# FIR Report

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## Special Fire Issue



OREGON STATE UNIVERSITY EXTENSION SERVICE

## FORESTRY INTENSIFIED RESEARCH

SERVING SOUTHWEST OREGON THROUGH RESEARCH AND EDUCATION

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COVER PHOTO

The cover photo illustrates a burned area within the Siskiyou National Forest that is typical of much of the forest burned in southwest Oregon during 1987's fires. Photo courtesy of the Siskiyou National Forest.

The Southwest Oregon Forestry Intensified Research Program (FIR) is a cooperative effort between the College of Forestry at Oregon State University and the Pacific Northwest Research Station of the USDA Forest Service. The FIR Program assists foresters and other resource management specialists in solving complex biological and management problems endemic to southwest Oregon. FIR specialists organize, coordinate, and conduct educational programs and research projects specifically tailored to meet the needs of this area.

Established in October 1978, the FIR Program is supported jointly by Oregon State University, the Bureau of Land Management, USDA Forest Service, O&C Counties, and the southwest Oregon forest products industry. It represents a determined effort by the southwest Oregon forestry community and county governments to find practical solutions to important forest management problems.

The "FIR REPORT" is one of the principal methods of reporting recent technological advances and research results pertinent to southwest Oregon, and alerts area natural resource managers to upcoming continuing education opportunities. Comments and suggestions concerning the content of "FIR REPORT" are welcome and encouraged. This newsletter is prepared quarterly and is mailed free on request by contacting us at this address: FIR REPORT, 1301 Maple Grove Drive, Medford, OR 97501.

For the FIR Staff,

Ole T. Helgerson
Reforestation Specialist

# Inside

This summer's historically large wildfires in Oregon and California created special problems for land managers. The goal of this issue of the FIR Report is to present information that will help individuals and organizations in solving these problems.

In departure from past issues, articles are organized by main headings that correspond to major management concerns with additional sources of information listed in the bibliography. The writers of these articles have summarized existing information and presented new ideas of use to silviculturists, biologists, soil scientists and land managers. Because of space limitations, articles focus primarily on southwest Oregon fires. We hope, however, that this information is also useful to readers elsewhere.

Special thanks are due to those who prepared articles for this issue under a short deadline; personnel from the Umpqua, Siskiyou and Rogue National Forests, Region Five of the U.S. Forest Service, and the Oregon Department of Forestry for contributing statistics; the 'Forest Log' of the Oregon State Department of Forestry for use of the map showing fires in southwest Oregon; and to all others who helped.

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# Introduction

## HISTORIC FIRE YEAR FOR OREGON AND CALIFORNIA

Fire is an integral part of the natural history of forest ecosystems in Oregon and California, and this summer's fires were especially historic in their magnitude and duration. An unusually dry spring, summer and fall caused this most recent fire season to start earlier and last longer than is typical. A lightning storm in the week of July 15 started several fires in southwest Oregon, but accompanying rain and cool weather allowed firefighters to quickly control these blazes. Two fires caused by humans during this time, however, grew into major conflagrations before being controlled.

A more extensive lightning storm arriving on August 30 started fires throughout California and Oregon. In Oregon, more than 600 fires started in Douglas, Josephine, Jackson and Klamath counties from more than 1,600 lightning strikes recorded within a 12 hour period starting on August 30. Subsequent weather remained hot and dry, allowing individual fires in Oregon and California to expand rapidly, often combining with adjacent fires. Inversions slowed firefighting and increased hazards to firefighters. The large number of fires and their extent strained the resources available for fire fighting, also allowing individual fires to expand. Most of these fires were brought under control by the end of October, but the last major fire in southwest Oregon, the Silver Fire Complex, was not controlled until rains fell in early November.

The phrase "fire complex" gained broad use during this 1987's fire season. This phrase refers to groups of expanding and coalescing individual fires that were large enough to require staffing and logistical support as a manageable unit. This concept was first used in Oregon in 1986 in fighting wildfire in the northeast part of the state according to Tim Keith, District Forester, Oregon Department of Forestry. The geographical extent of a fire complex is determined by terrain, transportation routes, and availability of fire fighters and equipment as well as the number, spread and location of individual fires. A fire complex may also be referred to as a fire, or as a complex as in the Silver Fire or Silver Complex.

In southwest Oregon (Douglas, Josephine and Jackson Counties), 39 large and small fires burned more than 183,000 acres of forest land. Sixty-six percent of these burned lands are managed by the USDA Forest Service, 23 percent by the USDI Bureau of Land Management, with the remainder composed mostly of industrial forest land, with smaller amounts of non-industrial private forest lands and county-owned lands (Table 1). Elsewhere in Oregon, more than 11,000 acres burned on six fires located on the Malheur, Winema, Fremont, Deschutes and Willamette National Forests. Including two east-side fires (Kitts Mills and Cowboy), fourteen fires of more than 1500 acres each, burned in southwest Oregon (Figure 1).

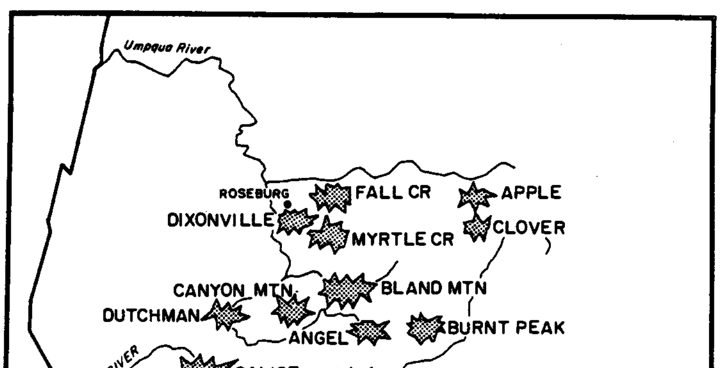


FIGURE 1.--Major fires of 1987 in southwest Oregon.

TABLE 1.--Southwest Oregon fires from August 30 lightning storm and two major fires from July.

| Fire Name | Acres burned by ownership: USFS (Forest)[1] | BLM (District)[2] | State | Other[3] | TOTAL | Approx. location of fire center: TWP | RGE | SECT | County |
|---|---|---|---|---|---|---|---|---|---|
| Packsaddle | | 58(R) | | 100 | 158 | 29S | 4W | 18 | Douglas |
| Little Lick | | | | 1113 | 1113 | 29S | 5W | 12 | Douglas |
| School Hollow | | 19(R) | | | 19 | 29S | 4W | 17 | Douglas |
| Big Lick | | 224(R) | | 225 | 449 | 29S | 4W | 7 | Douglas |
| Frozen Creek | | 265(R) | | 2164 | 2429 | 28S | 5W | 25 | Douglas |
| White Rock | | 2(R) | | 17 | 19 | 28S | 3W | 21 | Douglas |
| Lane Mountain | | 3(R) | | 88 | 91 | 27S | 4W | 26 | Douglas |
| Buck Creek | | 798(R) | | 688 | 1486 | 32S | 7W | 10 | Douglas |
| Canyon Mountain | | 3586(R) | | 1591 | 5177 | 31S | 5W | 15 | Douglas |
| Whitehorse | | 261(R) | | 90 | 351 | 32S | 4W | 26 | Douglas |
| Dutchman Butte | | 116(R) | | 60 | 176 | 31S | 8W | 21 | Josephine |
| Upper Myrtle Creek | | 1656(R) | | 1676 | 3332 | 28S | 4W | 12 | Douglas |
| Dodson Butte | | 2(R) | | 1124 | 1126 | 28S | 5W | 23 | Douglas |
| Fall Creek | | 1503(R) | | 1717 | 3220 | 27S | 3W | 20 | Douglas |
| Bland Mountain[a] | 1(UNF) | 3804(R) | 15 | 5774 | 9593 | 30S | 3W | 32 | Douglas |
| Angel Complex | 1695(UNF) | 450(R) | 680 | 500 | 3325 | 32S | 3W | 36 | Jackson/ Douglas |
| North Umpqua RD (misc) | 254(UNF) | | | | 254 | scattered | | | Douglas |
| Rocky Ridge[b] | 890(UNF) | | | | 890 | 28S | 3E | 21 | Douglas |
| Rogue/Umpqua Divide[c] | 265(UNF) | | | | 265 | 28S | 3E | | Douglas |
| High Rock | 190(UNF) | | | | 190 | 28S | 3E | 17 | Douglas |
| Apple | 2415(UNF) | | | | 2415 | 26S | 1E | 27 | Douglas |
| Clover | 1550(UNF) | | | | 1550 | 27S | 1W | 23 | Douglas |
| Jack | 153(UNF) | | | | 153 | 21S | 1E | 11 | Douglas |
| Snakebones[a] | 596(UNF) | | | | 596 | 24S | 2E | 5 | Douglas |
| Galice Complex | 5285(SNF) | 15120(M) | | | 20405 | 34S | 8W | 19 | Josephine |
| Longwood | 9916(SNF) | 110(M) | | | 10026 | 41S | 8W | 15 | Josephine |
| Silver Complex[d] | 96540(SNF) | 600(M) | | | 97140 | 36S | 10W | 13 | Josephine |
| Sykes Creek | | 6711(M) | | 3602 | 10313 | 34S | 3W | 29 | Jackson |
| Savage Creek | | 2799(M) | | 1232 | 4031 | 37S | 4W | 8 | Jackson |
| Ninemile Creek | | 1596(M) | | 45 | 1641 | 39S | 4W | 20 | Jackson |
| Kinney Mountain | 468(RNF) | | | | 468 | 40S | 4W | 23 | Jackson |
| Quartz Gulch | 10(RNF) | 286(M) | | | 296 | 40S | 2W | 2 | Jackson |
| Nine Dollar | 67(RNF) | | | | 67 | 39S | 4W | 36 | Jackson |
| Star Gulch | | 1735(M) | | | 1735 | 39S | 3W | 20 | Jackson |
| Rattlesnake[c,e] | 745(RNF) | | | | 745 | 47N | 12W | 15 | Siskiyou |
| Rock Creek | | 40(M) | | 228 | 268 | 33S | 3W | 11 | Jackson |
| Eagle Creek | | 282(M) | | 7 | 289 | 39S | 3W | 12 | Jackson |
| Sugar Pine | | 80(M) | | | 80 | 34S | 2E | 19 | Jackson |
| Lodgepole | | 28(M) | | 27 | 55 | 34S | 3E | 11 | Jackson |
| Burnt Peak | | 1351(M) | 195 | 2547 | 4093 | 32S | 1W | 34 | Jackson |
| Total | 121040 | 43485 | 890 | 24615 | 190029 | | | | |

1 UNF, Umpqua National Forest; SNF, Siskiyou National Forest; RNF, Rogue River National Forest

2 R, Roseburg; M, Medford

3 "Other" category composed mainly of industrial forest lands, with lesser amounts of non-industrial privately owned lands and county lands.

a Human caused, started July 15

b 288 acres in wilderness designated land

c wilderness designated land

d 51540 acres in wilderness designated land

e land located in California, but managed by RNF

In California the fires were more extensive. An estimated 775,000 acres burned in 29 major fires located primarily on national forests in the northern part of the state. These consumed approximately 3.5 percent of the National Forest land in California. Only 70,000 acres of this total were outside National Forest boundaries.

These fires provide foresters, land managers and forest scientists with unique opportunities--and problems. Foresters and managers are quickly evaluating damage and establishing work priorities for post-fire rehabilitation. Researchers have special opportunities to not only observe and measure the effects of wildfire on our forest ecosystems, but to also provide information to aid in the rehabilitation process that has started.

Within this process, technical information is needed to define management options. For example, FIR study plots located on the Tin Pan Peak Burn of 1981 (Figure 2) show that a potential for high survival and growth exists for seedlings planted on droughtier sites in burned areas. With information such as this available managers can focus on marshalling other resources to accomplish reforestation, or watershed protection and timber salvage programs. This issue of the FIR Report is devoted to the task of post-fire management. In it, scientists, silviculturists and land managers present knowledge and approaches that bear on defining and solving interrelated problems in watershed protection, timber salvage, and reforestation that were caused by this summer's wildfires.

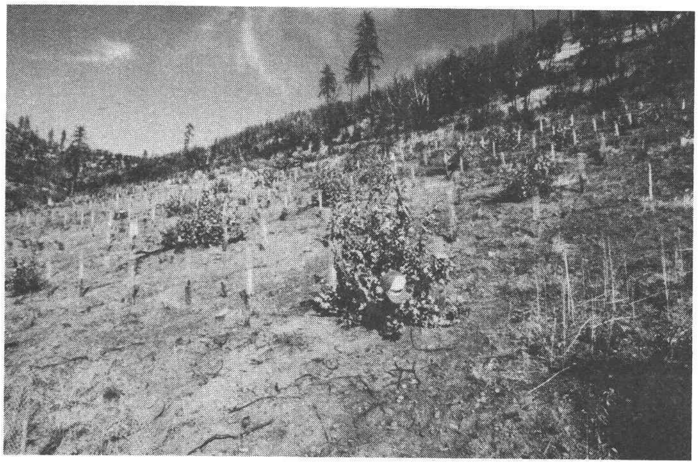

FIGURE 2.--Tin Pan Peak study plots in October, 1982, 8 months after planting (above), and in September, 1987 (below).

Ole Helgerson
Adaptive FIR

# The Fire Environment

## FIRE AND FORESTRY IN SOUTHWEST OREGON

### Importance of Fire

The dominant structure and composition of vegetation is usually determined by intense periodic events, such as flood, wind, volcanic eruption, or fire, rather than by long-term average climatic or site conditions. For example, the results of decades of constant- but gradual- erosion were much less pronounced than the changes that occurred in just eight hours during the eruption of Mt. St. Helens. Such disturbances reset succession, allowing an influx of pioneer species and sprouters at the expense of the more sensitive, climax or late successional species. These events are often labeled catastrophic from a human point of view; however vegetation has evolved with and because of these intense, repeated disturbances. Such events maintain a diversity of species and ecosystem health.

