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Forest Health in the Blue Mountains: A Management Strategy for Fire-Adapted Ecosystems

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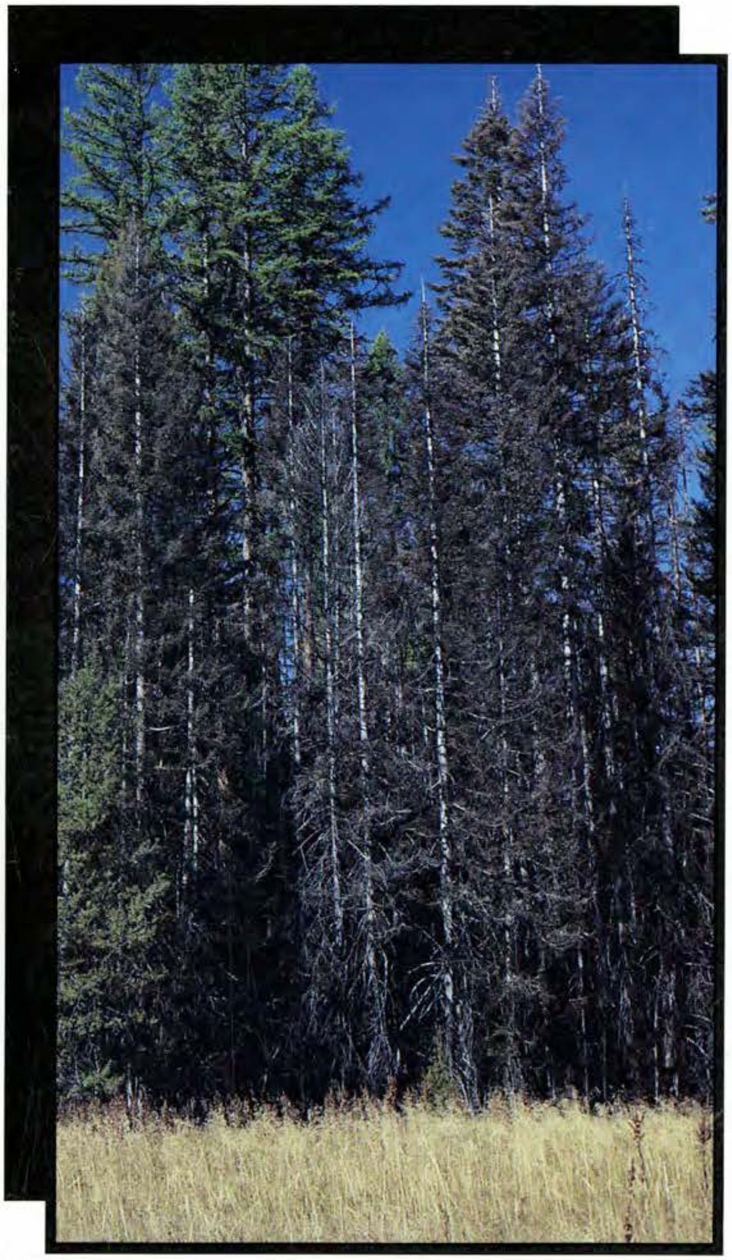

