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FOREST FUEL REDUCTION: CURRENT METHODS AND FUTURE POSSIBILITIES

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ABSTRACT — Due to recent catastrophic wildfires, forest fuel reduction has become one of the most discussed topics in forest engineering research. Considerable money and resources are being spent in an attempt to seek answers for tough questions. Lack of information, especially concerning mechanical fuel reduction methods, has stemmed several studies. This paper compiles the available methods – mechanical and non-mechanical approaches to reduce forest fuel levels. One major area lacking information concerned with mechanical fuel reduction is the few available cost and productivity estimates associated with harvesting small stems. Small stems, the target of fuel harvesting, prove economically difficult to extract from the forest due to their low value and high cost associated with their removal. Results from a recent study in Alabama examining a cut-to-length (CTL) operation combined with a small in-woods chipper showed that the low impact system can effectively reduce fuel loads and keep operations small and efficient. Also, the small in-woods chipper was able to process resultant biomass from the operation into a merchantable product (energy chips). In areas where markets are available, the energywood can be used as an alternative energy source. These results are not only applicable in Alabama, but also have implications in the Pacific Northwest (PNW), where forest fire hazards are greater. Through a review and compilation of recent studies on CTL and cable yarding alternatives in the PNW, these implications are explored for a range of factors.

INTRODUCTION

Recent wildfires in the Western United States have caused the forest management community to take a closer look at active management practices on National Forests and private lands alike. Wildfire is a natural occurrence in any forested ecosystem, but fires of a catastrophic nature can cause severe damage to property and the timber asset (Hollenstein et al. 2001). Due to political, social, and environmental concerns, sustainable management practices capable of preventing severe fires have typically been avoided. This negligence brings us to the current situation characterized by severely overstocked stands in poor health conditions making forests susceptible to stand replacement wildfires. Small trees tightly spaced in the understory of mature forests create a fire ladder increasing the risk of a possible stand destroying fire. This stagnation lowers stand vigor and not only produces a fire hazard but also makes trees susceptible to insect attack. There is ample opportunity and much interest in employing pre-commercial thinnings to these stands that could alleviate the overstocking problem along with wildfire hazard. With the given situation, foresters and the research community must actively seek appropriate methods to sustainably reduce the forest fuel loading problem.

FUEL REDUCTION METHODS AND TRIALS

Prescribed fire has been used in the past as an attempt to reduce understory vegetation and the amount of small trees and litter present on the forest floor fueling wildfires. This valuable management tool has received much criticism due to smoke management liability issues and the possibility for fire escape into severely overstocked stands which can become uncontrollable and cross property boundaries.

Manual removal of understory vegetation is another method of fuels reduction. The method has been ineffective due to the intensive labor requirements and the small area that can be treated in a given time. Also, without the protection of a machine cab, workers are directly exposed to the hazards associated with timber harvesting; therefore, safety is a major concern in manual reduction treatments. Although, manual operations have downfalls, they benefit from low capital cost which allows greater flexibility that could be beneficial for small landowners or treatment of sensitive and/or urban areas. A recent investigation by Rummer and Klepac (2002) studied the performance and cost of a manual reduction operation using a forwarder for primary transport compared to a small-scale harvester/forwarder combination in Wyoming. They report costs of $26.93 per ton for the manual operation and $40.94 per ton for the small-scale mechanized system. These results indicate that manual reduction is substantially less expensive than mechanized operations. Although, their cost estimate for the manual treatment includes a used, fully depreciated forwarder. They found that by employing a new forwarder, costs would increase by 37 percent to $37 per ton, which is comparable to that of the mechanized system.

A more common and typically productive approach includes mechanical forest fuel reduction through thinning of overstocked stands. Hollenstein et al. (2001) reported that mechanical harvesting contrasts from prescribed burning due to the fact that the removal is immediately effective, and does not result in air pollution or smoke management issues. They also state that reducing fuel loads by thinning should slow or prevent the possibility of catastrophic wildfires and also produce large amounts of non-merchantable material. Mechanical thinning incurs problems due to the fact that harvesting small stems is expensive and the resulting wood product has low value, producing high harvesting costs per unit or area (Watson et al. 1986, Bolding 2002). Few cost and productivity estimates have been assigned to mechanical fuel reduction systems (Bolding and Lanford 2001). This fact spurs researchers to find suitable systems that can be adapted to various terrain, vegetation, and species types. Productivity and harvest cost comparison of five mechanized fuel reduction treatments are summarized in Table 1.

Brown and Kellogg (1996) combined a harvester and a small skyline system in a fuel reduction treatment in eastern Oregon. They found system productivity to be 7 tons per scheduled machine hour (SMH). Total cut and haul costs were estimated to be $42.44 per ton. A similar study by Drews et al. (2001) compared the productivity and cost of a harvester/forwarder system and a harvester/yarder operation also in eastern Oregon. Their study found cut and haul costs for the harvester/forwarder system to be $45.73 per ton and $79.93 per ton for the harvester/yarder system. Bolding (2002) also investigated a CTL fuel reduction system in western Alabama. In contrast to other investigations, this study estimated the cost and productivity of a forwarder transporting non-merchantable material to a small chipper for processing into energy chips. System productivity was estimated to be 5.82 tons per SMH and cut and haul costs were $37.06 per ton.