Fire has been, for thousands of years, one of the most important periodic disturbances in the Pacific Northwest (Volland and Dell 1981, Agee 1981). Species composition and richness (diversity), stand structure, and the extent of old-growth forests are primarily dependent on the fire regime--how fire occurrence varies in time and space, although long-term effects on site productivity, including processes such as nutrient cycling and mycorrhizal relationships, are still poorly understood.

### The Fire Environment and Fire Regime

The effects of fire depend on its variability over time and space. The frequency, intensity, and duration vary in time; the extent and distribution vary over space. These variables define the fire regime that is dependent on the fire environment. The three most important factors in the fire environment are weather, fuels, and topography. Ignition source can be important. Records show that lightning- and man-caused fires are common in all areas of southwest Oregon.

Insight into past fire environments and regimes is gained by studying evidence of past fires. Charred snags, charcoal in the soil profile, even-aged stands, and fire scarred trees are all evidence of past fires. In most cases the year of the burn can be estimated; fire scars are the most accurate evidence. They often provide frequencies, and an indication of intensity. Small trees (less than 9 inches in diameter) that survive a fire are evidence of low intensity underburn. The boundaries (extent) can sometimes be estimated by species or age class patterns. Brushfields, hardwood stands, and even-aged stands of conifers are often fire generated. These patterns exist virtually everywhere in southwest Oregon.

## The Fire Regime of Southwest Oregon

Southwest Oregon has had a long history of major wildfires (Cooper 1939). Soon after the establishment of the Siskiyou National Forest in 1907, 179,000 acres burned in 1917 and 152,000 in 1918. Numerous other fires occurred during the first half of the century, with 1938 one of the worst years, having 50,777 acres burned. This year, 1987, is the third worst on record for the Siskiyou National Forest. Factors contributing to all of these large wildfires include long summers; high to extreme fire weather conditions (strong easterly, dry winds and lightning, steep terrain); large amounts of fuels; and limited access.

### Spatial Variation

The coast. The fire regime along the coast is dominated by the marine climate, with typically wet and foggy summer weather. Only fine fuels commonly dry out and large fuels retain moisture even during dry summers. (Fine fuels support ignition, carry the fire, and influence the rate of spread. Large fuels create the intensity and resource damage. Wet fuels, fine or coarse, do not ignite or carry a fire.) Productivity is high and fuels such as shrubs, branches, and dead trees accumulate rapidly. When lightning (the natural ignition source) occurs, the forest is usually too moist to ignite, or burns very slowly, despite an abundance of fuel.

Large fires typically occur, and after several extremely dry years are usually intense and extensive. The Tillamook and Oxbow burns are well known examples. The Coos Bay Fire of 1886 (300,000 acres) and the Bandon Fire of 1936 (144,000 acres) are less well known, but are indicative of the coastal fire regime. Fire-generated stands of Pacific madrone and tanoak on the Chetco River Basin are also indicators of the coastal fire regime. Surviving Douglas-fir have scars 90 to 150 years apart and the even-aged hardwood stands are often within that age class, evidence that major stand regenerating fires are infrequent.

The crest of the Coast Range. Summer fog and precipitation are infrequent enough to allow moderately sized fuels to cure. Productivity, except on serpentinitic and granitic soils, is high and fuels accumulate quickly. Moreover, dry lightning occurs often enough to provide an ignition source every year.

Fire occurrence in this area is extremely variable as indicated by fire scars and plant communities. Many areas are occupied by even-aged stands of fire-dependent species such as manzanita and ceanothus (Burnt Ridge, Onion Mountain) Pacific madrone, knobcone pine, and 80 to 90 year old Douglas-fir. In contrast, small stands of western hemlock can also be found in north facing, protected concavities. The presence of this sensitive climax species indicates that the site has not been burned, or burned very lightly since regeneration of the western hemlock. One area contained trees over 190 years old, with no evidence of having been burned, while a 196 year old tree in another area had a fire scar 22 years old. A ponderosa pine, too large to age, contained eleven fire scars dating to 1814, 1826, 1833, 1843, 1866, 1881, 1892, 1902, 1910, 1925, and 1980, for an average period between fires of about 17 years. We feel this tree represents the extreme and that a fire-free period of about 50 years, as based on stand age data, is generally more representative of this area.

Fire frequency along the crest is approximately twice that of the coast. Thus, the average fire will consume half as much fuel, and generally be lower in intensity, assuming that fuel accumulation rates are the same. Although fire intensity is negatively related to frequency, fire extent seems to be more dependent on accumulated drying and current weather.

Inland forest. Summer precipitation is rare, fuel production varies significantly between plant associations, and dry lightning occurs regularly. Fire frequency in productive plant associations (such as white fir) on south-facing, dry slopes is greater than in more north-facing counterparts. Frequencies averaging 20 years have been commonly found between Cave Junction and the Ashland Watershed (Atzet 1979; Atzet and Wheeler 1982).

Elevational differences. The occurrence of fire also varies with elevation. Rates of fuel production and drying tend to decrease as elevation increases. Decomposition of forest floor material is also slower. Only 22 percent of the Shasta red fir plots showed evidence of fire, whereas 39 percent of the low elevation Douglas-fir sites were burned.

### Temporal Variation

The fire regime varies with long-term weather cycles such as the ice ages or the more recent xerothermic period (a 4000-year-long period of elevated temperatures that ended 4000 years ago). However, we will deal only with the variation in the last 200 years, the period during which the present vegetation developed.

The present era (1910-present). Many plots throughout Southwest Oregon have fire scar patterns similar to the previously described ponderosa pine. Fire occurred at somewhat regular intervals prior to the most recent 50 to 70 years that are relatively fire-free. Forest records show that many fires were controlled during this latest period with literally hundreds of fires extinguished during some years (Cooper 1939, Siskiyou National Forest Records). This era of fire control has successfully reduced fire occurrence and the number of acres burned, and has lengthened the fire-free period, but has allowed fuels to accumulate.

The settlement era (1820-1910). Hudson Bay Company trappers, miners, ranchers, and other settlers valued forest resources other than timber. They used fire to eliminate vegetation, drive game, enhance forage opportunities, and clear land for ranching. Fire was forced on the land, regardless of fuel loads or moisture content. Thus, frequencies recorded in trees alive during that era such as the previously described ponderosa pine, may overestimate "natural" rates.

The pre-settlement era. Indians used fire to maintain hunting grounds. Fire kept shrubby vegetation within reach of game animals and sighting distances short. It is reasonable to believe that fire suppression was not widely practiced and that frequencies prior to 1820 are somewhat representative of "natural" occurrence rates for present weather conditions and vegetation types. However, we have the least information for that era.

## Summarizing Variation

Occurrence and behavior of fire are not completely random. They depend on an ignition source; fuel; weather conditions, particularly when they are extreme or an accumulation of several extreme years; and topography. All of these factors and the fire environment vary over time and space. Thus the resolution of fire regimes on a highly variable landscape requires site specific interpretation; averages make little sense.

## Fire Effects

The Angel, Longwood, and Silver Fires (in the Cow Creek, Takilma, and Kalmiopsis areas, respectively) did not burn uniformly. Within a fire's perimeter, some areas burned severely enough to be stand-replacement fires (all above-ground portions of the vegetation killed and over half of the forest floor materials consumed). But significant portions of each major fire either underburned (the fire crept on the forest floor, killed some shrubs and herbs, and consumed less than 25 percent of the duff layer) or were not burned at all. Such behavior typifies historic fire occurrence patterns.

For the Silver Fire, estimates of the area severely burned range from 15 to 20 percent, including brushfields, young plantations, and mature forest. Observation suggests that early seral stages burned the hottest and most completely. Young conifer stands, hardwood stands, and brushfields have densely distributed fine fuels (horizontally and vertically), and present a high-risk fire environment.

The percent of the Angel Fire that burned hot was in the same range as the Silver Fire, however, young plantations seem to have burned the hottest.

Estimates of intensely burned area on the Longwood Fire range from 30 to 50 percent. Although a variety of age classes and vegetation types were burned, observation again suggests that young plantations, and harvested units represented a greater proportion of the area severely burned.

The Longwood and Angel Fires were quickly controlled; therefore, the acreage burned is not likely to reflect the natural potential. The Silver Fire, however, burned significantly longer and more closely indicates the "natural" fire regime. Interestingly, it also overlapped greatly with the Cedar Camp Fire of 1938 that burned 34,670 acres just south and west of the Silver Fire.

## Natural Recovery Processes

Natural recovery rates and the species involved depend on the intensity of the burn and the species that occupied the site before the fire. For low intensity fires, species composition will change relatively little, except for aggressive invaders, usually herbaceous composites. For intense fires, plant composition can change radically.

## Strategies

Plant response can be categorized into any of four non-mutually exclusive categories: they succumb, resist, sprout, or reproduce. Even plants that are mortally wounded can, and often do, produce one last seed crop.

Western hemlock and white fir are examples of species that have thin bark and are often killed by low intensity fire, particularly when they are less than 9 inches in diameter. Both are climax species that tend to gradually dominate undisturbed sites. Their recovery depends on seed from nearby unburned "islands". Reinvasion can occur immediately but may take decades to centuries, depending on the intensity, frequency, and extent of burning.

Species with thick bark and bud scales (insulation) may often survive with no damage, or with less than mortal damage, to the living tissues in the buds or cambium. Douglas-fir, coast redwood, and ponderosa pine are examples of seral species that resist low intensity, frequent fires. In fact, their continued existence is somewhat dependent on fire or other disturbances. If they survive, they usually take advantage of newly available resources.

One of the most efficient methods of survival and recovery is sprouting. Even after intense fire the underground portions of many species remain undamaged. Sprouting takes advantage of existing root systems and associated stored carbohydrates without the wait for producing reproductive structures. Sprouting also assures that an adapted genetic strain will be faithfully reproduced.

The stimuli to sprouting are immediate and include heat and leachates of ash or charred wood (Keeley 1987). Tanoak, Pacific madrone, manzanita, elderberry, dwarf Oregon grape, little wood rose, salal, thimbleberry, blackberry, vanilla leaf, inside-out-flower, violet, western fescue, and brome were found within an acre on the Silver Fire four weeks after it burned. Tanoak sprouts were already eight inches tall and grasses had been browsed. Many species of the lily family, which reproduce from underground bulbs, also fit in this category. They survive underground but will not appear until spring.

Rather than produce seed in response to fire, some seeders produce seed and store it. Knobcone and lodgepole pine are examples of species that store seed, protected within a cone. Seeds from blueblossom ceanothus and snowbrush are stored in the soil and remain viable for hundreds of years. Heat and leachates stimulate or scarify the seed in preparation for germination.

Other seeders produce consistent and copious crops which are light and wind carried. They land all over but germinate on recently disturbed mineral soil free of competition. The fireweeds, groundsels, pussy-toes, asters, fleabanes, and other herbaceous composites use this strategy. They will begin to appear in the spring and summer.

## Human Influence

Human activities have significantly increased the potential for ignition, often igniting more fires than lightning. But the most profound effect is from the manipulation of fuels. Harvesting, fire prevention and suppression activities, fuels management, and other silvicultural activities have changed the density, distribution, and continuity of fuels. By altering microsites these activities also affect localized drying of fuels.

Harvest activities remove some fuels but rearrange and allow the drying of those remaining. Often the loading, distribution, continuity, and arrangement of size classes of slash requires fuel treatment to reduce the fire risk and resistance to control. The end result is usually the removal or consumption of a significant amount of organic material. Subsequent fire intensity, frequency, duration, and extent are highly likely to be reduced in this way. However, newly reforested young stands provide a horizontal and vertical continuum of flashy fuels that carry fire well.

We can assess the results of human influence on the fire regime on a site-specific basis and sometimes within a watershed. Such variation is on a scale we can measure and analyze without too much speculation. We have increased the frequency of fire, and likely reduced its intensity and extent in managed forests; and in some cases reduced its frequency and increased its intensity where we have attempted to exclude fire (e.g., wilderness). However, with the wide range of variation just since the settlers arrived, and the natural, spatial variation from the coastal to the inland forests, much more work needs to be done before we can do more than speculate on the influence of human activities. On the large scale, human-caused changes may be insignificant in a fire environment that we are powerless to control.

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David Wheeler
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## GENERAL WEATHER SUMMARY OF THE 1987 FIRE SEASON

This was the third consecutive year of below normal precipitation over southern Oregon. For 1985, 1986, and 1987 (September 1 through August 31st), the amounts recorded at the Medford airport were 15.77 inches, 15.98 inches and 16.30 inches which were respectively 4.07, 3.86 and 3.54 inches below normal. The Palmer drought index showed drought conditions early in the year. Although the 1986 fire season was a drought year, by comparison the 1987 fire season started out drier and got an early rolling start. The weekend before fire season officially opened, 70 fire fighters were battling fires in the Evans Creek Valley near Prospect. Fire management personnel were quoted at that time as saying that they were seeing a fire intensity normally not seen until late June.

The 1987 fire season opened three weeks earlier than normal and lasted until November 12th, a total of 186 days, which was the longest fire season on record. The previous record for longest fire season was 148 days in 1978. An example of the dryness that started this season was a comparison of the snowpack at Crater Lake National Park near the 6100 foot level, which was 2 inches on June 1, 1987 compared to 53 inches on that date in 1986, which was also a drought year. The normal snowpack for that date is 58 inches. Thousand hour fuel moistures were already in the teens to mid 20s in April and were running 5 to 10 percent lower than the April 1986 readings. Many high temperature records were broken throughout Oregon this summer while above normal temperatures and dry airmasses produced month after month of below normal precipitation over the district.

