Introduction

This project began at the request of the Washington Office Fire and Aviation Management staff. They asked the Missoula Technology and Development Center (MTDC) to identify or develop equipment and techniques to help managers reduce extremely hazardous fuel-loading (biomass) conditions in ponderosa pine ecosystems where managers wanted to apply prescribed fire (wildland fire for resource benefit) on a landscape basis. The biomass reduction would facilitate the safe use of prescribed fire to maintain the health and vigor of these stands, and make it easier to defend them from wildfire. One project constraint given to MTDC requires that the biomass be considered unmarketable. This means that the sale of products such as wood chips or poles can't offset the cost of reducing the biomass. The methods and equipment identified in this project should apply in other fire-dependent ecosystems.

When MTDC began gathering information about equipment suitable to treat landscape areas before prescribed burns, it quickly became apparent that a comprehensive catalog would not be feasible due to the volume of information, as well as the time and budget allotted to the project. To keep the size of the catalog manageable, the equipment that is commonly available and well known is not included (equipment such as chain saws, winches, skidders, excavators, loaders, nonleveling-cab feller-bunchers, and so forth). The catalog includes a variety of small and large pieces of equipment suitable for many different management objectives and budgets.

Because landscapes needing treatment may cover thousands of acres, machines with high production potential are highly desirable. Stand biomass that has no commercial value necessitates low treatment costs per acre. Some machines were included because they were inexpensive. Others were included because of their ability to operate on extremely steep slopes or rugged terrain (equipment such as self-leveling-cab feller-bunchers, extreme machines, monocable yarders, and so forth). Specialty equipment and systems of many types (low ground pressure machines) were added to the catalog, and so were attachments to commonly available equipment (such as excavator and skid-steer attachments that are particularly effective and efficient in reducing fuel loading).

The *Catalog of Machines and Specialized Attachments* section of this report is not a comprehensive source, but is a general overview of equipment available for manipulating fuel profiles before prescribed burns (or, in some cases, instead of prescribed burns). A reasonable effort was made to include most available types of equipment. The equipment and specifications come from data supplied by the manufacturers. This report is published only for the information of Forest Service employees, and does not constitute an endorsement by the Forest Service of a product or service to the exclusion of others that might be suitable.

Historical Perspective

With few exceptions, the condition of ponderosa pine stands in the American West has changed significantly since the turn of the century. With the arrival of European settlers, wildland fire began to be viewed as a threat to the land's new uses. Whenever possible, wildland fires were excluded from the landscape. This general policy remained in effect until relatively recently when the land managers began to recognize its harmful effects.

Fire has historically acted to control the regeneration and invasion of certain plant species. In the absence of fire, these species now occupy a much greater percentage of the landscape than they once did. Some of these species, such as Douglas-fir, are not entirely suited to the sites they have invaded and are now more susceptible to insects and diseases. Even on sites that are primarily ponderosa pine, trees can become stressed due to competition for moisture, light, and nutrients. Ladder fuels, provided by thick regeneration, now exist from the ground to the crowns of the mature trees. In addition to the increased biomass, the risk of high-intensity fires also has increased. This condition existed to some degree before 1900, but is so extensive today that it has become the norm in ponderosa pine stands.

The effect of these changes is that parent stands are now more vulnerable to fire. When a fire does occur, it will be of much higher intensity and longer duration than if the stand were in a more natural condition. Mature trees that would have survived periodic, low-intensity fires a century ago may be killed by today's high-intensity fires. A fire that would have been a low-intensity ground fire in a more natural stand might now become a stand-replacement fire.

The stands that require work before prescribed fire can be successfully reintroduced may be in the forest (multiple-use areas), at the residential/forest interface, or in wilderness areas. Treatment areas may have good road access or be roadless, and they may have been previously logged or may never have been touched. Slopes can range from flat to those that are steeper than the operating limits of the most sophisticated machinery.

Extent of the Problem

To help determine the extent of this fuel-loading problem, the Washington Office sent out a short field survey. Information requested included the approximate number of acres in ponderosa pine types that needed some sort of preburn treatment and a listing of equipment and techniques that have been used to reduce fuel loading. Some Regions noted that the answers to the questions on ponderosa pine-type acres needing preburn treatment were not readily available from recorded data. Some assumptions had to be made. Approximate reported acres needing preburn treatment were:

❏ Intermountain Region (R-4)—4,788,000 acres.

❏ Northern Region (R-1)—4,650,000 acres.

❏ Pacific Northwest Region (R-6)—3,655,000 acres.

❏ Southwestern Region (R-3)—846,000 acres.

❏ Rocky Mountain Region (R-2)—Substantial (4.4 million total acres in ponderosa pine or mixed stands, the percent needing preburn treatments was not stated).