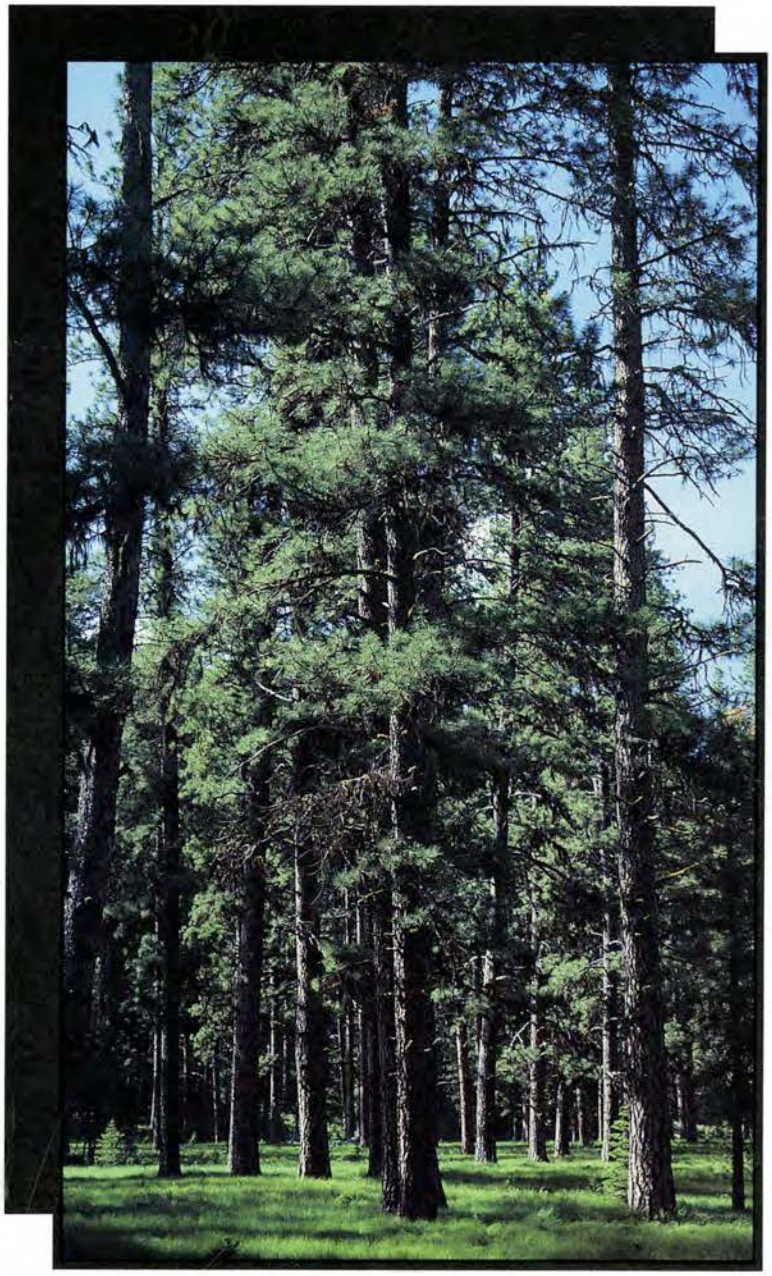

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Cover Photos

(Left) Spruce budworm mortality in a stand characterized by a high percentage of grand fir. (Right) Desired future condition of a stand dominated by ponderosa pine and western larch (with less 30 percent in true firs and Douglas-fir). (Photos by Clint Carlson.)

Forest Health in the Blue Mountains: Science Perspectives

Thomas M. Quigley, Editor

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Abstract

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The fire-adapted forests of the Blue Mountains are suffering from a forest health problem of catastrophic proportions. Contributing to the decline of forest health are such factors as the extensive harvesting of the western larch and ponderosa pine overstory during the 1900s, attempted exclusion of fire from a fire-dependent ecosystem, and the continuing drought. The composition of the forest at lower elevations has shifted from historically open-grown stands primarily of ponderosa pine and western larch to stands with dense understories of Douglas-fir and grand fir. Epidemic levels of insect infestations and large wildfires now are causing widespread mortality that has a profound effect on forest health by adversely affecting visual quality, wildlife habitat, stream sedimentation, and timber values. The Blue Mountain situation may foretell of a much broader forest health decline in the Western United States.

A management strategy to restore forest health at lower elevations will require that the seral ponderosa pine and western larch stands be managed for much lower tree densities and a more open coniferous understory than have been the case. A combination of silvicultural partial cutting and prescribed fire on a large scale will be needed to produce the desired future condition of healthy, open, and parklike forests. We have attempted to exclude fire from fire-dependent ecosystems with disastrous results. Now we must take bold steps in restoring forest health to the Blue Mountains through an integrated strategy of silvicultural and fire prescriptions.

Keywords: Forest health, ecosystem functions, fire, Blue Mountains.

Preface

The Blue Mountains of northeast Oregon and southeast Washington are composed of a complex mix of ecosystems, habitats, landforms, and economies. Several consecutive years of drought, epidemic insect infestations, and catastrophic fire are threatening the natural resources and the social and economic systems within the Blue Mountains. The general health of the forests is not good and may be worsening. A primary factor leading to the current deteriorated condition has been the exclusion of fire. Past timber management practices also have contributed.

This publication is part of a series on forest health in the Blue Mountains. The goal of this series is to provide a discussion of forest health issues from various science perspectives. The series will include discussions on several aspects: insects and disease; economic and social issues; fire; fish, riparian areas, and water quality; ecology and range; wildlife; and a summary of forest health public forums held throughout the Blue Mountains.

The Blue Mountains Natural Resources Institute has been the focal point for much of the discussion regarding the science issues associated with forest health. This organization, which includes over 60 partners, has broad representation and a strong interest in restoring health to the forests and communities of the Blue Mountains area. The Institute has fostered publication of these papers as one more step in the long process of restoring health to east-side forested landscapes.

Thomas M. Quigley

Introduction

The evolution of events producing catastrophic forest mortality in the Blue Mountains of Oregon due to pests and severe wildfires is reviewed by Gast and others (1991) and Wickman (1992). The relations are similar to those found in the northern Rocky Mountains as reported by Carlson and others (1985) and Carlson and Wulf (1989). Fire exclusion practices and high grading of western larch (*Larix occidentalis* Nutt.) and ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) over several decades have produced present day stands characterized by Wickman (1992) as thickets of sapling and pole-sized fir severely defoliated by western spruce budworm (*Choristoneura occidentalis* Freeman), scattered Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and grand fir (*Abies grandis* (Dougl. ex D. Don) Lindl.) being killed by bark beetles (Dendroctonus spp.), pockets of root disease killing fir, and scattered second-growth stands of ponderosa pine that often are infected with dwarf mistletoe (*Arceuthobium campylopodum* Engelm.). Also, in the past few years, high-intensity wildfires have consumed the dead and dying forests, where frequent low-intensity surface fires before 1900 maintained healthier open-grown forests dominated by pine and larch. The current 10-year epidemic of spruce budworm shows no signs of diminishing.