From June 26th through 29th, a weak upper level low pressure area spread moisture inland over the district to prompt red flag warnings for dry thunderstorms over zones 613 (Cascade Mountains from Crater Lake to California) and 614 (the Klamath Basin). Over 143 lightning fires were reported during that period on the east-side of the district. As moisture increased, the thunderstorms became very wet, prompting a flash flood watch, and on June 30th, 1.5 inch diameter hail fell from these thunderstorms near Klamath Falls.

The thermometer surged far above normal in July, with the Medford Airport reporting record temperatures of 107°F on the 13th and 14th. This abnormally dry airmass set the stage for fire starts near Canyonville and Cantral. The Bland Mountain Fire started in this hot, very dry airmass, and was fanned by a strong onshore flow created as an upper level low pressure area over western Canada pushed a pool of cool air south to a position off the Oregon coast. Relative humidities in the fire area dropped to as low as 7 percent as these onshore winds developed. The cold upper low then moved to a position off the south Oregon coast and pumped rain inland to help control the blaze. The cold air from this weather system dropped snow levels on July 17 low enough so that 4 inches of snow were reported at the 6100 foot level at Crater Lake National Park, but this was not soon enough to prevent the 10,600 acres burned and two fatalities at the Bland Mountain Fire. As unusually large, tragic, and costly as the Bland Mountain Fire was, it was only the next critical level in the evolution of the "Summer of Fire."

An upper level ridge remained over the district for most of August, continuing to dry the fuels within this area. By the end of the month, fire managers on the Fremont National Forest reported that the burn index was the highest on record. Relative humidities during daytime hours ran 10 to 20 percent from August 26 through August 30, with little recovery on the ridges. Longer range forecasts from the Medford Fire Weather Office expressed caution regarding the early stages of an evolving thunderstorm pattern, and as an upper level low pressure area developed off the California coast on August 29, the Medford Fire Weather Office issued a red flag watch for dry thunderstorms. Red flag warnings were issued on the morning of August 30 as moisture headed northward for the district. The birth of southern Oregon's most historic fire outbreak was underway (Figure 1).

September was one of the driest on record, with above normal temperatures in spite of smoke filled valleys. A thermal trough repeatedly built up along the coast and meandered back and forth across the fires. Due to the tinder dry conditions, an unusually high number of red flag warnings were issued as even moderate east wind patterns threatened a dramatically increased fire danger.

October followed this trend, and as control was reported on various smaller fires, the huge Silver Fire continued to rage. Records for the lowest 1000 hour fuel moistures were broken or tied in several locations in mid-October, with Bald Knob dropping to a 20 year low at 10 percent and Quail Prairie tieing a record

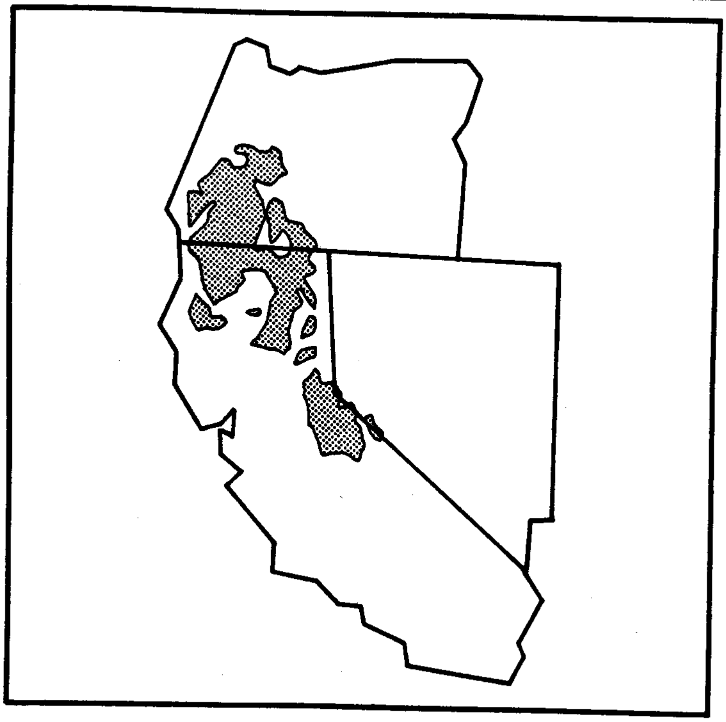

FIGURE 1.--Major lightning activity in southwest Oregon and northern California for 24 hours ending 0500 PDT, August 31, 1987. Data from USDI Bureau of Land Management, organized by the National Weather Service.

with a reading of only 9 percent. The Medford airport went through October without rain, and as an upper level low off the California coast brought wetting rains to the northern California fires, only some light sprinkles made it to the Silver Fire, but the increase in relative humidity from this weather system helped suppression efforts.

At the very end of October and the beginning of November, the jet stream finally made its way farther south over the Pacific Ocean and pushed welcomed rain inland over the district. The 99 day period without measurable rain at the Medford airport, that ended on November 1st, was the 4th longest dry spell on record. As moisture continued to surge along the jet stream and inland over the district, the fire season was finally called to a close on November 12th, a record 186 days from its ominously active start.

Fire starts for the 1987 season on the Medford Fire Weather District totaled 590 human caused and 1,195 lightning caused, with over 233,000 acres burned. The Siskiyou National Forest alone reported 112,048 acres, most of which were burned in the Silver Fire.

For more information, or to obtain a copy of the "Annual Fire Weather Survey - 1987," from which this article was taken, contact us at the Medford Fire Weather Office, 4000 Cirrus Drive, Medford, OR 97504, (503) 776-4304.

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# Soils and Watershed Protection

## WHAT IS THE POTENTIAL FOR SOIL EROSION AFTER WILDFIRE?

The potential for soil erosion on sites recently burned by wildfires is largely due to the reduction of organic material on the forest floor and to a lesser extent the loss of canopy. Whether erosion increases or not, however, depends on the timing and intensity of major storm events over the next few years and the recovery of vegetation covering the soil. Fire-caused changes within the soil that will increase erosion are probably minor.

### Water Repellency

Some water repellency of forest soils in southwest Oregon is natural and it often increases following burning. Based on a FIR study of prescribed burning of a site south of Grants Pass (Spring-White) where 67 percent of the soil was exposed by fire, water repellency increased after burning, remained higher than unburned controls throughout the summer, but disappeared following the first few fall rains (FIR Report 5(4):4). Water repellent soils have been identified on several of the wildfire sites of this past summer, but the water repellent layer was thin and discontinuous.

For water repellency to increase surface erosion, the infiltration capacity of the soil must decrease to less than the precipitation rate anticipated in storms. Based on the Spring-White data, prescribed burning reduced the infiltration capacity of the soil; however, the lowest infiltration capacity measured was 5.3 cm/hr (2.0 in/hr), with 94 percent of the observations exceeding 9.0 cm/hr (3.5 in/hr). The infiltration rate increased as the soils became thoroughly wetted in the first fall rain storms. Similar measurements of infiltration capacity on sites in the Longwood, Galice, and Silver Complex wildfires by the watershed staff of the Siskiyou National Forest found infiltration capacities to be highly variable and areas of low infiltration to be small and discontinuous. Preliminary results obtained from Alan Smart of the Siskiyou National Forest indicate that infiltration rates of 13 severely burned, non-serpentine soils were at least 3.8 cm/hr (1.5 inch/hr) and those of 4 serpentine soils ranged between 1.5 and 3.0 cm/hr (0.6 and 1.1 inch/hr). These measurements are continuing in an effort to identify higher risk sites which may need additional erosion control efforts.

### Surface Sealing

An increase in erosion from burned areas is most likely to result from either raindrop splash on exposed soil, or large storm events that saturate the soil profile, causing water to flow overland. The loss of soil cover affects the potential for increased erosion from both of these reasons.

Observable changes in the soil surface and resulting erosion result from raindrop splash rearranging soil particles and destroying weak aggregates because of the loss of potential cover. As a result, the bulk density of the surface soil and the concentration of coarse fragments on the surface increase. After three years at Spring-White, bulk density of the fine soil at the 0-5 cm depth on the burned plots was 0.50 $Mg/m^3$ compared to 0.28 $Mg/m^3$ in unburned plots. The concentration of coarse fragments from raindrop splash and sometimes from frost heave over winter will help armor many of the soils counteracting further effects of splash and reduce the velocity of surface flow. Raindrop splash produces a soil surface which appears to be seriously eroded, but this may be deceiving. Accumulation of sediment behind logs, in depressions, and in channels where eroded material in overland flow should accumulate is a better indicator of surface erosion.

A live plant canopy reduces the potential for erosion from raindrop splash and overland flow. A canopy temporarily intercepts raindrops, reducing the velocity at which they strike the ground. Some intercepted precipitation also flows down the stem to the ground. The plants also produce litter to cover the exposed soil, reducing surface sealing and velocity of any overland flow.

### Rainfall Intensities and Erosion

Major storm events may saturate the entire soil profile, causing water to flow laterally through the soil at or on the surface. Loss of the forest floor, and not changes in the infiltration capacity, is most likely to increase erosion during these storms because of the hydrologic properties of the lower soil profile and parent material. The infrequency of large storms combined with the increased armoring of exposed soil protects the soil from erosion by overland flow. The greatest potential for erosion will occur if large storms occur this fall and winter before the soil becomes armored and cover is reestablished.

Winter storm intensities greater than 5.0 cm/hr (2.0 in/hr) are rare, although they have occurred. The two largest storms of the last 10 years yielded 24 and 37 cm (9.5 and 14.6 in) of rain in 24 hours (FIR Report 5(2):10-11) at sites west of the Silver Complex Fire, with maximum one-hour intensities of only 2.1 and 2.9 cm (0.83 and 1.1 in.), respectively. Intensities most often ranged between 0.8 and 1.8 cm/hr (0.31 and 0.71 in./hr). During the last 5 years, the maximum storm intensity recorded at a FIR research site between the Silver and Galice Complex fires was 1.0 cm/hr (0.39 in/hr). Thus, wildfire induced changes in the infiltration capacity of the soil that have been measured recently should not affect the potential for erosion. The direct effects of wildfire on soils are less in southwest Oregon than other regions because of the relatively thin forest floors common in the region.

### Grass Seeding

The widespread seeding of cover crops will only reduce surface erosion for a specific set of events. Seeding has the greatest potential to reduce erosion if an adequate cover can be established before the first large storms occur. During subsequent years, natural cover and armoring of the site will reduce the potential for erosion. Unfortunately, the success of late fall seeding to develop an adequate cover is expected to be poor and may be less so this year because of the unusually dry fall. However, some burned areas sown with annual ryegrass shortly after the fires show good germination, that may provide some protection where temperatures remain high enough to allow continued growth.

The Spring-White infiltration study clearly shows that grass seeding is not required on every burned acre. This is also supported by our experience with thousands of acres of slash burning. Further, the seeding rate in selected areas may be relatively low. Ground cover of as little as 35 percent has been shown effective in reducing erosion. Seeding of annual rye at 5 to 7 pounds per acre should serve to provide cover for forest land. For fire trails and other heavily disturbed sites, the rate may need to be two to three times higher.

### Riparian and Channel Treatment

Intensively burned riparian areas generally need more protection than upslope land, especially on granitic and some serpentine soils. Highly successful treatments used on the Bend Watershed Fire included felling fire-killed trees on contour to trap sediment. Large woody debris already on the forest floor was also bucked and shifted by hand as needed to create barriers to soil movement. Pieces as small as four-inches in diameter and 10 feet long were used. In the 1970 Quail Creek Fire along the Rogue River, numerous "gully-plugs" of the native woody material were used to create sediment traps in steep draws. Although the "plugs" were successful in trapping some sediment, observations indicated that sediment transport by overland flow was minor, apparently because the infiltration capacities were more than adequate for post-fire storm intensities. This conclusion was confirmed by the small amount of material trapped above "plugs." Portions of the burn were also salvage logged with cable systems where at least partial suspension of logs was achieved. An increase in sediment production was not observed from these areas; however, soil cover increased following logging because of the tops, limbs, and broken logs scattered across the site.

### Water Bars

The long-standing practice of installing water diversion devices on skid trails and roads is sometimes overlooked on fire trails and other locations where fire-related traffic has created bare soil. Observations on several forests over the past few decades show that these areas are likely to be the predominant source of erosion within the burned watersheds. Of particular concern in some of the recent burns are abandoned roads and skid trails which were poorly constructed or closed when harvested several decades ago. Doubling the number of waterbars normally used may be justified to reduce the opportunity for diverting an accumulation of water to burned forest floor that is now less capable of absorbing it.

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## GRASS SEEDING AFTER FIRE

Following this year's fires, many requests have been made for grass/legume seeding recommendations. These requests ask that grasses and legumes be capable of germinating rapidly in dry soils, have rooting and growth characteristics that insure soil stabilization, provide wildlife forage, control weeds and shrubs, and be non-competitive to tree seedlings. Also, seed needs to be available in large quantities at a low price.

Unfortunately, research has not developed a proven recommendation to meet all of the demands of the current situation. However, research, practical experience, and observation have taught us that in addition to specific site characteristics (soils, slope, aspect, etc.), we need to consider the following questions when considering seeding:

- What weed and shrub control methods are economical and available to the private and public land managers?

- Are livestock and livestock management skills available to control the growth and root development of seeded grasses or legumes?

- Does wildlife need additional forage produced by seeding grasses and/or legumes or will sprouting shrubs provide for the wildlife needs?