❏ Southern Region (R-8)—Not applicable. However, due to recent storms, the treatment techniques can be applied to 40,000 to 80,000 acres of blowdown in the National Forests of Texas.

The equipment and techniques identified in the informal survey, along with associated costs and production rates, are summarized in Appendix A.

Project Constraints

Based on interviews with the project initiator, other fire and fuels researchers, and field personnel, this project has the following equipment and technique constraints:

- ❑ There is no current commercial value to site material.
- ❑ Continuous thinning slash is too hazardous to be left in place.
- ❑ Chemicals are not an option.
- ❑ Minimal soil disturbance is desired (displacement, compaction, and so forth).
- ❑ Minimal leave-tree damage is desired.
- ❑ Equipment included must be able to manipulate the unmerchantable material.
- ❑ Equipment included must be readily available.
- ❑ Equipment included must be reliable.

Because so many different management objectives are possible, this report is limited to suggesting several fuel-reduction approaches, identifying appropriate equipment, and making comments on the equipment's ability to meet project constraints. The reader is left to decide if the ideas or equipment presented in this report are suitable for local needs and if they meet applicable guidelines.

Revenue Considerations

Revenue-generating material would provide options to help reduce the treatment cost. When there is no product to generate revenue, the task boils down to finding the lowest-cost strategy to prepare the stands for prescribed fire. The acceptable preburn treatment costs are influenced by the value of the resources that must be protected from catastrophic fire. It is more acceptable to spend large sums near residences and developed areas than in remote forest lands. Care should be taken so monetary considerations do not adversely affect the overall objective. A "cheap" prescribed burn can burn up the resource. Even if a low-cost treatment leaves the desired vegetation, loss of intangible or intrinsic values such as sensitive wildlife habitat—especially for threatened and endangered species—may have costs that are difficult to quantify.

Some acres can be treated inexpensively because little or no preburn treatment is needed, slopes are gentle, and only a small burning and holding crew is needed. Other acres may cost much more to treat and must be averaged with the inexpensive acres to make the overall treatment cost acceptable. This typically occurs when breaks or buffers are created to make the more difficult areas safer to burn. Low-cost units are frequently burned first so Districts can stay within their budgets while meeting resource targets. This creates a potential problem, since low-cost units are not necessarily the ones that have the highest treatment priority. When the more difficult acres are tackled, fewer low-cost acres may be left to average with them.

Increasing concerns about environmental implications of past forest management practices have led to the development of ecosystem restoration and management techniques, where fire hazard and pest problems are addressed in conjunction with timber-production activities. Such cost recovery is beyond the scope of this report. For a discussion on evaluating restoration prescriptions in ponderosa pine stands and the degree to which the value of product removals might underwrite treatment costs, see Product and Economic Implications of Ecological Restoration by Carl E. Fielder and others, Forest Products Journal, Volume 49, Number 2.

Auxiliary projects, such as commercial and individual firewood gathering and post and pole operations, may help offset some costs but rarely get the job done and do not significantly impact revenues. If forestry equipment is already in the woods on another project, it may be considerably more cost effective to use the existing equipment rather than to bring in other machines.

Other Considerations

A particular machine or method may be used not only to meet objectives from a fuels standpoint, but can also assist in meeting silvicultural objectives (regeneration, thinning, and other resource values), NEPA (National Environmental Policy Act) requirements and mitigation measures. These considerations may even set parameters that dictate or highly influence the choice of suitable equipment or the right approach for a particular situation.

In some cases mechanical treatment may be the total treatment because of local regulations limiting smoke, as in California, where alternatives to fire must be considered. Where followup with prescribed fire would otherwise be the normal course of action, managers will have to be satisfied knowing they have made a difference in fire behavior by decreasing dangerous fuel levels.

When hazardous biomass is reduced, all down wood or live vegetation other than ponderosa pine does not have to be removed. Other vegetation and down wood will contribute to diversity and the long-term sustainability of these ecosystems. Brian Ferguson, regional silviculturist from the Intermountain Region, recommends considering mosaics that allow diversity instead of getting rid of all vegetation. Mosaics can reduce fire potential across landscapes by breaking up fire patterns. In some areas, down wood can be left to provide opportunities to meet forest management plan long-term productivity standards for coarse woody debris (greater than 3 inches diameter), provided the debris does not contribute to excessive fuel loading. Machines could be used to distribute the debris.

Brian stated that recent discussions with staff from the Rocky Mountain Research Station (Moscow, ID) resulted in recommendations to rearrange fuels on the forest floor and to use broadcast burns instead of firing concentrated piles. According to this perspective, the use of extremely hot prescriptions and burning large piles can be detrimental to site productivity and nutrient recycling. Broadcast burns result in more uniform distribution of nutrients.