The ecological deterioration evident in the Blue Mountains has disturbing implications for similar forest types at other locations. A widespread forest health emergency has been reported in many parts of the West (American Forests 1992). The situation in the Blue Mountains may be a window to a much broader forest ecosystem decline problem.

The alarming proportions of this forest health problem prompted an on-the-ground review of conditions in September 1991 by an interdisciplinary group of representatives from the Malheur, Umatilla, and Wallowa-Whitman National Forests (NF); the Pacific Northwest Region; and the Pacific Northwest and Intermountain Research Stations. The objectives of the review sponsored by the Blue Mountains Natural Resources Institute included:

1. Initiating discussions concerning the role of fire in east-side forests with emphasis on what is known and not known.

2. Establishing the initial framework for potential research to address the role of fire in achieving or maintaining forest health.

3. Bringing together scientists interested in helping to set an agenda for future research on the role of fire in east-side forests.

4. Broadening the understanding of the issues and opportunities related to fire in east-side forests.

The September 10-12, 1991, review included an overflight of affected areas in the Wallowa-Whitman NF and visits to the 1989 Canal wildfire near Joseph; Gumboot area in Hell's Canyon National Recreation Area; Sullivan Gulch and Frog Heaven sites in the La Grande Ranger District, Wallowa-Whitman NF; and three stops in the proposed new perspectives demonstration areas in the North Fork John Day Ranger District, Umatilla NF. Review participants who had not seen the Blue Mountains recently were shocked by the severity and widespread extent of the forest mortality; they concluded that it would be valuable to produce this brief white paper to underscore the seriousness of the situation and to present a strategy for the management of fire-adapted ecosystems in the Blue Mountains to restore forest health.

Figure 1—The Blue Mountains were named for the smoke and haze from wildland fires that continually shrouded the region during the dry season.

The Fire Situation

For thousands of years, fire shaped the composition and structure of North American forest, woodland, shrubland, and grassland ecosystems (Pyne 1982). The Blue Mountain region with its abundant vegetation, long dry summers, and frequent lightning storms had the necessary ingredients for fires to spread across vast areas of the landscape. Historians note that this region was named in recognition of fires that shrouded the area in smoke and haze (Hall 1967, Shinn l980) (fig. 1). Explorer Peter Skene Ogden reported extensive fires burning across this region during his travels in 1825-27, and until the turn of the 20th century numerous other journalists wrote of widespread burning attributable to ignition by lightning, Native Americans, and European-Americans (Shinn 1980, Wickman 1992).

Fire history has been reconstructed by dating the annual growth rings associated with fire wounds on surviving trees (Arno and Sneck 1977). In the low-elevation forests and on dry sites at middle elevations, where ponderosa pine once was a major forest component, fire intervals averaged 10 to 25 years (Arno 1988, Hall 1976). These fires burned in the understory and perpetuated open parklike stands with grassy undergrowth. The stands were dominated by the fire-resistant pine and, on wetter sites, western larch. Nineteenth century travelers reported riding horseback or even pulling wagons for miles through these untracked forests (Wickman 1992).

In the higher elevations and on moist sites at middle elevations, fire played a more complex and variable role in forest structure. Here it left a mosaic of lethally burned areas mixed with unburned areas and patches of nonlethal underburning. Fire intervals were longer, apparently ranging between about 40 and 150 years, but again fire-adapted tree and undergrowth species were favored by this burning regime. These included western larch, lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.), whitebark pine (*Pinus albicaulis* Engelm.), evergreen ceanothus (*Ceanothus velutinus* Dougl.), and a number of other wildlife forage species. The variable pattern of burning was virtually assured by the landscape mosaic of vegetation and fuels. This resulted from differences in topography, microclimate, soils, past fire mosaics, and changing weather and fuel moistures that occurred as the fires burned unchecked through summer and early autumn.

Figure 2—High-intensity wildfires like the 1989 Dooley Fire are threatening people, property, and natural resources with increasing frequency in the Blue Mountains.

By the early 1900s, a drastic change in the ecology of Blue Mountains ecosystems had begun with the attempt to exclude fire (Agee 1990, Kauffman 1990). Foresters of this era, whose formal training was based on forestry concepts developed in the humid environments of northern France and Germany, viewed fire as highly undesirable. Similarly, stockmen lamented the loss of winter forage when cured grasslands burned. The complex ecological role of fire generally was not recognized, and many educated people considered fire to be a scourge introduced by human negligence. At this same time, heavy grazing and cultivation in valleys and some other areas removed so much grass fuel that surface fires could no longer spread easily across the landscape.