TABLE 1. — Comparison of five mechanized fuel reduction treatments.

System	Reference	Treatment Location	Productivity (tons/SMH)	Cut-n-haul cost ($/ton)
Harvester/small yarder	Brown and Kellogg (1996)	OR	7.00	42.44
Harvester/small yarder	Drews et al. (2001)	OR	5.40	79.93
Small-scale harvester/forwarder	Rummer and Klepac (2002)	WY	2.88	40.94
Harvester/forwarder	Drews et al. (2001)	OR	8.10	45.73
Harvester/forwarder/chipper	Bolding (2002)	AL	5.82	37.06
Average			5.84	49.22

BIOMASS REMOVAL AND UTILIZATION

Most fuel reduction operations will be conducted in thinnings instead of clear-cut harvests. In thinnings, merchantable stems can be processed into products and the resulting logging slash (limbs, tops, and foliage) could be removed from the site at the same time to further reduce fuel loads. Although removal of slash will decrease the woody material present on the forest floor and possibly decrease fire hazards, there is also a nutrient loss that must be evaluated. For mechanical systems to become effective in reducing fuel loads, attention must also be given to the possible soil and site productivity implications associated with removing understory vegetation.

Barber and Van Lear (1984) examined the rate of weight loss and nutrient dynamics in decomposing woody loblolly pine logging slash in South Carolina. They state that logging slash contains relatively high nutrient concentrations essential for tree growth and if slash is removed, it will not be allowed to recycle naturally and will potentially have an effect on long term site productivity. They found that 76 percent of K, 56 percent of Mg, and 47 percent of Ca is released from loblolly pine logging slash during the first 5 to 6 years after harvesting. This indicates that the nutrient gains from logging slash will be most important after the regeneration period. Several studies address nutrient removals from whole tree harvests but little information is available concerning nutrient removals from fuel reduction treatments. Therefore, it is unclear if nutrient removals from fuel reduction harvesting adversely affects site productivity.

Samuels and Betancourt (1982) developed a computer simulation (FORMAN I) that modeled long-term fuel harvesting and its impacts on woodlands. Their model suggests that long-term population growth has an effect on woodlands. This reiterates the fact that as human population increases there will be a need for alternative sources of energy. Forest managers must take this fact into account when deriving long-term management objectives for our current forests, private and public. Stokes (1992) reported that most use of forest biomass for energy is by the forest industry. He also found that industry is more interested in utilizing residues taken to mills with conventional products instead of the recovery of forest residues.

There is no doubt that an opportunity exists to supplement our energy resource by sustainably managing forests for renewable energy production. If this scenario becomes reality, in the future, we will also have to be sensitive to the possible environmental and soil impacts associated with fuel reduction harvesting for alternative energy. Most current fuel reduction strategies focus on alleviating the fire hazard and not for intensively farming forests solely for biomass energy production. In contrast, fuel reduction strategies should be operations that regain control of stands in poor health. A typical fuel reduction harvest removes an overstocked understory and thins merchantable trees to a target density. This type of harvesting removes entire trees less than some merchantable size class and the residual slash (limbs, tops, and foliage) from felled merchantable trees. Such silvicultural practices would be able to restore the health of many of our forests. Nutrient removals do not appear to be significant enough to offset the benefits gained through the reduction of hazardous fuels; however, little literature is available addressing such concerns. Therefore, there is definitely an opportunity to further explore how a stand reacts to a fuel reduction thinning. With a predicted human population increase, we must find sustainable ways to harvest understory hazardous fuels for energy production to supplement our growing energy requirements.

Adegbidi et al. (2001) reported that the production of woody biomass for energy is being developed in industrialized countries as well as the United States. Yoshioka et al. (2002) reported that woody biomass as an energy resource has recently attracted much attention in Japan. They expect the energy utilization of woody biomass to contribute to revitalizing the forests products industry, which has been depressed for some time. There is much opportunity for this type of revitalization to occur in the United States. Much of the problem facing the United States is the fact that few bioenergy processing facilities exist. The utilization of the energy potential contained in woody biomass will be slow to gain wider acceptance without such facilities in place. Many countries are currently employing such operations for supplemental energy. Research is needed to assess a sustainable approach to the management of our forests in a fashion that reduces fuel loads and produces alternate energy.

CONCLUSION

Based on the results of this brief examination there appears to be a growing opportunity and need for research in the area of fuels management. Future research should address concerns such as:

1. The cost and productivity of purpose built small-scale harvesting equipment for extracting non-merchantable stems over a range of stand and terrain conditions,
2. Alternative products produced from non-merchantable material, such as energy chips or other engineered products,
3. The expansion of suitable bioenergy processing facilities,
4. The amount of merchantable material that must be removed to offset the costs of a fuel reduction treatment,
5. New harvesting and extracting technologies (i.e. purpose built harvesting heads, and composite residue logs from slash baling techniques),
6. Site productivity and soil impacts during and following a fuel reduction harvest, and
7. Decision support models for landowners and contractors, public and private, to aid in choosing an appropriate fuel reduction treatment and harvesting system along with costs and productivity.

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