- What is the soil moisture situation and how does this relate to establishment of conifer seedlings?

If answers to these questions indicate a positive potential for grass/legume seeding, then managers must decide which species and varieties are suitable for revegetation purposes. Examples of grasses and legumes with potential for seeding on burned areas of southwest Oregon include:

- Annual ryegrass (Lolium multiflorum), a vigorous, winter active annual, good winter cover crop, establishes rapidly, strongly competitive.

- Perennial ryegrass (Lolium perenne), a relatively short-lived, rapidly developing vigorous perennial bunchgrass, tends to go dormant in summer.

- Orchardgrass (Dactylis glomerata), a vigorous long-lived bunchgrass, tends to go dormant in the summer, high palatability to livestock and wildlife, competitive with other species including conifer seedlings.

- Sheep fescue (Festucum ovina), a vigorous tufted bunchgrass, forms a very heavy root mat in surface soils, palatability is low for both livestock and wildlife, slow in establishing but once established will form a dense sod.

- Tall fescue (Festuca arundinacea), a vigorous coarse, long-lived bunchgrass, forms deep roots, tolerates high levels of grazing and is very competitive with other species. May stay green throughout the summer.

- Pubescent wheatgrass (Agopyron trichophdrum), a long-lived sod forming grass, establishes quickly, tolerant of grazing.

- Subterranean clover (Trifolium subteraneum), a winter annual legume, prostrate stems, producing high yields of palatable forage, very tolerant of close grazing.

- White clover (Trifolium repens), a taprooted perennial legume, spring/summer growth, high palatability, often used in Coast Range seeding mixtures.

These plants and others are described in "The Oregon Interagency Guide for Conservation and Forage Plantings" (see Bedell et al. in the bibliography).

A general rule of thumb for successful fall seedings in Southern Oregon dryland areas is we need to seed between September 15 to October 15. Earlier seeding may get enough rain for germination but not enough for sustained growth. Low temperatures and frost heave are problems with later seedings. In 1987 we did not have adequate rain until too late in the fall for adequate establishment.

Seeding rates for various species are also important considerations. For example, one pound of subterranean clover contains 60,000 seeds, while one pound of white Dutch clover contains 800,000 seeds. Excessive seeding rates can change the plant impact from that of a bunchgrass to a sod grass.

Seed availability and cost have a true influence on seeding recommendations, especially in 1987. This year, due to several million acres of land being seeded to permanent dryland vegetation to comply with the Conservation Reserve Program, the price of seed has increased substantially. In 1984 intermediate wheatgrass cost 85¢ per pound and this year it cost $6.00 per pound. Ryegrasses are the exception as their prices have remained fairly constant, with annual ryegrass at 25¢ per pound and perennial ryegrass at 65¢ per pound.

In summary, the fires of 1987 and rehabilitation plans have illustrated that we need to develop better research information, ensure that seed supplies are adequate for emergencies, monitor seeded and unseeded burned areas, and ensure that rehabilitation plans are based on scientific information instead of political pressures.

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## INSIGHTS FROM SCS AND TIMBER INDUSTRY ON SEEDING FOR SOIL AND WATER PROTECTION

### SCS Notes

From a soil conservation standpoint, the when, where, how much, and what varieties of cover to plant for erosion control on burned sites depend on site and soil conditions, the grazing regime, the ability to manage seeded cover, and the needs to protect the soil resource and water quality, according to Ed Weber, District Soil Conservationist with the USDA Soil Conservation Service in Medford. Lacking strong guidelines defined by research, he says that the prescribing of seeding depends greatly on individual perception of site conditions and management concerns.

Sites that have highest priority for protection are steep, with granitic soils and few natural propagules to capture nutrients and retard soil erosion. Such sites will also benefit from waterbars and seeding of fire trails and roads. Flatter sites or those with less erosive soils need less protection.

The seeding of grass on sites to be planted with conifers can present a reforestation dilemma if herbicides or grazing cannot be used to control competition. Conversely, some grass species may suppress the growth of brush germinants and thus can be used to change the composition of the ecosystem. He feels that there is still much to learn regarding competition between ground cover and conifer seedlings.

Species that are not usually used but that may be less competitive include dwarf red fescue, sickle keel lupine and senecio. Among more common species, pubescent wheatgrass forms a heavy, competitive sod, but is preferred by deer. Sheep fescue at 20 lbs/ac. seems to provide good ground cover, appears to be less competitive in the first two years of establishment, and self-thins to bunches in that time. It is, however, unpalatable except to deer and sheep early in the growing season. Sherman big bluegrass, a recommendation from the Interagency Manual, grows well only on very well drained sites and should not be used on clay soils. Annual rye requires high fertility to do well and without control, may be too aggressive for conifers in the first year at higher seeding rates, although it's vigor, and that of perennial rye, declines after two or three years. Dry land orchardgrass looks promising because the plants stay small and the species is grazed by cattle and elk. The Berber and Palestine varieties appear promising for this area.

Seeding of industry lands

Given the management considerations of burned forest lands, Ken Wearstler and Russ McKinley of Boise Cascade Corporation decided to seed selected burned areas to stabilize soil movement and minimize adverse effects on soil and water. Potential land management benefits of seeding include capture and retention of mobile nutrients and reduction of germinating brush, leading to easier-to-manage vegetation complexes. They fully recognized that fall and winter weather would greatly influence the success of seeding and its ability to control subsequent plant communities, but felt that potential benefits made seeding worthwhile.

Areas selected for seeding were steep, in some cases included granitic soils, had lost most aboveground organic matter, and included drainages that fed directly into Elk Creek and Lost Creek Reservoir. Evidence of severe erosion after previous fires was also used to select sites. Cover species - chosen for rapid germination, ease of control, and competitiveness - were applied on a site-specific basis as determined by the need for cover, nutrient capture, soil and water protection, and vegetation management.

Two mixes were used. Commercial forest land (approximately 2400 acres) received 20 lbs. per acre of 75 percent annual rye and 25 percent birdsfoot trefoil. This mix was felt to be less competitive and to offer ease of control. Non-timber lands (approximately 800 acres) were seeded to a mixture of 50 percent sheep fescue, 30 percent pubescent wheatgrass, and 20 percent birdsfoot trefoil at 20 lbs. per acre. This mix was regarded as offering the best control of woody weeds and enhancement of future management opportunities. The seed was applied by helicopter between October 9 and October 13. Ideal post-seeding weather was felt to be a series of light rains with three to five days of fair weather between storms. Adverse conditions were felt to be heavy initial rains with cold, cloudy weather.

As a followup on the germination of these seedings, Ed Weber noted that as of December 10, grass seeded on non-timber land was approximately 3/4 inch tall. The legumes were just germinating and were thus in jeopardy of being frozen. He observed no visible sediment in the stream beds at that time. By the end of December, Ken Wearstler noted that seeded hillsides were green in appearance. Subsequent observations will indicate how well these and other seedings succeed in meeting management goals, given the intensity and frequency of this winter's storms.

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# Timber Salvage and Environmental Impacts

## SALVAGE, SANITATION, AND FUEL HAZARD REDUCTION AFTER WILDFIRE

Management of forests burned by wildfire is complicated because burned trees represent a mixture of biologic and economic benefits and liabilities. For example, merchantable trees may be viewed as important economic resources to be salvaged, lest their dollar value be lost. Damaged trees can be viewed as potential insect breeding grounds that may result in epidemics outside fire areas. Killed trees can increase fire hazard in a future forest, requiring managers to consider fuel reduction. On the other hand, damaged and dead trees left on the site can help natural regeneration and wildlife, reduce erosion, and help maintain long-term site productivity. Balancing these potential benefits and liabilities is often difficult and the source of much debate. The dilemma is best resolved by addressing the interaction between management objectives, economics, and biology of burned areas on a site-specific basis.

Management Tradeoffs

Management objectives for a burned area must be considered before post-fire activities are pursued. For example, rehabilitation of areas allocated to timber production in a forest plan will be viewed differently from areas allocated to wildlife. Federal agencies are obviously more constrained by this issue than private timber companies. Where planning constraints allow, managers may also assess if fire has changed planned objectives and may seek input from their constituencies (see articles by Ferris and Greenup, p. 21; and Lewis, p. 20, this issue).

Economic Considerations

The economics of salvage harvest operations and other post-fire activities must be considered. Uneconomical salvage operations are difficult to justify simply because merchantable timber has been killed.

Access is critical for timber salvage in unroaded areas. The cost of new roads must be weighed against the value of the timber removed and other benefits of a road network. Low standard roads offer a lower cost alternative. These usually disturb less ground and can be more easily closed after use. Helicopter logging is an alternative in environmentally sensitive or high road cost areas, but requires greater timber values and/or volumes to be feasible. Some isolated or smaller areas will undoubtedly go unsalvaged if helicopter logging is the only feasible alternative.

Areas with large merchantable timber offer the best opportunities for economical timber sales, regardless of terrain and other harvesting-related variables. Fire-killed sapling to pole-size stands that are not economically feasible to salvage leave fuel loads that may predispose sites to very hot future burns. For example, plantations established among heavy slash loadings burned very hot in 1987, leading to speculation that site productivity was reduced. In areas without slash and with good control of competing vegetation, young trees were killed, but soil damage was not obvious. The fires in these areas did not appear to concentrate heat on the soil surface.

Benefits to long-term site productivity and future fire management from post-fire fuel treatments must be balanced against the costs of yarding unmerchantable material or prescribed burning, the difficulty in accomplishing prescribed burning given the vagaries of weather and air quality restrictions, and the probable delay in regenerating the site. The short-term benefits of fire-supplied site preparation are critical when development of vigorous competing vegetation is highly probable and tools to deal with it are limited (see article by Walstad et al., p. 19). This is a challenging issue as land managers seek less costly reforestation practices and less site disturbance (i.e., no burning), but yet attempt to manage future fires in a fire-adapted environment (i.e., manage fuels).

## Nutrients and Insects

A parallel issue of concern is the impact of post-fire harvesting and prescribed burning on nutrients and productivity. This complex issue is best addressed on a site-specific basis. Most productivity researchers agree that soil organic matter is critical for nutrient and moisture retention. They express concern when fires destroy aboveground organic matter and particularly when soil organic matter is lost. The thin forest floors common to southwest Oregon are easily consumed by fire, but may also be replaced rapidly by litter from grasses, forbs, and shrubs that quickly reoccupy sites following most fires. The role of large woody debris is more controversial. Some scientists feel that large dead trees are best left on the site to provide long-term input of nutrients and organic matter; others suggest that large tree boles are independent micro-systems that contribute little to the soil. The latter group argues that, in the long run, these large logs lead to hotter fires that consume greater amounts of organic matter and harm site productivity, offsetting the otherwise positive organic matter contributions.

Much has been made of the potential for insect population buildups within burned areas that could lead to mortality outside the fire perimeter. Ragenovich (p. 15) suggests insect epidemics resulting from the fires in southwest Oregon are unlikely because of the late season of the burns and because of the dominance of Douglas-fir in the burned areas. Therefore, the benefits associated with salvage under the auspices of protecting areas outside the firelines do not appear to be very relevant in this case. For areas dominated by dense, pole-sized stands of pine species, insects may be of greater concern.

## Reforestation

Dead and damaged overstory trees can enhance reforestation by providing shade for germinating and planted seedlings. Good quality, properly planted seedlings will probably benefit little from shade. However, survival of germinants, marginal quality seedlings, those not planted well or those planted under adverse weather conditions will improve with shade, particularly on hot, droughty sites. Damaged trees may also produce a seed crop for natural regeneration. If natural regeneration is desired, careful scheduling of salvage operations helps ensure that all possible seed is produced.

Phil Weatherspoon (p. 14) provides a good summary of ways to evaluate damaged trees' potential to survive; however, predicting the occurrence of stress-related cone crops is not as easy. Joe Zaerr (tree physiologist, Dept. of Forest Science, OSU) provided guidelines for selecting potential cone-producing trees in the absence of data from studies. He states that most stimulation of stress cone crops comes from damage to a tree's roots or bole, and not from crown damage. Production of cones requires carbohydrates that are produced only when a viable green crown is present. Stored carbohydrates in the roots may be adequate for initial floral bud formation, but are not adequate to produce a seed crop. Therefore, trees completely defoliated by fire are probably poor candidates for cone production. For pines with almost total crown scorch, but with surviving buds and 1-year-old conelets, it is likely that the conelets will abort and the trees put energy instead into developing new foliage. Zaerr suggests the best candidates for stress cone crops may be medium-sized trees with a major portion of their crown intact, that have been partially girdled by fire around the base of the tree, or that have roots damaged by longer burning surface fires near their bases. He suggests trees damaged to near death are poor candidates for significant cone production.

## Wood Deterioration

While reasons exist for retaining damaged trees as long as possible for potential regeneration and site protection benefits, deterioration of both standing and fallen trees begins soon after the fire is out.

Ragenovich (p. 15) points out that wood-boring insects begin to mine sapwood and heartwood immediately after fire and cause lumber degrade. Most activity, however, will occur in the spring and summer following fire.

Kimmey (1955) provides a good discussion of deterioration of killed timber. Deterioration includes bluestain and decay. Bluestain affects pines primarily, causing degrade, but not loss of strength. Decay may include sapwood or heartwood or both, depending upon the species of fungi involved. Rate of deterioration depends on tree size, tree species, and the proportion of sapwood to heartwood (Table 1).

A report produced by John Dale (Forest Pest Management, USFS, Region 5) indicates that deterioration of pine sapwood during the first year is primarily from bluestain. Sapwood rot does not begin until the second year. White fir does not suffer from bluestain, but both sapwood and heartwood decay rapidly. In comparison, sugar pine and Douglas-fir have high proportions of decay-resistant heartwood that is salvageable for many years.