Organized fire suppression became increasingly efficient after about 1930, and by mid-century all fires of low and moderate intensity could be extinguished (Agee 1990). At the same time, fuels—including forest floor duff, dead woody material, and dense conifer thickets—were building to alarming levels in many stands (Hall 1976, Weaver 1967). Since the late 1970s, an abundance of large, severe wildfires in the Blue Mountains and elsewhere in the inland West suggest that attempts to eliminate fire have simply led to a different fire regime—one characterized by uncontrollable fires burning in heavy fuels (Arno and Brown 1991) (fig. 2).

Although this situation now is widely recognized, its solution is elusive. It might seem plausible to let natural fire regimes return, especially in wilderness or other "natural areas." One problem is, however, that even in large, natural areas, fires do not stay where they are welcome (illustrated by the 1988 fires in the Greater Yellowstone area). Instead, they spread into valuable timber stands having fuel accumulations, private lands, ranches, summer homes, and towns. Even in the fire-adapted ponderosa pine types, fuels often build up to such an extent that ancient trees, which survived many fires in past centuries, are now killed in modern fires. Because of fire exclusion and selective logging, modern fires also may not restore the historic seral vegetation types, such as ponderosa pine. Therefore, instead of simply returning to a philosophy of letting fires burn, it may be necessary to use restoration forestry involving silvicultural cutting of unwanted trees, prescribed burning for site preparation, and planting of desired species.

Future Alternatives for the Blue Mountains

Forest health in the Blue Mountain region is complex and closely tied to available water, nutrients, and periodic fire. Several years of drought, a strict fire suppression policy, selective harvesting for seral species, and heavy grazing have stressed plant communities, expanded the distribution of grand fir and Douglas-fir on droughty sites, and contributed to invasion by exotic species. These altered ecosystems have proven susceptible to insect infestations, disease epidemics, and catastrophic wildfire, leading most people to conclude that the forests of the Blue Mountains are unhealthy. We have several options from which to choose future management programs: (1) continue present management, which largely excludes fire (status quo); (2) manage the landscape with fire; and (3) use new approaches to landscape management without fire.

Status Quo Management

Continued status quo management of strict fire suppression, selective harvest of seral species, isolated prescribed burning projects, and heavy grazing will do little to improve the health of the Blue Mountain ecosystems. Insect and disease infestations will spread to areas currently unaffected. High-intensity, stand-replacement wildfires will occur in areas that evolved historically with frequent, low-intensity surface fires. Natural reproduction of larch and pine will continue to be poor as a result of the removal of the fire process that establishes conditions favorable for germination and growth. Firs will continue to replace shade-intolerant conifers (for example, larch and pines) in many forests. Other components of the ecosystem, such as shrubs, forbs, and wildlife, also will be impacted by the shifts in vegetative makeup and invasion by exotic species.

The real consequence is that status quo management will leave us with seriously degraded ecosystems offering little value in an ecological, aesthetic, or economic sense. This option goes counter to the values and concerns of society today, such as biological diversity, beautiful and "natural" landscapes, healthy plant and animal communities, and long-term productivity.

Landscape Management With Fire and Timber Harvest

If society believes that the historic structure of these forests was healthy and desirable, then prescribed fire on a large scale could be used in Blue Mountain forest ecosystems to convert stands to more natural conditions (fig. 3). Prescribed fire and silvicultural treatment will have to be performed in landscape-sized efforts, if the conversion is to work in the same way as past natural disturbance processes. Reintroduction of periodic prescribed burning on a landscape scale could increase biological diversity, improve the vigor and vitality of plant communities, improve the

Figure 3—Prescribed fire on a larger scale at lower elevations can return areas in the Blue Mountains to the desired future condition of more open, parklike stands that are less susceptible to insect mortality and high-intensity fires.

availability of plant species palatable to ungulates, stimulate cone crops from seral species, decrease the invasion rate of exotic species, reestablish natural species mix, and reduce wildfire hazard. The result would be a forest more fire tolerant and pest and disease resistant than we now have. Fire has other effects on a site, such as thermal, chemical, nutrient cycling, and soil structure, the roles of which are still inadequately understood. Current knowledge indicates, however, that long-term loss of nutrients and decline in productivity can be avoided through proper management. Harvesting practices should leave on site some tree crowns and large downed woody material. Fire should be prescribed such that some forest floor duff and large woody material remain. The use of prescribed fire to accomplish stand-management objectives historically performed by fire helps ensure that any unknown roles of fire in the ecosystem will be preserved.

