversion processes. This review of stump harvesting examines the harvesting systems and equipment, feedstock quality, and identifies environmental considerations related to the practice of stump harvesting.

Harvesting Systems and Equipment

Stump harvesting in Scandinavia is becoming more common. Their studies into stump harvesting occurred in the 1970s and 1980s as a way to increase the amount of raw material for the pulp industry. Their research has been renewed with the recent interest in bioenergy. Because increased use of forest fuel requires larger and larger procurement areas, the inclusion of stump material within shorter distances could make this resource more economical to harvest.

Stump harvesting is usually restricted to final harvests in Scandinavian countries. Hakkila and Aarniala (2003) report that fuel yield from stumps can be as high as the yield from above-ground residues. It is not typically implemented in thinnings because of the risk of damaging the remaining trees in the stands.

Excavators are the typical equipment used for extracting stumps and root masses (Hakkila and Aarniala, 2003; Vickery, 2008; and Henningsson, 2008). A boom-mounted attachment is used to lift, then shear (or split) stumps into smaller pieces. Some operations use the attachment to pull soil back into the hole in preparation for planting. Some boom attachments are manufactured with a separate metal piece welded to the outside to aid in filling and smoothing the soil back into the stump hole.



Figure 1. Stump lifting and splitting attachment

Many of the stump harvesting production references are for spruce, pine and birch in Scandinavian countries. For stump lifting after a regeneration harvest, lifting time increases as stump diameter increases (Henningsson, 2008). Also, stump volume has a positive relationship with stump diameter (Palander, 2009). On the other hand, stump diameter has an inverse relationship with stump processing time (Laitila, 2008). These relationships are not as well documented in the United States. The relationships between stump processing times and the impacts of soil types on processing times are not known for many tree species and soil type combinations in the United States. However, a late 1970s era publication (Sirois, 1977) tested a machine that was commercially available at the time, a Rome THX Tree Extractor. With this machine, researchers were able to shear the lateral roots of trees, and then extract the stumps with an upward pulling action. In testing common hardwood species of the southern United States (sweet gum (*Liquidambar styraciflua* L.), hickory (*Carya* spp.) southern red oak (*Quercus falcata* Michx), and white oak (*Quercus alba* L.)), researchers determined that the amount of biomass available in the stump and in the main root mass was about 18% of the total above-ground biomass available in each stem. Stems of up to 9 inches in dbh could be extracted fairly easily, and red oaks were easier to extract than the other species. Trees were pulled from two different soil types, but the significant variable for predicting the shearing and extraction forces of the forest operation was dbh. Lateral root depth, coupled with the limited 10-inch shear depth, impacted the ability to extract some stems by this machine. In general, the lateral root depths of pine aren't as deep as the hardwoods tested in this study.

Smaller stump sizes in younger material may not be economical to harvest. In the United States, non-industrial forest lands that are being converted to other uses are another opportunity to harvest biomass from stump material. This biomass can be in the form of large stumps, but can also be found in standing younger trees. When stumps are harvested from these younger stands, loggers have used a whole-tree pulling method rather than stump lifting. This requires a different type of excavator attachment. A logger in Georgia is using a demolition grapple for this purpose. The excavator grips single trees or multiple trees and pulls them out with the main root mass attached.



Figure 2. Demolition grapple attachment

Operator protection for worker safety is a concern when using excavators in forest operations. Previous research by Rummer et al (2003) analyzed the rollover performance and thrown object performance of hydraulic excavators and recommended improved standards to the International Organization for Standardization (ISO). The current standard for self-propelled machinery for forestry roll-over protective structures (ISO 8082: 2003) does not apply to machines having a rotating platform with a cab and boom on the platform.



Figure 3. Whole tree harvesting with stumps attached

A fledgling stump harvesting system in Finland is comprised of an excavator for extraction, off-road transport by forwarders, and special large-volume trucks for transport to mobile or stationary comminution equipment (Hakkila and Aarniala, 2003).

Forwarders are not as common in the United States as they are in Europe. In ground-based harvesting systems, in-woods transport is typically accomplished by skidding. Skidding stumps and split stumps is probably not the most

effective way to move the stump material to the logging ramp. Off-road transport would need additional research to determine the best methods to be implemented in various regions of the United States.

Two different stump harvesting systems have been observed in two locations in the southeastern United States. In a land clearing operation in Alabama, stumps were lifted and split using an excavator with a stump lifting and shearing attachment. No attempt was made to fill in the holes. The split material was loaded onto off-road dump trucks to transport the material to a horizontal grinder located in a log processing area of the land clearing. A trailer-mounted loader was used

to feed the material into a horizontal grinder. There wasn't a planned time lag to allow for transpirational drying of the biomass material.