TABLE 1.--General decay characteristics of five timber species.[1]

| Species[2] | Blue-stain | Sapwood | Heartwood | Salvage Period by Tree Size: Average | Salvage Period by Tree Size: Large trees |
|---|---|---|---|---|---|
| WF | No | very thick, rapid decay | rapid decay | 1-2 | 4 yrs |
| PP/JP | Yes | thick, slow decay | thin, slow decay | 2-3 | 5 yrs |
| SP | Yes | thin, slow decay | thick, slow decay | >5 | 10 yrs |
| DF | No | thin, slow decay | thick, slow decay | >10 | 20 yrs |

[1] Table provided by John Dale, USFS, Region 5

[2] WF - white fir
PP/JP - ponderosa pine/jeffrey pine
SP - sugar pine
DF - Douglas-fir

Dale's report breaks down each species into a year by year accounting of deterioration:

White fir

Deterioration -

By the end of the 1st year - 10-20% of gross cubic foot volume (CFV) with incipient decay.

By the end of the 2nd year - sapwood often extensively decayed; 50% of gross CFV and 70% of board foot (BF) volume.

Salvage is not economically feasible for fire-killed white fir after the second year, except for some lower logs from large trees. White fir on north aspects at high elevations, however, may produce considerable salvage in the third year and some in the fourth year.

Ponderosa/Jeffrey pines

The principal loss in pine in the first year or two is from lumber degrade rather than from culled material.

Deterioration -

By end of 1st year - little decay, 1/4 of sapwood (CFV) with bluestain.

By end of 2nd year - 1/2 of sapwood (CFV) with incipient decay, but some pines with little decay; most sapwood with bluestain.

By end of 3rd year - only very large trees contain enough sound BF volume to be salvaged.

Sugar Pine

Deterioration -

By the end of the 1st year - extensive blue stain in sapwood, little decay (2%).

By the end of the 2nd year - 3/4 of sapwood generally deteriorated.

By the end of the 3rd year - general deterioration of sapwood. Large trees will remain mostly sound for 5 years or more.

Douglas-fir

Deterioration -

By the end of the 3rd year - sapwood generally deteriorated, very little bluestain.

By the end of the 4th year - deterioration begins to penetrate heartwood.

Large trees will remain mostly sound for 5 years or more. Douglas-firs dead for 17 years may have less than 35% of the heartwood decayed.

Douglas-firs 100-200 years old - salvage within 3-4 years

Douglas-firs 200-400 years old - salvage within 10-15 years

Douglas-firs 400+ years old - salvage within 10-20 years.

Chris Roemer, Zone Check Cruiser for the Rogue River and Siskiyou National Forests, and Mel Greenup, Forest Silviculturist for the Siskiyou National Forest, have updated the deterioration information for southern Oregon and combined it with value information from the Forest Service R-6 Timber Appraisal Handbook to produce estimates of "economic recovery" of dead timber (volume times value) over time. They generated four hypothetical stands that ranged in species composition and tree size. After 2 years, economic recovery was reduced to about 40% of green timber values for all stands. After 7 years economic recovery values had dropped to 10-20 percent of original value.

Summary

Decisions to conduct salvage, sanitation, and fuel reduction activities after fire must be based on site-specific evaluations. However, in general, where large portions of drainages were burned during 1987 and immediate artificial reforestation is not feasible, it seems important to protect surviving trees for possible seed production and site and watershed protection. Some flexibility exists in the scheduling of salvage logging with respect to species characteristics and tree size, but prompt harvest minimizes volume and value losses. The value of dead trees on the site to promote regeneration, reduce erosion, and provide habitat, organic matter and nutrients must be balanced against the future fire hazard created by this residual slash. Strategic fuel treatments within portions of watersheds or even parts of the stands may enhance our future ability to coexist with fire in a fire-evolved environment.

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EVALUATING DAMAGE TO TREES FROM THE 1987 WILDFIRES

The 1987 wildfires have confronted many land managers in California and Oregon with massive challenges in salvaging and rehabilitating damaged resources. Tree mortality is obvious in many areas, and prompt salvage of timber to minimize loss of value is normally the preferred treatment. Elsewhere, however, damage to trees is only partial and the probability of survival is not always clear. To determine and implement proper silvicultural prescriptions in such areas, planners and timber markers need criteria for evaluating survival potential of fire-damaged trees.

In 1961, Willis Wagener published guidelines for estimating the survival of fire-damaged ponderosa, Jeffrey, and sugar pines, Douglas-fir, white and red firs, incense-cedar, and giant sequoia in California (see bibliography). Wagener's geographic and species coverage and his consideration of cambium as well as crown damage make his guidelines still the best we have available for these species in California and Oregon. I recommend his publication to those actually involved in assessing fire damage to timber.

How much crown damage can a tree survive? According to Wagener, sugar pine, Douglas-fir, true firs, incense-cedar, and giant sequoia usually survive foliage scorch up to 65% of pre-fire crown volume, assuming cambium damage is not severe. This crown damage threshold applies to late-season fires (applicable to the extensive 1987 fires), and to trees of good vigor growing on better-than-average sites. The threshold decreases (i.e., trees will tolerate less crown damage) if tree vigor or site quality is poorer, or if the fire occurs during the active growth season. Overall, little refoliation within scorched portions of crowns can be expected for these species.

In contrast, ponderosa and Jeffrey pines have stout twigs and buds that provide significant protection from heat damage. In late-season fires, therefore, a substantial fraction of the foliage-scorched part of a crown may have surviving buds that can produce new foliage during the next growing season. Under the same conditions and assumptions mentioned for the other conifers, ponderosa and Jeffrey pines can tolerate up to 80% foliage scorch, provided that twigs and buds survive within at least 50% of the prefire crown volume. Unfortunately, these surviving portions of crowns are difficult to identify until several months after the fire--an argument for delayed marking in stands having ponderosa or Jeffrey pine as a major component. A very recent study by Harrington (1987) states that mortality is greatest for pine when crowns have been damaged by fire from prescribed burning in the spring and summer, and is less when trees are exposed to fire in the fall.

Because crown damage can be seen more easily than fire-caused damage to other parts of the tree, the crown should be evaluated first. If the crown fails to meet Wagener's survival criteria, one need not look further. If it does meet the criteria, then possible damage to the cambium needs to be considered.

How much cambium damage is excessive? Wagener indicated that sugar pine can survive killing of up to 60% of the bole circumference at ground level. He used a threshold of 25% for other conifers. Based on my own data for true firs and general observations for other species, I think 25% may be an appropriate cambium damage threshold when crown scorch is also near the limit, but it could probably be increased to at least 40% for species other than sugar pine when crown scorch is light or absent.

How does one identify cambium damage? It is <u>not</u> equivalent to charring or blackening of the bark, although bark charring can provide clues to its occurrence and location. To examine the cambium, remove a piece of bark and look at the inner surface of the inner bark--i.e., the wood/bark interface. Healthy cambium will be nearly white in color, and usually moist and slippery to the touch. By comparison, dead cambium is dry and discolored (usually brown), and adjacent wood is often infiltrated with resin. Look for cambium damage first near the ground on the side of the tree with the highest bark char, especially on buttresses and beneath deep bark furrows. Where evidence of a deep burn (e.g., white ash, little or no residual duff) exists, also check for damage at and below the original ground line caused by slow, smoldering combustion of duff around the tree.

For a timber marker or other person evaluating fire damage on a large number of trees, it is clearly impractical to examine the cambium at several spots on each tree. So the marker must establish mental correlations between degree of cambium damage and factors like species, tree size, extent and appearance of bark char (i.e., whether char extends into bottoms of bark furrows, how deep or fluffy the char is, how much the original furrow/ridge profile has been smoothed by bark consumption), and apparent depth of burn around the tree. To do this, the person should carry a hand ax and use it to check cambium condition frequently at first and regularly thereafter to keep a properly calibrated eye.

Bark beetles will kill some fire-damaged trees that otherwise would survive and may kill nearby undamaged trees as well, but this mortality is difficult to predict from Wagener's criteria. According to Iral Ragenovich (see following article) Wagener's criteria need to be modified for large, old growth pine, because older trees, whether damaged by fire or not, are more susceptible to any beetles in the area. She further states that under these conditions, undamaged old growth trees adjacent to the burned areas may be considered for monitoring of beetle infestation.

Much of the fire-caused mortality will be evident by the following growing season. Also, for ponderosa and Jeffrey pines, refoliation from surviving buds will be apparent by then. Where logistical and administrative constraints permit, therefore, marking of stands with large numbers of marginal trees is better delayed until the following spring. Given the large acreage of the 1987 fires, this may be practical in many areas since salvage of obvious, immediate mortality (first priority to minimize deterioration and loss of value) may necessitate delaying salvage operations in areas of marginal damage.

[Editor's note: This information is condensed from a presentation given at the 1987 California Forest Vegetation Management Conference. Proceedings to be published.]

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## INSECT MANAGEMENT

Insect activity after a catastrophic forest event, such as the extensive fires in southwestern Oregon during the summer of 1987, is natural and is part of the beginning of the process of Nature restoring herself. Two general categories of insects will attack fire-damaged trees: those that cause additional mortality in the fire-weakened or adjacent green trees (mainly bark beetles); and those that bore into the sapwood and heartwood of the fire-killed trees and cause additional damage through degrade (primarily flatheaded and roundheaded borers and ambrosia beetles).

## Bark Beetles

Most bark beetles are attracted to damaged, stressed, or weakened trees, and outbreaks occur when conditions are such that a population can build up to high levels. Each species of bark beetle has one or more preferred hosts. The most common bark beetles in the Pacific Northwest are the Douglas-fir beetle (Dendroctonus pseudotsugae) in Douglas-fir, the western pine beetle (D. brevicomis) in ponderosa pine, and the mountain pine beetle (D. ponderosae) in ponderosa and sugar pine. Trees that are most susceptible have cambium damaged by scorching. Although there may be a few individual bark beetles initiating attacks immediately after the fires in the fall, the main attacks will occur in the spring and summer of the year following.

Douglas-fir beetles prefer downed Douglas-fir; but will attack standing, weakened, or dead trees. Larger diameter Douglas-fir with 50 percent or more of the crown singed and any damage to the cambium, are the most susceptible to attack. Populations can concentrate and build up in these weakened trees, and the next generation of emerging adults will attack adjacent green trees the following spring. However, Douglas-fir beetles do not do well in standing green trees, and the outbreak will be short-lived. Trees that are severely scorched or burned will be unsuitable for beetle development. The cambium may be too damaged from heat; or a situation known as "sour sap" may develop.

The western pine beetle prefers large overmature ponderosa pine. Populations can build up in the fire-damaged trees, emerge, and continue to attack apparently healthy green trees. Adults attack during late spring and will continue until stopped by cold weather; there are two generations per year.

The mountain pine beetle will attack all pine species. Most often, it attacks stressed and weakened pole-size trees, but also will attack larger trees. It is less often associated with fire damage; however, in areas with a higher percent of pine, the impact from this insect may be more significant.

Outbreaks of pine engraver (Ips spp.) beetles can occur in all sizes of fire damaged ponderosa pine. Outbreaks will be intense, but will be of short duration.

## Wood Borers

Woodboring insects most often attack and bore into the sapwood and heartwood of trees that have already been killed by the fire. Their primary impact is the additional degrade caused by their mining activity. They begin attacking immediately following the fire, but the majority of their activity occurs the spring and summer following the fire. Attacks will continue for several years, as long as the wood remains sound. The damage to the sapwood and the heartwood from these insects, along with fungal deterioration, can be the factor in determining the limit of practical salvage in an area. The major wood borers are the flatheaded borers (family Buprestidae), the roundheaded borers (family Cerambycidae), and the ambrosia beetles or pinhole borers.

Although it most often inhabits trees that are already dead, the flatheaded fir borer, Melanophila drummondi, attacks and kills weakened Douglas-fir that have been stressed or weakened or are adjacent to a burned area. It is less important, however, than the Douglas-fir beetle.

The golden buprestid, Buprestis aurulenta, is one of the most damaging of the woodborers, because it can mine for years in boards that have not been kiln dried and can cause significant structural damage. In the forest, the life cycle lasts for several years, However, in buildings, development can take as long as 30 to 50 years.

## Guidelines for Insect Management in Fire Damaged-Areas

Following are general guidelines for selecting stands and trees for management. However, each situation must be evaluated on its own merit and management objectives.

- Prioritize areas to be treated. Salvaging an entire large burn area strictly for the objective of preventing insect damage is not recommended. All areas should be evaluated for priority and benefits for salvage.
- Salvage to minimize losses and damage from insects. Salvaging in the current fall and spring will remove trees that are a high risk for bark beetle attack. Salvaging in the following summer and fall will remove bark beetle brood from the area. Salvaging within the next 2 years will minimize impacts from woodboring insects.
- Retain green trees within burn areas. Whenever possible, individual trees or groups of green trees should be left within a burned area to provide a natural seed source and wildlife habitat and cover.
- Minimize logging damage to leave trees.

Three types of trees will occur within a burn area: those that have been killed outright; those that have been damaged to varying degrees; and those that occur as green trees within the burn area or in fingers along the fringe of the burn.

Identifying and retaining the green trees wherever possible is the highest priority. Next, select and remove the susceptible and moderately damaged trees that occur adjacent to the leave trees. When selecting which trees to remove, look for indicators of the health of the tree. A tree's recovery depends on: its species; percent of crown scorched; amount of scorching on circumference and height of bole; site quality; incidence of root disease and mistletoe; and size - larger diameter trees are more attractive to bark beetles.