Fire and its ecosystem benefits can be returned to the Blue Mountain landscape through the use of prescribed fire (broadcast burning, underburning, prescribed natural fire, and stand replacement fire). It is important to keep in mind, though, that we are working against 100 years of buildup of horizontal surface and vertical (ladder) fuels once kept in check by natural fires occurring every 10 to 25 years on ponderosa pine sites. Removal of unnatural fuel accumulations and manipulation through mechanical harvest can be coordinated with prescribed fire to obtain desired results. We will need to modify current unnatural stand conditions before fire can play its historic role. Do we have sufficient expertise and knowledge to intelligently apply fire in a landscape-size effort?—an effort that would effectively bring back the natural fire cycle and reduce the potential of epidemics caused by insects and disease, as well as reduce the threat of catastrophic fire in these heavy fuels. Yes, with the caveat that we need to initiate action immediately to define new prescribed burning approaches and quantify a range of ecosystem effects. To return to fire as an extensive ecological process also will require funding far above current levels for prescribed fire use. We must begin by drawing on existing research on fire effects and fire ecology, followed by new, problem-specific research and demonstration sites to refine and develop the role of prescribed fire in the future of the Blue Mountains.

Fire is not a tool to be used on all sites or in all situations. It is, however, a tool that should be available and understood when management strategies are designed for the natural resources of the Blue Mountain region. Proper application of fire often may be the best option for meeting specific objectives while creating the fewest adverse environmental effects. If fire is to be effective in converting a forest to a healthier state than it is in now, an adaptive fire management strategy must be adopted in a landscape-size effort that will integrate fire effects research and prescribed fire planning technology.

There will be uncertainties as we undertake such vast landscape-level "experiments," and we must build into them the means to capture knowledge about ecosystem response. We might ask the question, What is required to make land management a "real" experiment that contributes to the knowledge base for ecosystem management? Scientists, in collaboration with managers, need to formulate the questions and hypotheses and bring to the ecosystem experiment the appropriate experimental design and scientific rigor. Adaptive management provides a process for adjusting management in response to results provided by the research and monitoring framework. In adaptive management, information from research and monitoring is used to continually evaluate and adjust management relative to predicted responses, management objectives, and predetermined thresholds of acceptable change.

Landscape Management Without Using Fire

It may be possible to apply mechanical and chemical management techniques in the Blue Mountains to encourage a fire-adapted ecosystem without the use of prescribed fire and the associated air quality degradation. Stand dominance by pine and larch could be reestablished through a series of stand entries for selective harvesting followed by natural regeneration or planting. Fuel buildup could be reduced by mechanical treatment thus reducing wildfire potential. Chemical treatment could be used to reduce the threat of exotic species.

Some of the obvious conditions that have resulted in an unhealthy forest may be solved without the use of fire. Can treatments other than fire duplicate fire's nutrient cycling, cleansing, and thermal roles and have less impact on the site and surrounding environment? In many cases, probably not. Alternative treatments, such as mechanical manipulation and herbicides, could prove damaging to the ecosystem and unpopular with the public. Considering the many unknown components of the relation between fire ecology and forest health, it is risky to assume that a fire-dependent ecosystem can remain healthy without fire. Scarification (heavy machinery use and soil scraping) as a substitute for fire often is detrimental to soil productivity and invites invasion by exotic weeds.

A Management Strategy

A strategy to maintain forest health will require that the seral ponderosa pine forests be managed for considerably lower tree densities and much less of a coniferous understory than currently is true. Desirable stand densities can differ depending on productivity of the sites. Healthy forests generally will appear open and parklike. Clumps of trees and understory thickets can be scattered throughout. Forage production will be greatly increased and risk of catastrophic wildfire greatly decreased. The forest truly will support multiple benefits.

To achieve this landscape, a combination of silvicultural partial cutting and prescribed fire will be needed to manage the overstory and understory vegetation. Understory fires should be repeated about every 10 to 25 years to match historical fire frequencies. Repeated understory fires will be needed to control unwanted dense fir regeneration and to prevent accumulations of fuel that could support intense wildfires. Traditional seedtree and shelterwood silvicultural systems may be appropriate for securing regeneration in different situations. Long-term goals should include maintaining a continuous, open overstory of healthy seral pine and larch through innovative forestry systems involving retention shelterwood, single tree selection, and group selection systems in conjunction with periodic underburning. Planting of seedling ponderosa pine and larch will be necessary in many areas to obtain adequate regeneration.

Because many stands now are excessively dense and contain many dead and dying trees, restoration to healthy forest conditions will require different approaches from those needed to maintain healthy forests. Where large quantities of standing dead trees are present, salvage logging should be encouraged to remove unnatural accumulations of fuel and obtain wood products. Prescribed fire often is desirable after salvage logging to reduce fir regeneration, prepare seedbeds for pine and larch, and stimulate shrub and herbaceous vegetation. Removing excessive amounts of large dead woody material will reduce the likelihood of severe soil heating from both prescribed fire and wildfire. Where large quantities of downed dead woody material cannot be removed mechanically, two or perhaps three prescribed fires conducted at high fuel-moisture contents over several years may be needed to restore desirable conditions without adverse impacts.

