Life Cycle Analysis of the Logistics in Forest Residual Removal for Potential Bioenergy Production

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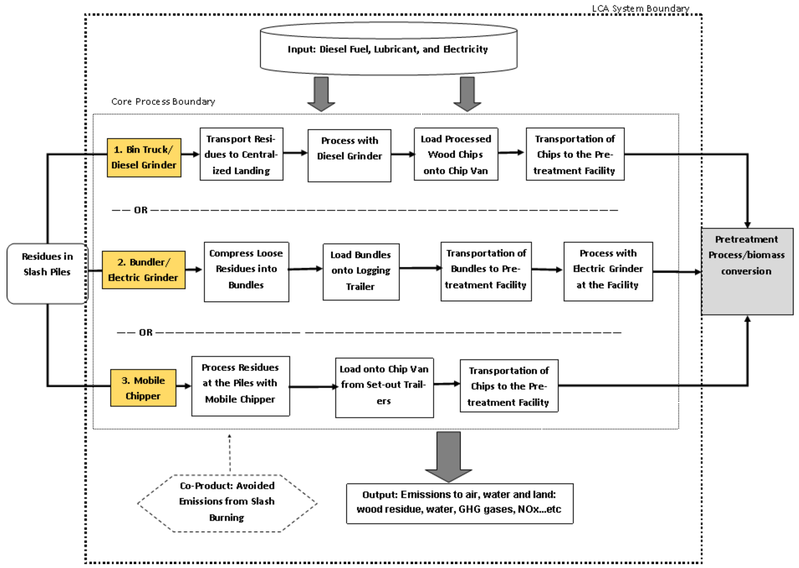
Background

The residual woody biomass (a.k.a harvest slash) produced during forest harvest operations in the Pacific Northwest, is generally burned in the forest or left on the forest floor to decompose. Drop-in biofuel production from these residual cellulosic feedstock can provide an alternative to utilizing this unused resource and simultaneously displace fossil based fuels. However, it is crucial to understand the impacts of each individual process during energy production (i.e. collection, transport, processing, pretreatment, etc.) to access the benefit of replacing fossil fuel with such alternative energy.

In this paper, we modeled the environmental impacts of several residue collection and transportation systems in the Pacific Northwest region using a life cycle assessment approach. The distance of dirt road was set constant at 1 mile, and the rest of the distance was distributed between gravel road and paved highway. The distributions of the distances changed on a 10% increment for both road types until the percentage of paved highway reached 45% and the percentage of gravel road reached 55%. Depending on the conditions of study sites, the loading and unloading time of residues was calculated and used as the idle time for the vehicles.

System Boundary



Goal

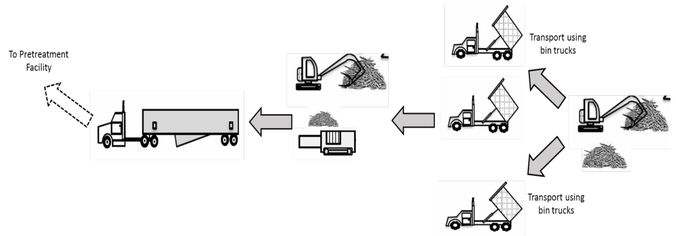
The primary goals of this paper are:

a) to provide information on the potential environmental impacts of forest residue-based energy generation during various collection and transportation process scenarios, and
b) accessing the effects of different road conditions and distances and their role in residue transportation to better understand the appropriate processing system for various site conditions, and for more efficient site selections of slash piles and bioenergy facilities

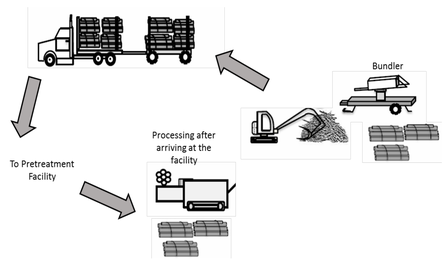
System Scenario Description

This study analyzes three collection and transportation scenarios of forest residue removal. The total distance from the forest site to the pretreatment facility is 50 miles:

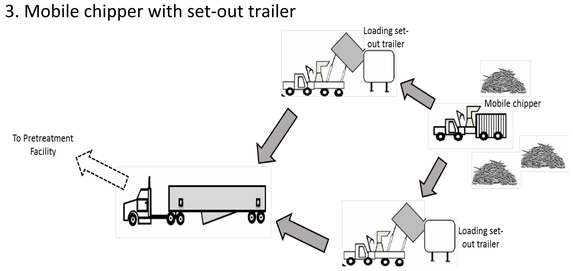
System 1. Bin truck with stationary grinder at centralized landing



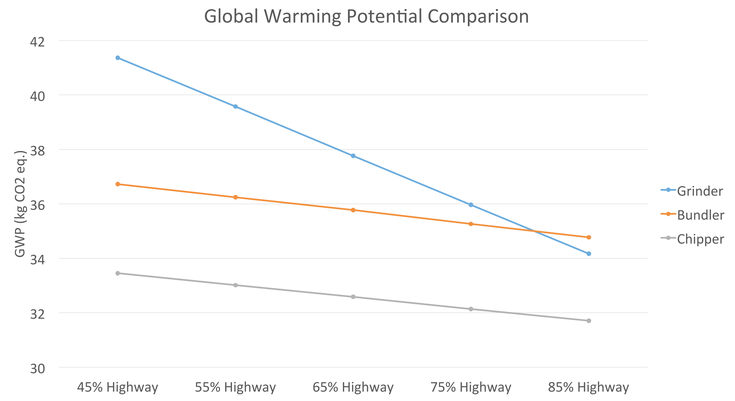
System 2. Bundled at the site without grinding (processed with electric grinder at facility)



System 3. Mobile chipper with set-out trailer



Impact Assessment



Assumptions

Some assumptions were made during the analysis:

- Since fuel consumptions are different depending on the load the vehicles carry, the average fuel consumptions for when the vehicles were loaded and empty were used in the analysis. The time required for loading/unloading and turn-around was assumed to be 0.2 hours for bin trucks, 1.23 hours for chip van and 0.7 hours for logging trailer.
- The wood species were not differentiated in this study. The slash piles were assumed to be mixtures of softwood and hardwood residues. Slash pile could contain a certain amount of soil content, which may contribute to the total mass of residues evaluated in this study.
- Equipment used in the systems were assumed to be in good shape and any impact of part replacement or repair was not considered. The capital costs and impacts of equipment production were not accounted for.

Conclusions

- For all the three Systems, as the distance travelled on gravel road by both the chip van and the bin truck increased, the transportation stages contributed more to the overall emissions produced and global warming potential.
- The similar rate of decline for Systems 2 and 3 were surprisingly similar, although the impacts discussed in this paper for System 3 are lower than those of System 2 overall.
- Since Systems 2 and 3 only required a single stage of transportation instead of 2-stage transportation as in System 1, the overall emission produced from transportation was reduced to lower rates.
- Despite some limitations, the study provided a framework for estimating the transportation logistics of woody biomass removal, which served as a reference for the establishment of bioenergy facilities in the Pacific Northwest region.
- The results suggested that, depending on the locations and characteristics of the forest sites, different system should be applied. For example, for sites with easier accessibility, the most common system, System 1, can be used. For those slash piles located deeper in the forests, Systems 2 and 3 should be considered since they vary less with road conditions and distance.

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NARA is led by Washington State University and supported by the Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30416 from the USDA National Institute of Food and Agriculture.

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