THINNING AND PRESCRIBED FIRE AS METHODS TO REDUCE FUEL LOADING - A COST ANALYSIS

CHALMERS, Stuart R. and HARTSOUGH, Bruce R.

ABSTRACT

Fire is a natural and necessary ecological function in United States forests, but fire prevention has led to a historic buildup of fuels. These unnaturally high quantities of both surface and vertical fuels can result in catastrophic fires. A national study (Fire and Fire Surrogates) is being conducted to compare thinning, prescribed burning and combinations of the two as methods to reduce fuel loading and therefore reduce the risk of catastrophic fires. The work described in this paper examines the economic costs of thinning and prescribed burning to reduce fuel loading. Thinning costing is based on measurement of productive/scheduled hours, standard machine costing, plus analysis of volumes of timber harvested, extracted and sold. A novel datalogger is used to calculate scheduled and productive hours. Thinning costs will be used to evaluate an existing small tree harvesting model (ST Harvest). Prescribed burning costing will be based on an expert opinion approach, with validation via a bottom up costing approach. The importance of this economic data in the context of the overall Fire & Fire Surrogates study is discussed.

INTRODUCTION

Around the turn of the 20th century, authorities in the United States (US) introduced policies to suppress all wildfires and prevent the use of prescribed fire on forested lands (Arno *et al*. 1997; Skinner and Chang 1996). Over the last 20 to 30 years the realization that fires are a natural and necessary part of forest ecology in most of the US has meant that there has been increasing use of prescribed fire, and wildfires have been allowed to burn under certain predefined conditions. However the exclusion of fire has changed the natural ecological pathways, leading to forests with higher densities of stems, high quantities of surface litter and branches, and fire intolerant species dominating over fire adapted species (Agee 1991, 1993, 1994; Arno 1980; Barden 1997; Caprio and Swetnam 1993; Cowell 1998; Dieterich 1980; Guyette and Cutter 1997; Kilgore and Taylor 1979; Mutch and Cook 1996; Swetnam 1990; Taylor and Skinner 1998; Sutherland 1997; Touchan et al. 1996; Van Lear and Waldrop 1989; Waldrop et al. 1987; Wills and Stuart 1994; Wright 1996; Yaussy and Sutherland 1993). These conditions are widespread and create more fuel and increased chances of catastrophic fire in the event of a fire being ignited (Dahms and Geils 1997; Parsons *et al* 1987; Stephens 1998; Weatherspoon and Skinner 1996). Despite the good intentions of the fire exclusion policies they have ironically created forests that are now far more prone to devastating fire.

It is now generally accepted that forested land should be returned, by reducing fuel loading, to conditions similar to those of the pre-fire suppression era, so that when an area does catch fire it does not produce catastrophic consequences.

Three basic methods may be used to return the forests to natural fire-evolved conditions:

1. Prescribed burning to remove surface fuels and kill smaller live stems.
2. Thinning to reduce stand density and minimize crown touching therefore reducing the risk of crown fires.
3. Combinations of the two above techniques - prescribed burning and thinning.

Fire and fire surrogates (FFS) study

The extent to which alternative fuel and stand treatments restore ecosystem structure and function is largely unknown. A team of scientists and land managers designed an integrated national network of long-term research sites to address this need, with support from the USDA/USDI Joint Fire Science Program. The project is called the **Fire & Fire Surrogates** (FFS) study (http://ffs.fs.fed.us/). The principal objective of the FFS study is to quantify the initial effects (first five years) of fire and fire surrogate treatments on a number of specific core response variables within the general groupings of (a) vegetation, (b) fuel and fire behavior, (c) soils and forest floor (including relation to local hydrology), (d) wildlife, (e) entomology, (f) pathology, and (g) treatment costs and utilization economics. The human dimensions of the problem are important. Treatment costs and utilization economics, as well as social and political acceptability, strongly influence decisions about treatment alternatives.

The authors are researching the treatment costs element of the FFS study, where three basic objectives have been outlined.