Use of prescribed fire will need to increase about 10-fold to restore and maintain healthy seral pine and larch forests. This will require new approaches to planning, financing, and conducting prescribed fires; for example, burning large areas that extend beyond sale unit boundaries may be the most economically efficient and ecologically compatible way to maintain these stands in a healthy state. The cost of such a prescribed burning program will likely be larger than one budget line can support—and benefits will accrue to more than one resource. Funding prescribed fires through multiple budget line items, including wildfire abatement, would be consistent with Forest Service policies. New ways of assembling burning crews to conduct large prescribed fire programs on small administrative areas will be needed. Grazing by livestock may require occasional constraints to provide adequate fuel for supporting prescribed fire and to permit recovery of herbaceous vegetation. Increased efforts to obtain public understanding and support will be necessary because the appearance of the forest will change. Smoke and char from prescribed fires will be apparent.

Values, Attitudes, and Tolerances Needed for Success

Air Quality

Reintroduction of fire to fire-dependent ecosystems has the potential of degrading ambient air and impairing visibility in class I areas. These negative effects of fire contradict current state and national air quality regulations. Scientists will need to describe—and the public will need to understand—the tradeoffs among increased prescribed fire, inevitable wildfire, ecosystem health, and public exposure to smoke. The public has previously chosen to bear the costs associated with cleaner air. Will the public choose to rate air-quality values higher than forest-health values? If so, reintroduction of fire at levels necessary to imitate natural fire frequencies probably will be impossible and forest ecosystems will continue to deteriorate, thereby lessening resource values and resulting in catastrophic wildfires and catastrophic smoke episodes.

Credibility

A portion of the public has lost confidence in the ability of the forestry community to successfully manage the Nation's forests. Previous forest management practices have resulted in the current condition of the Blue Mountains. Why trust that a new management philosophy can correct the situation? This perception needs to be dispelled through management decisions that rely on and are supported by extensive, credible research results; a commitment to manage forest lands using techniques that closely imitate natural processes; and a commitment to public involvement in forest management decisionmaking in the Blue Mountains.

Funding

Whereas current management strategies are driven by short-term economics, restoration of degraded ecosystems will require a long-term plan that includes funding mechanisms tiered to ecosystem health and maintenance objectives in addition to existing functional lines. The resurrection of seral forests in eastern Oregon will require significant public money. Western spruce budworm in many of the existing grand fir and Douglas-fir stands has killed 60 to 70 percent of the standing conifer volume, thereby greatly reducing profitability from sale of timber. Stand rehabilitation will require considerable outlay of capital to prepare the site for planting (or in some cases, natural regeneration where seed source is not limiting). In short, it seems unlikely that proceeds from sale of on-site timber can finance the needed rehabilitation.

A management strategy for eastern Oregon forests therefore must focus on both the biological and monetary means of achieving desired future stand and landscape conditions. The biological part may be the easier to accomplish. For the most part, we know what needs to be done and how to do it. But Congress must be convinced that a serious problem exists and that special appropriations of money will be needed to accomplish the work. If steps are not taken now to convert the forests back to seral conifers resistant to most insects and diseases, then the potential yield of timber products must be revised downward to reflect losses that will occur in future rotations.

Resource Management Specialists

Many people within the National Forest System are trying to implement a philosophy of sustaining healthy ecosystems, but some of our traditional resource management approaches need to change. This may be especially true in cases where more prescribed fire is needed to restore ecosystem health, but specialists remain committed to independent, functional goals for such things as visual quality objectives, sediment load, and thermal and hiding cover for wildlife. Instead of each interdisciplinary team member adhering to rigid standards for their functional area, specialists will need to be flexible to achieve the broader objective of sustaining ecosystem health.

Line Officer Commitment

Making a successful transition from the current management of forest stands in the Blue Mountains to the management of landscapes will require a special commitment by line officers at the Regional, Forest, and District levels. New requirements in terms of internal interdisciplinary cooperation, public involvement and understanding, risk taking, funding, and interagency communications will challenge everyone's ability to perform effectively. Progress will depend on whether leadership is focused on the goal of sustaining forest health. Evaluating and rewarding line officers on their contributions towards sustaining healthy ecosystems might provide the necessary incentives to promoting commitment. Contributions that might be considered include:

1. Reducing the density of Douglas-fir and grand fir stands or understories.

2. Increasing substantially the use of prescribed fire at the landscape level.

3. Maintaining mature ponderosa pine and larch in the overstory.

4. Achieving successful regeneration of pine and larch.

5. Reducing acres burned by high-intensity wildfires.

6. Increasing available forage.

Performance criteria will have to be measured over several decades. It has taken years to arrive at the current unhealthy situation; and it will take many years to reverse these conditions.

Future Research and Development Needs

Although fire effects and fire ecology research results are available to be used in initial development of an adaptive fire-management plan, more research is needed. Direct and indirect interactions among fire and pests, pathogens, vegetation response, wildlife, water, soil, nutrient distribution and cycling, and air quality are complex and not fully understood. This lack of understanding inhibits the ability of land managers to describe the fire regime needed to produce a specific ecosystem response. A well-organized, interdisciplinary approach is the only way to address prescribed fire and the forest health problem. Thus, it is important to refer these research needs back to the context of ecosystem-scale experiments, where scientists and managers will be implementing a strategy of adaptive management.