For additional detail and guidelines for managing and identifying fire-damaged trees that are susceptible to insect attack, see Kimmey and Furniss (1943) and Wagener (1961) in the bibliography.

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## WILL THIS SUMMER'S FIRES BE GOOD OR BAD FOR WILDLIFE?

You may occasionally hear someone say that a particular scheme for managing vegetation (such as clearcutting) is "good" for wildlife. Conversely, were the fires "bad" for wildlife? The fact is, both phrases are "empty." No management scheme or natural event can be entirely good or bad for all wildlife species.

Forest fires burned 10 percent of the Siskiyou National Forest's land base from August 30 to the end of October of 1987. The Silver Fire Complex alone extended over 96,000 acres. All of the Siskiyou National Forest provides wildlife habitat, and fire modifies wildlife habitat. Questions arise. What were the effects of the fire on wildlife habitat? What changes may occur in animal populations?

These questions can be addressed by considering basic wildlife facts. As humans, we think of ourselves as individuals, and we tend to think of animals as individuals too. Ecologically, we should think of wildlife in terms of species (or populations). A large variety of wildlife species inhabit southwest Oregon; the Siskiyou National Forest alone harbors over 250 different species of mammals, birds, amphibians, and reptiles. The distribution of these species depends on habitat. For example, meadow areas have their own characteristic group of wildlife species, whereas old growth forests harbor a different mix. Other habitat types have other species mixes. Many species may require more than one habitat to meet it's needs for food, water, shelter, and reproduction. In other words, diversity is the watchword in the wildlife world, and any habitat change will produce winners, losers, and spectators.

The recent forest fires were an agent of positive habitat change. Although some areas were severely burned, many areas were not. The fires have created a mosaic of habitats, and this mosaic has markedly increased habitat diversity. No wildlife species appear to be seriously affected, either positively or negatively by the fires. Populations of species that are dependent on older forest stages are expected to decrease (spotted owls, hermit warblers, red tree voles, etc.). For these species, such as the spotted owl, habitat has been reduced, but not significantly; areas that were only underburned are still habitat for these birds. Their prey base may be affected for a short time, but the owls will continue to be found in the fire areas. For example, in November, two owls answered our calls in a spotted owl habitat area in the burned Indigo Creek drainage. Populations of species that utilize younger forest habitat (bluebirds, brush rabbits, blacktail deer, elk, etc.) should increase. For example, forage quantity and quality will increase in burned areas, with deer and elk as the major beneficiaries. On the Siskiyou National Forest overall, no serious population fluctuations are expected for any species, including those that sometimes cause reforestation problems.

Some individual animals are directly killed by wildfires, although most mobile animals are able to avoid approaching flames. Some displaced animals will eventually die. Their original homesites may no longer be suitable habitat; and potential new homes may already be occupied by other individuals or may be only marginally suitable. We found a dead fawn in the Longwood Fire area; although a pathetic sight to human eyes, in a sense this animal's death was a symbol of the habitat rejuvenation to come. Death represents a pause before a forthcoming surge of productivity. In another sense, the fires created a vacuum, into which life soon flowed back. Even recently burned areas were not void of life. Spider webs hung from many dead branches; Steller's jays, ravens, and other birds let us know they were there too. Fresh deer tracks were evident. I visited the China Hat area three weeks after the Silver Fire had swept through. Smoke-chasing bark beetles had already bored into the sugar pine. Woodpeckers would be close behind.

Fire is an integral part of the ecology of southwest Oregon. Over the long-term, our rather frequent fires may result in lower overall site productivity, through soil erosion and loss of organic matter; and indirectly, periodic fires may lower the capability of the land to produce wildlife biomass. Regardless of this, our local wildlife species cope rather well with fire--but as species, rather than as individuals. Wildlife species living in our area either worked out silent partnerships with fire long ago, or they disappeared. If wildlife populations are dispersed throughout a large physiographic area, significant natural events such as widespread large fires should have little net effect. Populations of individual species may fluctuate up or down, or remain constant, but as long as suitable habitat is available over a large area, viable populations of each species will be retained.

A larger question of species viability exists: could a combination of human and natural events (e.g., changes in the age composition of timber stands and wildfire) result in the eventual demise of individual wildlife species? Not long after settlers of European origin arrived in this area, they began to manipulate wildlife habitat through timber harvest. This manipulation has resulted in a shrinking land base devoted to mature and old growth forest, and their attendant animals. This changing pattern of land use may someday make some of these wildlife species more vulnerable to natural events such as extensive wildfires. However, our wildlife species were not endangered by the 1987 fires. In terms of wildlife and wildlife habitat, the fires of 1987 were not catastrophic. Although various wildlife species ended up as winners, losers, and spectators, no species will disappear. In fact, overall, the results appear to be positive: habitat diversity has been significantly enhanced.

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Siskiyou National Forest

# Reforestation

## CHOOSING BETWEEN PLANTING, DIRECT SEEDING, AND NATURAL REGENERATION

Choosing a regeneration method is easier to discuss on paper than it is to accomplish in the field. Field decisions are often aided by first considering the alternatives on paper, however, and this discussion may help in selecting the methods that are most appropriate for specific situations encountered in regenerating the areas burned in 1987.

Planting tends to be the most certain, risk-free method of re-establishing trees on a deforested site. Initial seedling growth is faster in a nursery than it is on most field sites, and the larger planted seedlings have a head start on seedlings that originate from seeds that germinate on site. Growth of the planted seedlings is often interrupted by planting shock, however, and suitable planting stock is not always available. (See related articles by Campbell and Adams p. 17, Owston and Rose p. 19, and Walstad et al. p. 20). Particularly when attempting to plant forests burned in wildfire, waiting until seedlings are produced in a nursery gives competing vegetation a head start. Even when suitable stock from a proper seed source is available, planting crews and administrative personnel may not be available or access may be impossible for snowbound high-elevation sites. Planting, moreover, is much more expensive than direct seeding or natural regeneration.

Direct seeding eliminates the costs involved in nursery stock production, storage, transport, and planting. Regeneration can be accomplished immediately, before vegetation occupies the burned site and without waiting for nursery stock to be produced. When seed spots are used, spacing can be controlled to obtain uniform stocking. (This is impractical with broadcast seeding.) Nearby, on-site seed sources are not required. A large quantity of seed from a local seed source is required, however, and most of that seed is wasted. Rodents and birds destroy almost all unprotected seeds, and seed protection is difficult. Rodent poisons and bird repellents have unacceptable side effects. Mechanical protective devices are not yet practical. They are expensive, cannot be used with broadcast seeding, and do not prevent insect damage.

Seed collection, nursery operations, and stock transport are eliminated when natural regeneration is used; and the crews for planting or spot seeding are unnecessary. Limited access to high elevation areas during the planting season is not a problem. Planting shock is avoided, and early root distribution is better in naturally established seedings than in planted seedlings. As a result, naturally established seedlings sometimes outgrow planted seedlings of the same age (age determined from time of germination, not time of planting).

A nearby seed source is essential if natural regeneration is to occur (within two tree heights for best results, but up to 10 chains for Douglas-fir, 5 chains for western hemlock and the true firs, 2-1/2 chains for ponderosa pine and sugar pine). Some seeds are produced nearly every year, but the good crops necessary to withstand rodent predation occur infrequently. Therefore, adequate natural regeneration does not occur every year, even when seed sources are nearby. It is often accomplished over a prolonged period, and 5 to 15 years may be required to obtain full stocking. Stocking may be irregular, because seedling distribution is not uniform in a naturally established stand. Species to be managed are limited to the species growing on a site, but centuries of natural selection guarantee that the seedlings of those species will be well adapted to local site conditions. Suitable seedbeds must be available when a good seed crop occurs. The fires of 1987 left excellent seedbeds. Some seedbeds may last until a good seed crop provides the necessary seed on some sites, but others may disappear under competing vegetation.

Identification of suitable sites is the key to success in obtaining natural regeneration. Harsh, dry sites constitute poor risks. Shasta red fir and western hemlock usually regenerate well, however, and the presence of either species is a useful indication of suitable conditions for natural regeneration. Where adequate moisture is available, poor sites (e.g. site class V) tend to regenerate more successfully than good sites.

Site quality certainly should be considered when choosing any regeneration method. The poorer the site or the less confidence a land manager has in the future value of his timber crop, the less economic justification there is for incurring planting costs on areas where nature can be depended upon to do the job eventually. When resources are limited, planting efforts should be directed toward the best sites and deferred on the poor sites.

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## CHOICE OF SEED SOURCE IN SOUTHWESTERN OREGON

When large areas must be rapidly regenerated after a catastrophic event, such as a major forest fire, and seeds of local origin or proven adaptability are limited, deciding which seed sources to use is difficult, yet critical, to future plantation survival and productivity. In this paper, we provide some general guidelines for seed transfer of Douglas-fir in southwestern Oregon.

Coastal Douglas-fir, like most western conifers, is genetically diverse within local populations, not only in growth rate and tree form, but also in a host of other traits related directly to adaptability, such as pest resistance, tolerance of cold and drought, and timing of the annual growth cycle. Thus, although stands from different areas may differ in average genetic potential, stands may often overlap considerably in genotypes common to both.

Given the little that is known about adaptation of forest trees, the mixture of genotypes found in a natural stand of trees is assumed to be the mixture of an adapted stand. The local mixture might be replaced by a mixture that can produce more wood per acre per year; this potential for increased wood production is the rationale for tree breeding. Furthermore, using seed from non-local origin also might increase productivity. But when the genotypic mixture is changed from the local type, we cannot be certain--without adequate testing--that we are not also changing susceptibility to disease, insects, frost, drought, or some other potentially destructive event. Therefore, every seed transfer entails some risk that part or all of the resulting stand will be poorly adapted. Potential loss from poor adaptation ranges from minor reduction in productivity or quality to severe damage or loss of entire stands. If loss does occur, it can happen during regeneration--or much later. The least well-adapted trees might die early, the better adapted later, and the nearly adapted might live, but yield less product or product of poorer quality.

The safest course in seed transfer is to choose a seed source with at least some genotypes in common with the local population. With the appropriate information, the proportion of seed of local type in any potential seed source can be estimated. The genetic composition of natural populations usually changes along environmental gradients. The genotypes of local type consequently make up a smaller and smaller proportion of the seed lot as the regeneration seed is chosen from farther and farther away along these gradients. Genetic changes occurring over geographical or topographical gradients often reflect the underlying environmental changes (e.g., in winter temperature, summer moisture, frost-free days), with the steeper genetic gradients associated with more rapid environmental differentiation over the same physical distance. Thus, as genetic gradients associated with geographical or topographical distances steepen, the risk of seed transfer increases.

Knowledge of genetic gradients, then, is the basis for estimating proportions of local genotypes in a transferred seed-lot. Reports by several researchers include information on direction and steepness of gradients in northern California and southwestern Oregon. Steep west-east gradients exist in the region, following trends of annual and seasonal precipitation. The steepest gradient apparently coincides with the high mountain ridge closest to the coast. Other studies, not designed specifically to investigate gradients, indicate a fundamental difference in the annual pattern of height extension in seedlings of coastal and inland populations of Douglas-fir in southwestern Oregon. Even this difference has a hint of a coast-inland gradient. Some genotypes of the inland pattern are found in coastal populations and vice versa.

Another major gradient in northern California and southwestern Oregon follows elevation. This gradient is influenced by distance from the ocean, latitude, and other variables. In the eastern part of southwestern Oregon, effects on genetic gradients depend jointly on distance from the ocean, east-west aspect, and elevation. These interactions suggest that several genetic gradients will influence choice of seed lots in any seed transfer.

Recently, information about genetic variation along gradients and within populations has been combined to provide quantitative seed-transfer guidelines for southwestern Oregon. The procedure estimates the proportion of non-local genotypes in transferred seed. Before seed-transfer decisions can be based on such information, however, we must decide what is a reasonable limit to the proportion of non-local types permissible in a seed lot. This limit can be based on the probability of obtaining a local genotype as a crop tree. In this model, local genotypes are available as crop trees should non-local types falter before rotation age. The model suggests that several factors will influence the proportion of local genotypes among crop trees at rotation. Obviously, the fewer the seedlings planted per crop tree, the smaller the chance that at least one will be of local type, unless all are of local type. Mortality during regeneration or in early precommercial thinning also lowers the probability; early regeneration failures and removals of local vs. non-local types in early thinning are likely to be more or less at random. Based on these considerations, insuring at least 50 percent of genotypes of local type within the transferred lot seems to be reasonable.

Any transfer of seed calls for a decision about direction of transfer. Genetic gradients almost always follow lines between places where stands are more productive to places where they are less productive. Trees in productive stands generally are faster growing, have longer non-dormant seasons, and are less resistant to drought or cold stress. Trees in less productive stands are slower growing but more resistant. Therefore, if the planting site is somewhere between the least and most productive ends of a genetic gradient, as is usual, a silviculturist with alternative sources of seed has a choice. Seed can be moved from the more productive or the less productive direction on the gradient. If the seed is taken from the more productive side, the non-local genotypes in the seed lot will be more productive than local types on the average, yet more susceptible to potential damage from environmental stress. If seed is taken from the less productive side, the non-local types will be more hardy than the local types, but also slower growing. Thus, either productivity or survival can be emphasized in many transfers of seed.

Any rule-of-thumb for seed transfer is made imprecise, at best, by the complex genetic and environmental gradients in southwestern Oregon. Current information, however, suggests the following guidelines for directional transfers of Douglas-fir (Figure 1). At the same elevation, first, do not transfer seed between coast and interior across the main ridges in the Coast Ranges; and second, within a rectangular area with boundaries at the northern California border, the crest of the Cascades, Roseburg, and Cave Junction, seed probably should not be moved more than about 20-25 miles in any direction. At elevations below about 3200 feet, movements either toward or away from the southeast corner of the rectangle (the Ashland region) are likely to cause the greatest risk per mile of transfer. Above 3300 feet, the worst directions are east or west, especially in the eastern half of the rectangle.