1. Quantify the costs of fire and fire surrogate treatments.
2. Over the life of the study, quantify the economic consequences on utilization of fire and fire surrogate treatments.
3. Develop and validate models, and successively refine recommendations for ecosystem management.

The FFS project began in April 2000 and has funding until 2004. There are 11 forest sites involved in the study in nine States (see Table 1).

Table 1: FFS study site summary

Study Site	State	Thinning Technique Notes
Lubrecht Forest (University of Montana)	Montana	Costs calculated using expert opinion
Wallowa-Whitman National Forest	Oregon	Harvesters & forwarders. Harvesting complete.
Wenatchee National Forest	Washington	Chainsaw & helicopter (Non-FFS sites will be used to evaluate cable yarding costs)
Klamath National Forest	California	? No future harvesting. Harvesting completed before start of study – used alternate site.
Blodgett Forest (University of California)	California	Chainsaw & skidder
Sequoia National Park	California	No thinning, just burning
Coconino & Kaibab National Forests	Arizona	? Late 2001
Santa Fe National Forest	New Mexico	? Prob. 2002
Mayakka River State Park	Florida	Understory removal only
Clemson University Experimental Forest	North Carolina	Disc feller buncher, grapple skidder & loader
Wayne National Forest	Ohio	Chainsaw & skidders

One of the main objectives of the study is to calculate the costs of all operations. For the thinning element this will use standard machine costing techniques. Actual costs will be calculated for prescribed burning operations, however, due to the small size of the individual treatment blocks (10 hectares) it is felt that expert opinion should be used to calculate more realistic prescribed burning costs for units of operational scale.

Economics of prescribed burning

Expert opinion is likely to be the main method for costing the prescribed burning treatments in the FFS study. However a review of the literature on the economics of prescribed burning reveals large differences in per-area costs (Cleaves & Brodie 1990, Cleaves & Haines 1995, Cleaves *et al* 2000, González-Cabán & McKetta 1986, González-Cabán 1997, Jackson *et al* 1982, Rideout & Omi 1995, Vasievich 1980, Wood 1998). The variability in costs is largely influenced by the size of the prescribed burn (Cleaves *et al* 2000, Rideout & Omi 1995, González-Cabán & McKetta 1986, González-Cabán 1997). A second important source of cost variation is the manager's perception of the risks involved in the prescribed burn and hence the equipment and personnel required. (Wood 1988, González-Cabán & McKetta 1986, González-Cabán 1997). Cortner *et al* (1990) examined the factors that affected perception of risk and found that the factors varied amongst managers - although safety and resources at risk were viewed as the most important.

Cleaves *et al* (2000) conducted a survey of prescribed burning in National Forests across the USA and found that average costs across forest regions varied from $23 to $223 per acre. In this survey there were regional differences, with the north and west having the highest costs and the south and east the lowest costs. Although the reasons for the large regional differences were not specifically studied, they appear to be partly linked to mountainous terrain increasing the cost of fire line installation. Fire lines are fuel free strips such as roads or rivers that prevent the spread of fire. Where these are not available an expensive plow line must be created. Costs of fire line preparation are affected by burn unit size (Cleaves & Brodie 1990, Wood 1988, Vasievich 1980), with larger burns having lower per acre costs due to increased chances of finding natural (free) fire lines and lower edge to area ratios.

Other factors that can affect prescribed burning costs include: ignition type, mop up requirements, potential damage from escape, smoke management, aesthetics and safety (Cleaves & Brodie 1990).

Understanding of prescribed burning costs is hindered by a lack of accurate records. For example, González-Cabán & McKetta (1986) found that the recorded accounting costs for prescribed burning where less than the more realistic costs derived using an economic cost concept. Hesseln (2000) recommends at the end of her economic review of prescribed burning that economic theory should be advanced by:

- understanding the economic effects and ecological outcomes of prescribed fire,
- understanding the cumulative economic effects of successive burns,
- and objectively defining risk for a variety of prescribed burning scenarios.