Demonstration Areas and Adaptive Management

A network of large demonstration areas in the Blue Mountains will provide the opportunity to showcase, monitor, and evaluate the results of management practices designed to restore forest health. At this time, five demonstration areas are being planned: two in the Wallowa-Whitman NF, one in the Malheur, and two in the Umatilla. Other areas may be added in the future.

A concept of adaptive management will be applied to the demonstration areas so that as much useful information as possible can be gained from management activities. Monitoring and evaluation of management results will permit the continuing adjustment of management strategies as new information is acquired. All studies, monitoring, and evaluation should involve an interdisciplinary team of land managers and scientists. With an interdisciplinary approach, ecosystem response can be linked directly to fire type, thereby laying the groundwork for development of fire prescriptions to meet specific objectives.

Natural Fire Regimes

Historic fire regimes throughout the Blue Mountains region need to be described. Fire history studies describing natural fire frequencies and intensities are needed. Historic smoke emission levels and visibility conditions also need quantifying.

Ecosystem Response

Immediate fire effects—The immediate effects of fire need to be characterized: fuel consumption, fire behavior, and heat pulse studies on prescribed fires and wildfires covering a range of site types throughout the Blue Mountains region. With this information, fuel consumption models currently in use for logging slash can be validated and new models developed to include natural fuels. This modeling capability allows managers to design and demonstrate new prescribed fire approaches to accomplish fuel consumption objectives for specific fire-effects results. Interactions between ecosystem processes and fire are complex. Ecosystem response systems are needed to describe how fire affects pathogens, vegetation, wildlife, water, and air quality at different intensity levels.

Nutrients, soil, soil structure, and productivity—Forest composition and fuels are only two of many components in the Blue Mountains forests altered by fire exclusion, selective logging, and possible changes in climate. Conversion from presettlement low-density stands of western larch, Douglas-fir, and ponderosa pine to the present high-density stands of Douglas-fir and grand fir has been accompanied by large accumulations of woody biomass, dead material, and forest floor fuels. These components probably are at greater levels than have ever existed in the lives of these ecosystems. Large accumulations of biomass and detritus aboveground likely have been accompanied by a change in the distribution of essential plant nutrients such as nitrogen, phosphorus, and sulfur. For low-density stands, it can be hypothesized that much of the total site nutrient capital was belowground. Large accumulations of biomass and detritus aboveground would tend to increase the proportion of nutrients situated aboveground. These aboveground nutrients, however, are largely unavailable. Nutrients such as nitrogen, phosphorus, and sulfur are concentrated in the foliage, small branches, and in the forest floor. Tree boles are composed primarily of carbon, and removal of tree boles exerts only a minor impact on essential plant nutrients. Because many nutrient elements are volatilized by burning (especially broadcast slash burning), this causes substantial losses of nitrogen, phosphorus, and sulfur from foliage, small branches, forest floor, and surface soil. Not all volatilized nutrients are lost to the atmosphere. Redistribution can result in nutrient increases in the soil. Losses are directly proportional to the amount of biomass consumed. Excessive losses may adversely impact site productivity to an extent possibly unacceptable for sustainable resource productivity.

Nutrient losses assume even greater importance because most forested sites of the interior Pacific Northwest are already limited in nitrogen and sulfur—two nutrients most vulnerable to loss by burning. Demonstration areas need to be established to monitor and evaluate the long-term dynamics of nutrient cycling.

Ash from Mount Mazama and other volcanic eruptions form the surface soil mantle over much of the Blue Mountains. These soils are poorly developed, low in nitrogen and sulfur, and structurally fragile. Excessive heating has the potential to remove much of the organic carbon, nitrogen, sulfur, and phosphorus and to break down soil structure. Research should determine the short- and long-term effects of fires of different intensities on soil structure and nutrients to gain a complete picture of the effect of fire on sustainable resource productivity.

Plant succession and vegetation diversity—Fire exclusion has altered the present course of plant succession, and it is certain that reintroduction of fire will change it again. Shifts in composition toward grand fir and Douglas-fir as the dominant tree species have been accompanied by the development of an understory representative of more mesic habitats. Seed reserves from pre-fire exclusion may no longer be viable, and sprouting species may have lost vigor to the extent that they no longer are a viable entity even when the overstory is removed. We therefore cannot presently predict how plant succession and vegetation diversity will respond to various intensities of fire, season of burn, and fire frequency.

Research should focus on the effects of fire and mechanical management alternatives on dynamics of plant succession and diversity of vegetation. Special attention should be given to the present kinds and amounts of seed reserves in the forest floor and soil and to the species and vigor of sprouting species. This should give some clues to successional direction after treatment.

Exploring Alternatives to Fire

Research also should examine the consequences of managing forest residues and large accumulations of biomass without fire. How do we stop the reinvasion of fir species without periodic fire? Can objectives accomplished by fire be achieved with the mechanical management of residues and the new tree crop? How serious are unnatural side effects of mechanical management, such as soil compaction? Can they be mitigated? Measures that can be implemented as part of harvest include leaving residues in place or rearranging them with lop and scatter methods. Excessive residues can be removed for the chip market in many instances. Chipping and leaving the material at the site is another alternative that needs examining for effects on soil nutrient availability.