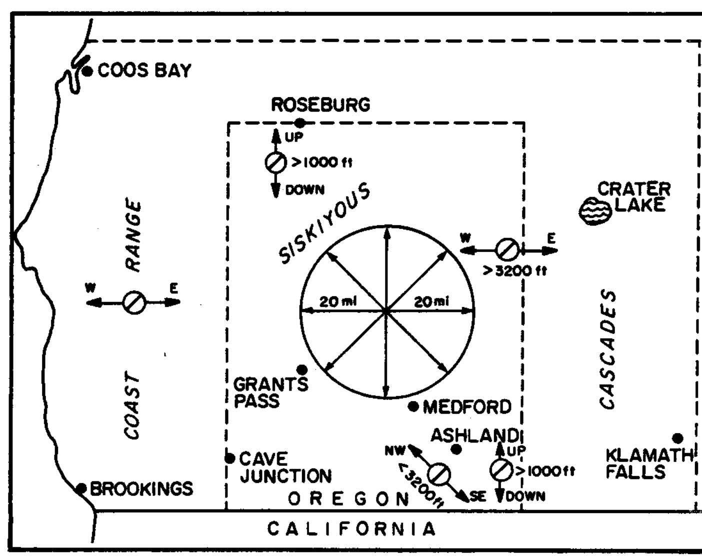


FIGURE 1.--Map showing suggested limits to transfer of Douglas-fir seed in southwest Oregon.

Transfers in elevation with little change in map location should be restricted to less than 1000 feet, especially in the northwestern and southeastern quadrants of the rectangle. Adaptational risks caused by transfer in both direction and elevation are roughly additive; for example, if a transfer of 500 feet in elevation is contemplated, then the limit in direction should be about 10-12 miles. If the elevational transfer is 750 feet, the limit in direction would be 5-6 miles.

Even within the limits suggested above, seed transfers of any distance in southwestern Oregon may be between areas of different productivity. If the planting site is well prepared and above average in productivity, choosing a seed source from the most productive alternative source within the limits may be good strategy. If the planting site is severe, choosing a seed source from a site even more severe might help ensure a good stand at harvest. If Douglas-fir does not grow on a more severe site within the suggested limits of transfer, perhaps the planting site should be regenerated with a better adapted species. For example, ponderosa of Jeffrey pine may be more suitable on droughty sites or true firs on the high, cold sites.

In making these general guidelines, we had to create restrictions that may be unnecessary in specific cases. For example, a transfer in elevation can partly compensate for distance in some directions but not in others. This type of compensation cannot be generalized, unfortunately, in southwestern Oregon. The best way to choose among alternative seed sources is to directly calculate the proportions of non-local genotypes for each alternative by using a computer program (IBM-PC compatible) that can be obtained from Bob Campbell.

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## OBTAINING SUITABLE STOCKTYPES

Shortages of planting stock are bound to occur in southwestern Oregon during the 1987-88 planting season due to the large acreage burned during the past summer. Furthermore, demand for the next several years is apt to exceed the capacities of forest tree nurseries that normally supply the region. Seed supplies may also be inadequate for some species and seed zones. Successful reforestation in the face of such shortages will depend on careful planning and avoiding expediencies that violate biological principles--forest managers should continue to take the steps that research and experience have shown to be necessary for plantation establishment. Hurried planting of unsuitable seedlings might well negate any advantage of the reduced plant competition resulting from the fires.

One problem is deciding on the most effective use of the current crop of seedlings. Our advice is to plant the most productive sites first--getting these areas back into production quickly makes the most economic sense, and success is more likely because productive sites are usually less harsh than poor ones. The supply of seedlings can be "stretched" to cover more area than normal by instituting several practices both at the nurseries and in the field:

Nurseries--

- Lift seedlings carefully and under soil conditions that minimize root damage. Root wounds caused by tearing lateral roots off of tap roots result in poor field survival. Current practices of culling root-wounded seedlings should be maintained (Owston, unpublished).

- Do not cull seedlings for excessive size--especially because of stiff, wide root systems. Instead, take whatever means necessary to plant them well.

- Consider lowering cull standards to accept 2-0 seedlings with stem calipers down to 3.5 mm as long as the root systems appear to be well-balanced with the tops--recent research has shown these seedlings to have survival potential comparable to seedlings with larger caliper (Owston, unpublished).

- Consider lifting and planting as 1-0's, some seedlots originally intended for 2-0's rather than waiting another year. Choose seedlots that have a large portion of seedlings of plantable size (those with root volumes >2.5 cc and minimum caliper of 3 mm). If quantities justify, replant the remainder (minus genuine runts) into transplant beds for use the following year.

Field --

- Plant at no closer spacing than 10 x 10 ft and consider spacing of 12 x 12 ft.

- Consider not planting areas bordered by live trees such as clearcut edges where natural seedfall might be expected.

Another issue is deciding how much 1-0 or container stock to order for the 1988-89 planting season. These stocktypes might do well in heavily burned areas where plant competition and animal populations are down. Our advice, however, is to not go beyond actual experience at using these stocktypes--stick with nurseries that have a proven record of producing acceptable seedlings. As a general rule, experience has shown that stock quality overrides stocktype; i.e., seedlings of adequate size and good physiological condition, that are handled and planted carefully, perform well in the field regardless of their stocktype.

The situation created by the 1987 wildfires certainly calls for careful planning and thoughtful risk-taking. However, to avoid breaking away from standards that have been shown to be acceptable in recent years, it is imperative that careful logic be used to guide the decision process. A major point to remember is that seedlings are living organisms subject to environmental pressures. When that fact is considered, you will see that reasonable risks can be taken without wasting money and adding to the vast economic losses already sustained.

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## FIRE, VEGETATION MANAGEMENT, AND SEEDLING ESTABLISHMENT

Management of competing vegetation will bear strongly in determining the success of post-fire reclamation efforts. Numerous studies done during the course of the FIR Program and elsewhere have documented the adverse impacts that herbs, shrubs, and hardwoods have on conifer regeneration. Although there are occasions where such species are necessary for soil stabilization, rhizosphere functions, wildlife maintenance, and long-term site productivity, more often than not they seriously impede the survival and growth of conifers. Probabilities of successful conifer stand establishment can be maximized by carefully selecting sites and implementing specific treatments without impairing site stability or productivity. Burned sites can be prioritized for reforestation by assessing site characteristics and potential vegetation management problems. Regardless of how a site is ranked for reforestation priority, it is critically important for reforestation efforts to succeed within the first year or two after planting. Failure to ensure this greatly increases the difficulty of subsequent reforestation efforts.

High-Priority Sites

These sites are more productive and deserve high-priority attention during the initial stages of the reforestation effort, because prompt reforestation will minimize productivity losses and yield greater financial returns. Vegetation management problems, however, vary between general categories. These include:

Easily regenerated and managed sites. Probabilities for success will be greatest on sites that are readily accessible, easy to plant, and easy to tend. Dealing with such sites first also allows opportunities to identify and correct technical and logistical problems before more difficult sites are attempted.

Previously well-stocked, highly-productive conifer sites. Such sites have already demonstrated the capacity to grow conifers, and problems from sprouting shrubs and hardwoods should be minimal because of their general absence from the previous stand, although germinating woody and herbaceous vegetation may need to be controlled.

Highly-productive sites where severe herb and brush competition are anticipated. Delays in reforesting sites that are rapidly occupied by herbaceous and woody competitors will greatly increase the difficulty of subsequent reforestation. If such competitors gain too much of a headstart, it will be necessary to prepare the area again before conifers can be established.

Former brushfields dominating good sites. The wildfires in this case have provided "free" site preparation. As with the preceding situation, if the sites can be planted promptly with conifers and brush sprouts controlled for a few years, it should be possible to convert the sites to conifers.

Low-Priority Sites

These sites are typically, but not always, less productive. The less productive sites represent substantial portions of the areas burned by this summer's fires. Thus prompt reforestation on these sites is also important. However, deferring artificial reforestation on these sites in favor of more production and easier-to-regenerate sites will help to minimize losses in timber productivity and reduce reforestation expenses.

Sites where scattered seed trees still survive (or are likely to survive long enough to produce a cone crop). In the absence of competing vegetation, natural regeneration will gradually fill in many of the "holes" created by the underburn. Best chances are on north-facing slopes where conifer stands were largely free of brush at the time of the burn.

Low-productivity sites or sites difficult to plant. The cost of conifer establishment on these sites is higher relative to financial returns, especially if maintenance treatments are necessary.

Sites where dominant shrubs and hardwoods have suffered minor damage from the fire. Such areas can be expected to quickly return to their former condition. Control efforts will be difficult and expensive.

Treatment Suggestions

Several approaches are suggested below for maximizing the probability of successful reforestation:

Plant fewer trees per acre, but tend them more carefully. With limited numbers of seedlings available and other logistical constraints, it makes sense to plant fewer trees than normal, but to take better care of them if reduced levels of planting are consistent with seed transfer considerations (see article by Campbell and Adams p. 17, this issue). If carefully planted and tended, perhaps as few as 200 trees per acre are needed to successfully reforest an area. This approach will stretch seedling supplies, allow more acreage to be covered quickly (assuming other factors are not limiting), will minimize the cost of subsequent spot treatments for weed control, and will decrease the need for precommercial thinning.

Plant ponderosa pine on droughty, south-facing slopes. Ponderosa pine tolerates drought and competition for water better than Douglas-fir. On sites of intermediate or questionable droughtiness, consider planting a mixture of ponderosa pine and Douglas-fir.

Spot treatments for herbaceous weed control. Results of numerous studies in southwest Oregon and northern California point to the importance of controlling grass and forb competition if conifers are to survive and quickly develop (Fig. 1). In order of decreasing effectiveness and practicality are herbicides, paper mulching, and hand scalping. Riparian zones and other sites seeded to grass deserve priority attention. Weeding will be needed in the first and second years, and possibly for several years thereafter.

Avoid planting trees next to large hardwood stems, stumps, or burls. Studies of tanoak and madrone recovery indicate that the larger the parent stem, the more quickly these species sprout and regain their former size (Fig. 2). Planting in good microsites between clumps will minimize the need for hardwood control and maximize the likelihood that conifer seedlings will ultimately develop into crop trees.

Be prepared to apply brush control by age 3 or 4. Again, results of numerous studies indicate that sprouting shrubs and hardwoods begin to strongly influence conifer development by the third year, even though visual effects may not be manifest until the fifth or sixth year (Fig. 3). The best time to control the sprouting shrubs and hardwoods is while they're still small.

More detailed information on each of the above techniques or topics is available from the articles

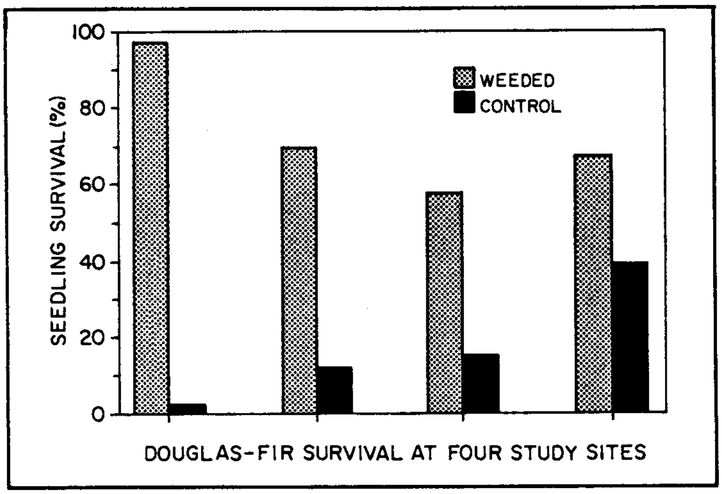


FIGURE 1.-- Effect of weeds on first year survival of Douglas-fir seedlings at four study sites in southwest Oregon.

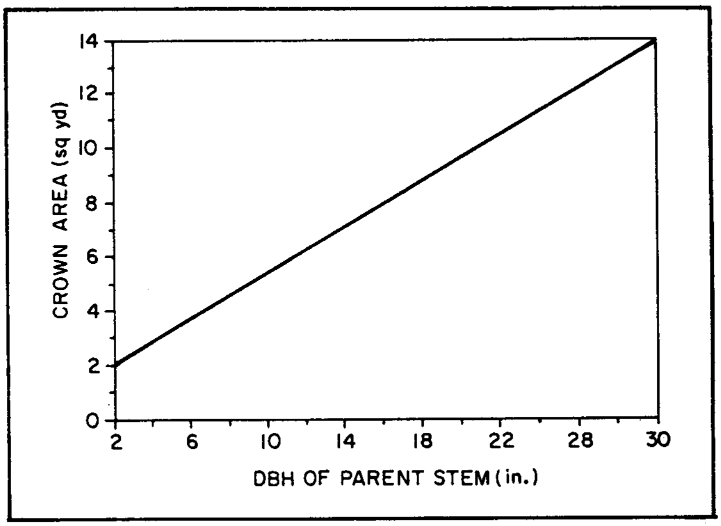


FIGURE 2.--Predicted tanoak crown area after six years.