Modeling of prescribed burning costs is difficult primarily due to the unquantifiable effect of managers' risk perception on prescribed burning costs. Therefore, in using expert opinion to calculate costs it will be necessary to use local experts. To validate the local experts a bottom-up cost method should be used.

Harvesting Model – ST Harvest

One of the economic objectives of the FFS study is to develop and validate small tree harvesting models to aid in modeling of forest management alternatives. Hartsough *et al* (2001) developed a small tree harvesting model, ST Harvest, which was designed for the above purpose. ST Harvest combines results from a wide range of published empirical studies in the Pacific Northwest and similar sites and produces a weighted average cost per 100 cubic feet ($/CCF). The ST Harvest model is composed of 55 individual cost models for the following nine functions: Chainsaw Felling, Felling & Bunching, Harvesting, Skidding, Forwarding, Cable Yarding, Processing, Loading and Chipping. Each of the individual cost models is given a weighting depending on its applicability to the conditions of a specific harvesting scenario , based on the original site conditions of the published model. The model calculates total harvesting cost (cut, process, extract) for four ground based systems and two cable systems. The model is designed for long term planning rather than producing accurate individual site costs. ST Harvest has been verified by using point estimate data from published sources for felling and bunching, harvesting, skidding, forwarding, cable yarding and processing.

The model was implemented as a Microsoft Excel workbook, with the user providing the following inputs: trees to be removed per acre, average tree volume, area of treatment, yarding distance, percentage slope and move-in distance. The ST Harvest model will be further validated by using costs calculated from the harvesting data collected during the FFS study.

METHODS

If research funds were plentiful we might go to each of the sites and conduct detailed time-motion studies for each of the harvesting and prescribed burning operations. However, the available funding and geographic spread of the sites means that a more minimalist approach is required. Most of the data will be collected by local researchers so a consistent approach is required to both allow results to be compared and to minimize individual bias.

Thinning cost evaluation

To evaluate the cost of thinning a range of basic data needs to be collected (see Table 2). The productivity of individual machines or operators is not important as it is the total harvesting system that is being evaluated. This means it will only be necessary to calculate the volume harvested and extracted form each treatment and the working hours of all the machinery on the site.

A datalogger was designed at University of California at Davis to enable the calculation of on-site scheduled and productive machine hours by recording both equipment engine time and equipment motion (Engine & Motion Dataloggers). The Engine & Motion Dataloggers have two sensors that detect vibration: one detects small amplitude, higher frequency vibration caused by a running engine, a second monitors larger amplitude vibrations caused by motion of a machine across terrain or a swinging boom.

Table 2: Basic data to be collected for evaluating harvesting costs

Element	Component	Potential Data Source
Machines	Purchase price + finance	Contractor or Manufacturer (make, model & options)
	Depreciation	Miyata (1980)
	Consumables	Miyata (1980)
	Repair	Miyata (1980)
	Machine capacity (size, speed)	Manufacturers data.
	Annual working hours	Contractor or standard 1600 hours
	Scheduled & Productive Machine Hours on site.	Operator Logs, UC Davis Engine & Motion Dataloggers.
	Cost to move machine	Site supervisor
Operators	Pay & Benefits	Local expert opinion
Supervision & Planning	Time	Site supervisor
	Supervision costs	Local expert opinion
Production	Volume data	Before and after sample plots cross referenced with haulage scale tickets.
Site	Slope	Topographic map or survey
	Area	Topographic map
	Extraction distance	Topographic map
	Standing volume before operations – by diameter and species	Sample plots
	Standing volume after operations – by diameter and species	Sample plots
Miscellaneous	Haulage	Contractors price per ton
	Facilities (roading, shelter, electricity)	Roading costs, hire costs

The Engine & Motion Dataloggers are installed on each piece of harvesting and extracting equipment. The data from each machine is downloaded weekly by the site supervisor and sent via Email to the authors for processing. The dataloggers are small and self contained, and at all but one site the machine operators have been happy for them to be installed. A short time motion study was conducted on two pieces of equipment at the South Carolina site to verify the accuracy of the dataloggers. We analysed a skidder and a loader on which the dataloggers were recording fewer hours than we expected. The time motion study revealed that the datalogger was working correctly on the loader but underestimating productive time by about 5 percent on the skidder.

