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BIOMASS & BIOENERGY

Economic evaluation of a roll-off trucking system removing forest biomass resulting from shaded fuelbreak treatments

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ARTICLE INFO

Article history:
Received 21 August 2008
Received in revised form
3 February 2010
Accepted 19 February 2010
Available online 21 March 2010

Keywords:
Harvesting and transportation
Slash removal
Wildland fires
Hog fuel grinding

ABSTRACT

Shaded fuelbreak treatments involve removal of understory brush and small-diameter trees to reduce fire hazards by disconnecting the continuity of fuels. As a result of these treatments, woody biomass (referred to as slash) is piled throughout the treated stand and later burned. Mechanical removal of slash has not been successfully implemented in many areas due to limited accessibility to sites and the high costs associated with collection and transportation of slash. To address these issues, a roll-off truck paired with a small skid-steer loader was used to collect and transport slash to a centralized processing site where slash was ground as hog fuel for energy production. ''Roll-off truck'' refers to a straight frame truck configuration in which a 30.6-m^3 container is rolled onto and off the straight frame truck by means of a truck-mounted winch system. This study was designed to quantify the operational performance and costs of removing slash piles using a roll-off trucking system in mountainous conditions in northern California. The overall cost to collect and haul hand-piled slash was $26.81/tonne with 22% average moisture content or $34.37/bone dry metric ton. The roll-off trucking system should be used primarily for short hauling distances since trucking costs significantly increase with small increases in hauling distance due to slow traveling speeds and low slash weight being hauled. Financial analysis indicated that contractors can receive high rates of return on their invested capital after accounting for inflation and income taxes, but limited work opportunities are a concern for them.

1. Introduction

A fuelbreak is a strategically located wide block, or strip, on which a cover of dense, heavy, or flammable vegetation has been changed to one of lower fuel volume or reduced flammability [4]. Shaded fuelbreaks are often created by altering surface fuels, increasing the height to the base of live crowns, and opening the canopy by removing trees [1]. This practice has been commonly implemented on National Forests in northern California to break up the continuity of fuels, improve firefighter safety, and confine wildfires to one watershed area. In mixed conifer vegetation types, a high level of crown closure (typically around 60%) is recommended in order to reduce re-growth of brush and small trees after the treatments. Chainsaws are often used to fell brush and small trees (<20.32 cm in diameter at breast height) and cut them into small pieces for hand-piling. Piles of woody biomass (called ''slash'' hereafter) are placed throughout the treated

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0961-9534/$ – see front matter
doi:10.1016/j.biombioe.2010.02.009

stand, with adequate spacing to reduce residual stand damage from pile burning. These piles are subsequently consumed by burning when weather conditions and the slash moisture content are within specified prescriptions.

Burning slash piles is a commonly used fuel treatment practice, but it is associated with several concerns including smoke production, residual tree mortality, and the risk of fire escape. These concerns limit the number of burning days, which often delays the completion of the fuel treatment and subsequent forest management activities. Furthermore it can cost $370–$2100/ha to implement, depending on the amount of fuel and the characteristics (species, size, and arrangement) of slash piles to be burned (Curran, 2008; personal communication, USDA Forest Service, California).

As an alternative to pile burning, mechanical removal of slash piles has been considered to avoid the negative effects and constraints associated with slash burning. At the same time it can also create opportunities to utilize slash to produce energy and bio-based products. Slash can be ground into hog fuel which is transported using wood chip vans to cogeneration/power plants to produce steam heat and/or electricity. Hog fuel is a term describing biomass fuel that has been processed by a mechanical shredder or grinder and is normally used as a fuel source for heat or energy production. It is a whole-tree product that includes bark, leaves, and stem wood.

Slash utilization can also include forest residues resulting from commercial thinning and timber harvesting operations. However, this approach has not been well implemented on a practical level because of limited accessibility on forest roads and the high costs associated with collection and transportation of these materials [5]. Typical slash recovery operations for energy production use a grinder and chip vans. These machines are brought to landings if chip vans can access these locations. Forest roads in the western US are built for hauling logs using stinger-steered logging trucks, and a typical chip van has limited access to harvesting sites due to sharp curves, steep grades, and low ground clearance. Because of limited accessibility, woody biomass amounts that can practically be supplied for utilization are substantially less than gross forest biomass available to harvest. The annual available biomass in California was estimated at 24.4 million dry metric tons, but the amount that could potentially be utilized amounts to only 13.0 million dry metric tons [8].

Besides limited accessibility for chip vans, high-cost machines such as grinders are significantly underutilized since landing slash piles are small (a grinder often spends less than one or two days grinding a pile of landing slash) and scattered over a large area. An expensive grinder (typically >$450,000) has to move frequently, resulting in low production rates. Logistical arrangements such as grinding location and hauling distance on forest roads between on-site operations and transportation to an energy plant have been a challenge as well. These difficulties are further complicated in northern California where terrain is steep and roads are typically not favorable for efficient transportation.

In this study we examined an alternative method to remove woody materials and increase accessibility to slash piled as a result of shaded fuelbreak treatments. In particular a ‘‘roll-off truck’’ with roll-on/off containers was tested to carry non-merchantable material for a short distance (less than 8 km) to a centralized processing site. ‘‘Roll-off’’ refers to a straight frame truck configuration in which modular containers are ‘‘rolled’’ onto and off of the straight frame truck by means of a truck-mounted hydraulic winch and a hook. A previous study indicated that a roll-off trucking system would significantly improve both accessibility to more forest residues and economic efficiency of the recovering process [7]. Further investigation is needed to broaden our knowledge for a wide range of applications of this technology into woody biomass collection and transportation.

The overall objective of this study was to evaluate the economic feasibility of removing hand-piled slash using a roll-off trucking system in mountainous conditions. Specific research questions include: 1) how much does it cost ($/hour) to operate the system consisting of roll-offs and a loader; 2) what are the potential productivities (tonnes/hour) in a wide range of work conditions for loading and transportation; 3) what is the economic maximum hauling distance in which a roll-off trucking system is financially feasible; and 4) what would it take to develop a profitable business that utilizes roll-off trucks in slash collection and transportation.

2. Study methods

2.1. *Study site and a roll-off trucking system*

A two-week trial of removing hand-piled slash using a roll-off trucking system was conducted on the Six Rivers National Forest in late July, 2007 near Mad River, California. Hand-piled slash (Fig. 1) was created by shaded fuelbreak treatments which also maintained 60% crown closure to reduce re-growth of brush and small trees within the understory. The shaded fuelbreak treatment prescription required cutting brush and suppressed understory trees less than 20.32 cm in diameter at breast height (DBH) which contribute to ladder fuels. These ladder fuels can allow fires to carry from surface fuels into the crowns of trees or shrubs with relative ease. The width of the shaded fuelbreak treatment varied with topography and vegetation but averaged 76.2 m on ridge tops and along roads.

Fig. 1 – Hand-piled slash from a shaded fuelbreak treatment. There were 198 slash piles per ha on average.