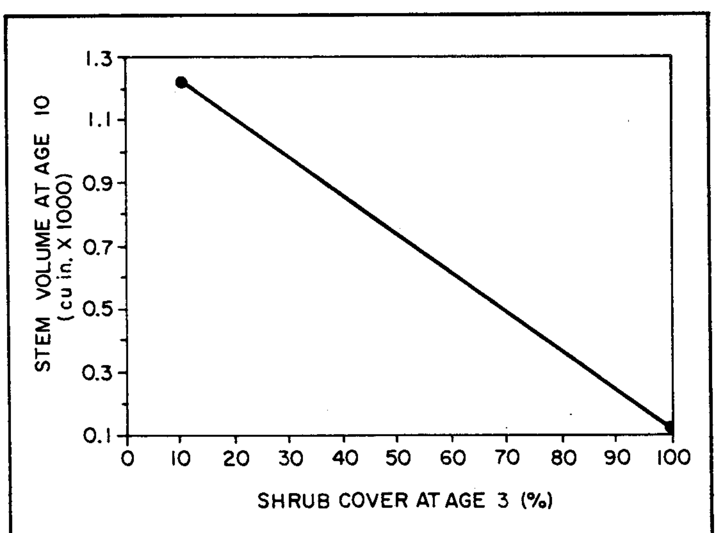


FIGURE 3.--Predicted relationship between Douglas-fir stem volume and earlier shrub cover.

cited in the bibliography or from us directly. Do not hesitate to consult us if additional information is needed. The shortcourse "Project Planning and Control in Forestry" taught by Dr. Brian Greber at Oregon State University might also be helpful in optimizing the reforestation effort.

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# Management Strategies

## BRIEF SUMMARY OF BLM FIRE REHAB ACTIVITIES

During the "Fire Bust" of 1987, 12 fires of significant size, totaling approximately 26,000 acres, occurred on lands administered by the Medford District BLM. Three percent of the District burned, destroying approximately 4,500 acres of submerchantable commercial forest stands and killing approximately 65 MM bd. ft. of potentially salvageable timber. Approximately 16,000 acres burned that included commercial timber stands where little mortality was observed, non-timber lands, or lands not capable of being placed in the timber base.

During the first day of fire suppression, an interdisciplinary fire rehabilitation team was set up composed of a silviculturist, a soil scientist, a fishery/wildlife specialist, a timber management forester, and a roads and facilities manager. The team was charged with developing site-specific rehabilitation plans (both for soil stabilization and reforestation); estimating timber salvage workloads; estimating damage to roads and structures; and estimating budget and personnel needs for all post-fire activities. In addition, the rehab team coordinated overall rehab actions with other landowners and agencies.

Planning for rehab actions involved the following steps:

- determination of the extent and type of resource damage from the fires;
- determination of the site specific resource management objectives for burned land;
- determination of the site specific actions needed to meet land-use objectives, and to reduce soil productivity loss, stream sedimentation, or off-site impacts. Emphasis was placed on interdisciplinary planning to assure that reaching objectives, such as reforestation or protection of rare plants, was integrated with soil stabilization actions.

Approximately 1,500 acres (6% of the BLM burned acreage) was seeded with annual rye grass for soil stabilization purposes. These acres consisted of severely burned sites, steep, relatively unstable granitic soils, and other areas with a high erosion hazard. Approximately 8 miles of stream channel stabilization were seeded by hand. Check dams were built at appropriate locations.

Immediate reforestation was planned for 3,540 acres, with reforestation of another 6,060 acres planned for next year when seedlings are available and salvage is completed. Total reforestation cost is estimated at $1,836,000. Approximately 65 MM bd. ft. of salvage is planned, with values projected at $6,500,000. (Reforestation cost for the fire is projected at about 28% of the timber salvage value.)

All submerchantable commercial stands will be replanted as soon as seedlings are available (most in 1988). Killed commercial timber in the intensive management base will be harvested promptly, with immediate reforestation. Harvest of timber from lands withdrawn from the timber base will be done under special silvicultural prescriptions that address the harvest and post-harvest treatments needed to achieve resource management objectives to which these lands were allocated. These objectives include: wildlife habitat, fisheries, soil stability, scenic management, and timber harvest. Timber on fragile sites will not be salvaged, if doing so would cause unacceptable site degradation or off-site impacts.

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## FOREST SERVICE WILDFIRE EMERGENCY REHAB

The evaluation and rehabilitation of National Forest System lands burned in wildfires is accomplished through a Forest Service process known as Burned Area Emergency Rehabilitation. A critical part of this process is quick evaluation of wildfire effects for subsequent protection of soil and water resources before heavy rainfall occurs. Heavy rainfall on burned soils could cause severe surface erosion and possible mass movement. Within 2 weeks of the August 30 lightning fires, emergency rehabilitative plans were funded on the Umpqua, Siskiyou, and Winema National Forests, with the objectives of quickly treating fire-damaged areas to minimize loss of soil and soil productivity, deterioration of water quality, loss of natural runoff control, and threats to life and property. Cost evaluations considered not only the economic benefits of treatment (versus no treatment), but also environmental and social benefits. These projects are not intended to be long-term; they only address immediate treatment measures for the first winter season. Emergency funds paid for helicopter seeding of grass on severely burned areas and stabilization of stream channels, but did not include long-term restoration projects such as reforestation of plantations and riparian zones.

An interdisciplinary approach is used to evaluate burned areas and to determine the need for emergency rehabilitation. Journeyman-level specialists with expertise in watershed management, forestry, engineering, and fish/wildlife are assigned to a burned area survey team. The size and complexity of a wildfire determines the number of team members and the type of technical skills needed. The team is responsible for assessing ground conditions, identifying what emergency situations exist, recommending treatments, providing treatment prescriptions, and applying for the emergency treatment funding. The team also works with the fire suppression organization to identify resource damage caused by suppression activity and recommends rehabilitative measures. For 1987's wildfires, the Umpqua teams found that about one-fourth of the areas within the fire lines were burned hot enough to require emergency treatment. The final phase of this process is evaluation. Each rehabilitative treatment is revisited to determine if it has met the objectives defined by the burned area survey team and the Forest Supervisor. Post-treatment evaluation also includes how well these treatments function and the need for maintenance work. This information helps determine whether additional treatments and funding are necessary, or whether the same treatments will be necessary for future fires.

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## SISKIYOU NATIONAL FOREST SILVER FIRE RECOVERY PROJECT

### Fire Rehabilitation and Recovery

The extraordinary dry lightning storms on the evening of August 30, 1987, started numerous fires on the Siskiyou National Forest, resulting in three major fire complexes. These were the Silver (96,540 acres), Longwood (9,916 acres), and Galice (21,140 acres, of which 5,000 acres are on National Forest land). Rehabilitation, analogous to first aid, has already been carried out on the three fire complexes. These efforts focused on the prevention of soil erosion from burned areas and fire roads by seeding annual rye grass with minor amounts of vetch mixed in (39 lbs/ac), applying N-P-K-S fertilizer (16-20-0-15 at 250 lbs/ac) and constructing erosion control structures when deemed appropriate (Table 1). Most of the burned areas that were seeded contain salvageable timber. Lesser amounts of the burned and seeded areas contain timber deemed not salvageable because of deficient size or volume.

**TABLE 1.--Fire rehabilitation statistics for the Siskiyou National Forest for 1987 fires.**

| Fire Complex | Aerial Seed (acres) | Aerial Fertilize (acres) | Hand Seeding (acres) | Cost | Completion Status | Fire Roads Treated |
|---|---|---|---|---|---|---|
| Galice | 750 | 750 | 84 | $111,000 | Done | Done |
| Longwood | 2,528 | 2,528 | 250 | $307,000 | Done | Done |
| Silver | 6,600 | 2,930 | 60 | $404,000 | Done | Done |
| TOTAL: | 9,878 | 6,208 | 394 | | | |

On the Silver Fire Complex, 43 straw check dams and one sandbag structure were constructed, using approximately two tons of straw spread over six acres. Several sediment traps were constructed below culverts using already downed logs. About 11 acres of contour felling were also completed. The project required 700 man-hours for completion, 475 of which were worked by a four-person crew formed for the project, and took three weeks to complete. The rehabilitation effort was finished one day before the first major fall rainstorm. At this time, water running through culverts was clear, indicating that rehabilitation efforts were effective. Further monitoring will better define the effects of these erosion control measures.

Recovery involves longer-term efforts and focuses on appropriate timber salvage and reforestation. Data gathering for these efforts started in mid-September when the Galice and Longwood Fires were largely under control. A total of 235 MMbf of dead timber is now estimated to exist on the three fire complexes (Table

TABLE 2.--Timber salvage on the Siskiyou National Forest from 1987 fires.

| Fire Complex | Total Acres | Forest Service Acres | Expected Salvage Volume (MMBF) |
|---|---|---|---|
| Galice | 20,405 | 5,000 | 15 |
| Longwood | 9,916 | 9,400 | 40 |
| Silver[1] | 45,000 | 45,000 | 175 |
| Indigo | | | (41) |
| Bald Mountain | | | (70) |
| Chinaman Hat | | | (14) |
| North Silver | | | (50) |
| Total | 74,321 | 59,400 | 235 |

[1] Unroaded lands outside of wilderness area. Volume estimates also given for the project areas of the Silver Fire Complex.

2). Much of this is proposed for removal. (See articles by Tesch p. 11, Weatherspoon p. 14, and Ragenovich p. 15, in this issue).

## Salvage and Recovery Management

The Longwood and Galice Fire Complexes were evaluated by their respective Ranger Districts for salvage and other recovery management. For the most part, those burned areas were accessible from existing road systems. Assessments of damage were being completed by individual Ranger Districts for forest resources including fisheries, watersheds, soil, timber, wildlife, and others.

Because of the size, the Silver Fire Complex is different. Special interdisciplinary teams evaluated fire effects on multiple use resources within the 45,000 acre unroaded area, with the 51,540 acre burned area within the Kalmiopsis Wilderness being monitored only for its natural recovery. Helicopters, horses, and mules were being used for transportation. Snowfall in November ended most field work on the Silver Recovery Project, although information is still being gathered whenever possible.

## Silver Fire Recovery Project

The burned land within the unroaded portion is scenic and rugged, containing steep mountain sides and rocky river canyons. Physiographic areas include the Illinois River, the Chetco River, and tributaries such as Indigo Creek and Silver Creek. Wide variations of fire burn intensity include everything from lightly underburned areas to large acreages of charred old growth and mosaics of intermediate intensities.

The Silver Fire Recovery Project was divided into four project areas for field inventory, data collection, and planning. Each project area, Bald Mountain, Chinaman Hat, North Silver, and Indigo, had a full interdisciplinary team collecting field data, assessing data, and identifying post-fire management alternatives. These teams also began an environmental analysis. A Cumulative Effects Team developed inventory guidelines so that each of the four area teams collects uniform data, allowing all burned areas to be assessed for cumulative effects. The four teams worked closely to develop alternatives that cross project area boundaries. These alternatives were to be developed by January 8, 1988.

As many as 120 people worked on the Silver Fire Recovery Project, representing most National Forests in the Pacific Northwest Region, as well as National Forests in New Mexico, Utah, Minnesota, Montana, Nevada, and California. The four interdisciplinary teams included wildlife biologists, silviculturists, soil scientists, fisheries specialists, landscape architects, transportation planners, recreation specialists, economists, and fuels and cultural resources technicians.

The area outside of the Kalmiopsis Wilderness has been the focus of local, regional, and national interest for many years. For this reason, public participation in the planning and review process was encouraged. A weekly news update informed the public as to progress on the Silver Fire Recovery Project and offered opportunities for input. Analyses of these inputs helped guide future management decisions.

## Reforestation

For reforestation of burned lands, the following considerations apply. Where knobcone pine or shore pine are major components of a stand to be harvested and/or reforested, planting will not be done except to introduce other species appropriate for the site. Live conifers will be retained wherever possible to supplement reforestation efforts with natural regeneration.

The amount of tree seedlings needed can currently be provided by available nursery sources. Seven nurseries are filling the need. Future seedling needs and reforestation dollars will depend on the rate of salvage harvesting. Estimated appropriated dollar needs for Fiscal Year (FY) 1989 are $900,000. Beyond FY 1989, estimated total costs for reforestation associated with this summer's fires are $7,000,000.

A total of 1417 acres of young plantations burned on the three fire complexes. Of this, 979 acres will be planted in FY 1988 and the remainder will be replanted in the spring of FY 1989. Stand ages ranged from those recently planted to 38-year-old young stands that had recently been precommercially thinned. Weed problems are anticipated with resprouting tanoak and madrone, and germinating ceanothus species, primarily *C. velutinus*. Few problems are anticipated with grass and legumes seeded for erosion control, because burned plantations typically were not seeded with these species. The acres of young stands burned by each fire are as follows:

Galice - 342 acres; 287 acres will be planted in FY 1988 for a cost of $144,000. This includes shading of some seedlings with styrofoam cups and animal damage control with short vexar tubes used as bud caps.

Longwood - 1,058 acres; 675 acres will be planted in FY 1988 for a cost of $151,500. This does not include shading or animal damage control. About 226 acres have been aerially seeded with surplus Douglas-fir seed to supplement planting in difficult areas. This cost about $1,500.

Silver - 17 acres burned and will be planted in FY 1988 for a cost of $8,500. This includes shading with styrofoam cups and animal browse control with short vexar tubes used as bud caps.

## Future Management Action

Development and publication of the environmental documents assessing the fires' impacts is tentatively scheduled for February and May 1988. Environmental Assessments for Chinaman Hat, Indigo, and the North Silver areas are scheduled for signing by the Forest Supervisor by February 15, 1988. A Notice of Intent to perform an Environmental Impact Statement (EIS) for the Bald Mountain portion has been announced, and a draft EIS is tentatively scheduled for March 7, 1988, with the final EIS to be completed on May 15, 1988. For more information, contact us at the Siskiyou National Forest, P.O. Box 440, Grants Pass, OR 97526; (503) 479-5301.

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