One important requirement is that the site supervisor records the date and time that a piece of equipment moves onto or off of a treatment block. This is a potentially weak link in the process especially if the contractors move their equipment before work is completed on a block.

For harvesting methods were we cannot utilize a datalogger, such as chainsaw felling or helicopter extraction, the site supervisor will keep a simple log recording date, unit, scheduled & productive hours and tree count.

Once the basic data in Table 2 is collected, standard machine costing methods (Miyata 1980) will be use to calculate the total cost of operations. Local expert opinion will be used to calculate the additional costs of site supervision and haulage. Any other costs associated with harvesting - such as those to build or upgrade forest roads - must also be included .

Prescribed burning cost evaluation

Local expert opinion will be used to calculate a total cost for the prescribed burning for each treatment; this evaluation will rely on local records of historic prescribed burns if they exist and are thought accurate.

It is anticipated that a simple bottom-up economic model will be developed to calculate the costs of prescribed burning. Stevens (1997) lists the main costs involved in prescribed burning, which include: personnel, fuel, fire line preparation, tools, fire trucks and other vehicles. The bottom-up cost model will be compared to the expert opinion costs.

RESULTS

At time of writing the available data is limited. Thinning costs should be available at the conference for three or four of the sites.

DISCUSSION

The economics of thinning and prescribed burning that will be addressed in this study are only part of a bigger study. The efficacy of thinning and prescribed burning at meeting the objective of reducing the probability of catastrophic wildfires will not be answered by financial examination alone. It is necessary to have a better understanding of both fire and thinning on forest ecology, herbaceous species, wildlife, soils and social issues. Social acceptance of potential fuel reduction systems is important. Public acceptance of harvesting is often difficult to find regardless of the objective, especially if it generates profit. Prescribed burning can also be a social problem when the smoke generated affects local communities. The even bigger sin of prescribed burning is when on occasion it becomes uncontrolled and devastates properties, as in the case of the Los Alamos, NM fire in May 2000. The important issue to remember is that if nothing is done to reduce fuel loading the forests will burn eventually, with potentially devastating results.

It is likely that thinning will prove to be a cost neutral or income generating method to reduce fuel loading. No matter what the ethics of a society, costs are real and budgets are limited, so any preventative measure that can cover its costs has to be seriously considered. The future is likely to bring a combination of both thinning and prescribed burning to reduce forest fuel loading. The exact situations where the two techniques will be used either separately or together will depend on the results of multi-disciplinary research, social opinion and the realities of cost.

BIOSKETCH

Stuart Chalmers is a visting scholar at the University of California at Davis. He left his native Scotland to discover what life was like on the other side of the pond. He has a degree in Forest Management (Aberdeen University, UK 1996) and a masters in Geographic Information Systems (Edinburgh University, UK 1997). Prior to starting work at UC Davis in January 2001 he worked for three years as a forester for the (British) Forest Enterprise. Contact info: srchalmers@ucdavis.edu, 415-876-4258.

Bruce Hartsough began his career in 1976 at Weyerhaeuser Company, evaluating and developing methods for harvesting small trees, in Oklahoma, Oregon and Washington. He then joined the University of California at Davis, studying logging with helicopters and cable yarders. His current research, much of it in collaboration with Raffaele Spinelli of the CNR Wood Research Institute in Italy, focuses on thinning to reduce fuel loading and improve forest health in natural stands, harvesting of short-rotation plantations, and collection of forest biomass for energy. He has degrees in Forest Engineering/Renewable Natural Resources (UC Davis 1976) and a doctorate in Agricultural Engineering (Auburn University 1986). He is currently Professor and Chair of Biological and Agricultural Engineering at UC Davis. He has served as chair of the ASAE Forest Engineering Research Committee and of the Short-Rotation Woody Crops Operations Working Group. Contact info: brhartsough@ucdavis.edu, 530 752 8331.

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