Once the initial residue problem is under control and biomass-contained nutrients are protected, it is likely that fire will be a practical means of maintaining the desired stand structure and reducing invading grand fir. We need to explore options of a mix of mechanical and fire management measures.

Air Resource Management

Prescribed fire has the potential to degrade ambient air and impair visibility. Wildfires occurring despite attempts at fire exclusion also impact the air resource. Pollutant dispersal and potential public exposures from both scenarios need to be assessed and tradeoffs defined. Potential fire occurrence and emission production from various fire management options need to be described. Mitigation techniques for wildland burning emissions need to be developed and quantified. Fire managers, air regulatory agencies, and the public must be informed of the tradeoffs among increased prescribed fire programs, inevitable wildfire, ecosystem health, and public exposure to smoke.

Conclusion

The forests of the Blue Mountains have been struck by a forest health problem of unprecedented proportions. Several factors have coincided to produce massive forest mortality: prolonged drought, fire exclusion policies, and epidemic levels of insect infestations. Since the late 1980s, large-scale wildfires in the dead and dying forests have accelerated the rate of mortality.

Figure 4—Silvicultural prescriptions combined with prescribed fire need to be implemented gradually over time to reduce the large amounts of dead material in the forest and contribute to open forest conditions.

The Blue Mountain scenario has been reported in the literature since the 1940s: open ponderosa pine, larch, and Douglas-fir forests at lower elevations burned naturally at rather frequent intervals, on the order of 10 to 25 years, maintaining rather open, fuel-free stands with few fir trees. The larch and pine overstory was harvested extensively, fire was controlled, and the composition of the stands shifted towards an unnaturally dense understory of Douglas-fir and grand fir in the absence of fire. The spruce budworm for the past 10 years has been enjoying a steady diet of Douglas-fir and grand fir, which has led to tree mortality, fuel buildup, and high-intensity wildfires.

The solution to this problem seems straightforward, but it has some huge barriers. The solution should start with harvesting what fir is possible without causing environmental impacts and retaining larch and ponderosa pine in the overstory for future regeneration purposes. Prescribed fire on a fairly large scale should be coupled with silvicultural methods whenever possible to enhance natural or planted regeneration of larch and pine (fig. 4). Where large quantities of standing dead trees are present, salvage logging should be encouraged to remove unnatural accumulations of fuels and obtain wood products. In areas where large quantities of downed dead woody material cannot be removed mechanically, two or three prescribed fires at high fuel-moisture levels might be needed to restore desired conditions without adverse impacts. This strategy would reduce the amount of fir in the stands over time and substantially reduce the threat of future insect infestations and large-scale wildfires. Over the long term, many of these forests could have silvicultural partial-cutting treatments to favor retention of an open overstory of pine and larch along with periodic underburning.

Managing for healthy forests in the Blue Mountains will depend on how well we can overcome internal and external barriers to burning on a scale large enough to make a real difference. The question of scale is a critical one. Each of the three National Forests in the Blue Mountains, the Wallowa-Whitman, the Umatilla, and the Malheur, currently burn about 1,500 to 2,000 acres per year. Staff at those Forests believe that they should each be burning about 20,000 acres a year to achieve immediate resource management objectives. Potential problems are numerous when we contemplate an annual change in prescribed burning in the Blue Mountains from 6,000 to 60,000 acres: air quality, sedimentation in anadromous fisheries, wildlife cover, visual quality, funding, and risk of fire escapes to name a few.

But if we embark on a major paradigm shift toward ecosystem management, then are we not going to have to make a shift in the way that we value such individual outputs as smoke particulates, sediment load, percentage of wildlife cover, and visual quality objectives? Placing the priority on valuing the health of entire ecosystems will require increased understanding and tolerance on the part of natural resource specialists and managers, as well as on the part of the general public, politicians, and regulatory agencies.

If we are not prepared to make the necessary changes to manage successfully for healthy and sustainable ecosystems, then the consequences of maintaining the status quo will be the aggravated increase of severe forest mortality resulting from insect and disease epidemics and high-intensity wildfires. We have taken drastic steps in attempting to exclude fire from fire-dependent ecosystems in the past. Now bold steps must be taken to effectively manage ecosystems with all processes in place, including prescribed fire and other treatments to the landscape in large enough and correct enough doses to make a difference.

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The fire-adapted forests of the Blue Mountains are suffering from a forest health problem of catastrophic proportions. A managment strategy to restore forest health will require that the seral ponderosa pine and western larch stands be managed for much lower tree densities and an open coniferous understory. A combination of silvicultural partial cutting and prescribed fire on a large scale will be needed to produce the desired future condition of healthy, open, and parklike forests.

Keywords: Forest health, ecosystem functions, fire, Blue Mountains.

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