In another land clearing operation in Georgia, pushed-over stump material and logging debris from a recent clearcut was pushed into large piles with a brush blade mounted on a dozer. A large horizontal grinder was moved to each debris pile where a trailer-mounted loader was used to feed the grinder. Because of the large pile size, a wheeled log loader was also used to move portions of the pile closer to the trailer-mounted loader, as needed.

Feedstock Quality

The typical Finnish consumers of stump biomass material are power plants that utilize fluidized bed boiler technology (Laitila, 2008). Although fluidized bed systems can accept a broad range of biomass specifications, there could be benefits from improving feedstock quality through harvesting methods. Several of the previously described harvesting systems recommend shaking the pieces of stumps before piling them in the harvesting area (Palander et al, 2009; AEBIOM, 2007) to release soil and stones from the biomass. This action should help decrease the ash content of the biomass.

In Scandinavian countries, piles of split stumps are left in the harvesting area to dry before being transported to roadside, and to allow rain to wash soil off of the roots. Once at roadside, they are again piled for further drying and storage until needed (AEBIOM, 2007). Sometimes, these piles are covered. This multi-stage process is believed to increase the feedstock quality by reducing both the amount of impurities and the moisture content in the biomass material.

In Finland, stumps are left to mature in the ground before being lifted (Laitila et al, 2008). During this maturation time, the cohesion between the roots and soil decreases. As larger roots start to dry, shrink and decay, the forces required to lift the stumps decrease. The result of this maturation time could be a reduction of soil in the biomass.

Blending at a delivery location is another way to improve the feedstock quality when using stumps for biomass. By blending the stump biomass with other biomass deliveries, a more homogenous and standardized product can be created.

Environmental Considerations

In Sweden, 30 years of study indicate that stump harvesting does not negatively impact the growth of the next stand. Egnell et al (2007) suggest that stump forwarding should follow the same path as used in the round timber extraction to limit soil impacts. Soil disturbance associated with stump lifting can be exacerbated with clay soils. In clay soils, larger amounts of soil loss can occur because it remains more firmly attached to roots. In the United Kingdom, the stumps are stored over winter to help the site retain soil through the action of rainfall and freeze-thaw (Forest Research, 2009). Apart from the obvious initial concerns regarding soil disturbance, there are other environmental considerations related to stump harvesting.

A benefit of stump harvesting is that it can reduce the spread of some root fungi. For example, some western United States species of conifers are susceptible to annosus root disease (Dekker-Robertson et al, no date). The disease causes crown yellowing and thinning, and decayed wood. When the roots of a healthy tree come in contact with diseased roots, the infection spreads. Annosus can live for decades in large stumps. One recommended way to control the spread of the disease is through stump extraction. Healthy stumps are also recommended for removal to provide a buffer around the infected area.

Carbon sequestration is another concern that arises with stump harvesting. Soil contains more carbon than the above-ground parts of the forest (Forest Research, 2009). Stump extraction can involve extensive, localized, soil disturbance that can increase decomposition rates and related carbon release from the soil. The impact of stump removal on carbon loss may be directly related to the proportion of soil organic matter found in different soil types. Egnell et al (2007) state that although a substantial amount of carbon is removed with logging residues and stump harvesting, it is minor over a 60-90 year rotation period. Revegetation may promote carbon sequestration that can help mitigate the negative effects on soil carbon loss. But, on land clearing sites where the land use is changing, the carbon impact may not be mitigated by revegetation. Research is needed to determine the relationship between carbon loss and soil types found in the United States to better understand the environmental impacts of stump removal.

Nutrient cycling is often cited as a concern from the removal of logging debris. This concern may also extend to stump harvesting in the United States. The mitigation of stump removal impacts on soil nutrients is addressed in a Finnish publication (Paananen and Kalliola, 2003). In stump extraction, the area of soil disturbance is limited as much as possible around each stump. After each extraction, the organic layer is covered with mineral soil to limit the release of nutrients and heavy metals. In addition, about ¼ of stumps and the greater part of all roots are left in the soil to benefit soil organisms.

The removal of stumps may have an impact on biodiversity. Stumps can provide a structural shelter or an environment for insects, mosses and lichens. Research is needed to determine the impact of stump removal on a variety of forest resources, and to develop guidelines on how to mitigate negative environmental impacts of stump removal.

Summary

There are a variety of studies available regarding stump harvesting. Most of the recently documented studies are in Scandinavia and Europe. Equipment is currently available in the United States to accomplish many of the harvest system functions. Additional research is needed to determine the impact of tree species, tree ages, soil types and other variables on feedstock quality, production rates, and costs of stump harvesting in the United States. Information on the environmental impacts of stump harvesting on a variety of forest resources is also needed.

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