A COMPARISON OF DRY AND MOIST FUEL UNDERBURNS IN PONDEROSA PINE SHELTERWOOD UNITS IN IDAHO[1]

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ABSTRACT: In a northern Idaho mixed conifer stand, the effectiveness of experimental shelterwood cutting and underburning were tested for returning stand dominance to seral ponderosa pine. Treatments included a moist fuels underburn, a dry fuels underburn and a no burn in shelterwood units, cut to leave 40 to 80 square feet of basal area per acre. These initial results are compared with those of five experimental underburns conducted in shelterwood units in west-central Idaho.

We describe the fires and compare fuel reduction, tree mortality, conifer regeneration, and initial postburn vegetation for the different burn and no burn treatments. Woody fuel reduction ranged from less than 30 percent in moist burns to as much as 70 percent in dry burns. Duff reduction ranged from less than 10 percent in some moist burns to greater than 90 percent in the dry burns. Tree mortality in mature ponderosa pine was light except locally where there was wind damage. Douglas-fir mortality was generally greater. On no-burn and moist-burn treatments, posttreatment vegetation was similar to the original vegetation. Dry-burn sites were colonized by resprouts from the original vegetation along with seedlings of native seral shrubs and both native and introduced herbs. Initial establishment of both ponderosa pine and western larch seedlings from planted seeds was much greater on burned, mineral soil microsites.
KEYWORDS: shelterwood cutting; underburning; ponderosa pine; prescribed fire

INTRODUCTION

Ponderosa pine (Pinus ponderosa var. ponderosa) is considered a seral species over most of its range in Idaho and western Montana. Because of its fire resistance, it was maintained historically as an abundant seral species by frequent

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low-severity fires ignited by lightning and Native Americans (Arno 1988). Since about 1900, fire has been largely excluded from these forests. This has allowed the more shade-tolerant species Douglas-fir (Pseudotsuga menziesii var. glauca) and grand fir (Abies grandis) to replace much of the pine. In the absence of surface fires, these species often grow in dense thickets or understories. They serve as fuel ladders that allow wildfires to crown and kill the stand. The densely stocked trees are also under physiological stress due to intense competition for moisture and nutrients, and are susceptible to root- and bole-rotting fungi, dwarf mistletoe (Arceuthobium spp.), and defoliating insects (Fellin 1980). In contrast, properly thinned stands of ponderosa pine on these sites are relatively resistant to damage from these agents.

Partial cutting of seral ponderosa pine stands typically removes much of the overstory pine and speeds up successional replacement by understory firs (Arno 1988). Clearcutting and planting can be used on some sites to re-establish pine. On many sites, however, ponderosa pine seedling establishment is hindered by intense competition from shrubs and sod-forming grasses or the characteristic harsh microclimate. Clearcutting in these forests can impact important wildlife values, such as big-game winter range, and it frequently conflicts with some people's aesthetic values.

Observations of succession and the natural role of fire suggest that combinations of prescribed fire and silvicultural partial cutting might be useful for maintaining seral ponderosa pine forests (Weaver 1943, Biswell et al. 1973, Arno 1988). However, this hypothesis had not been tested experimentally in the Northern Rocky Mountains. Therefore in 1984 we initiated studies to test effectiveness of different levels of shelterwood cutting along with different severities of prescribed underburning for establishing a healthy, regenerating, ponderosa pine dominated stand.

Although posttreatment response will be measured for a few more years, this paper describes the fire treatments, fuel reduction, and first year-tree mortality and postburn vegetation at the Priest River Experimental Forest site. We also report longer term vegetation development and tree mortality from the Payette National Forest experimental treatment units.

STUDY SITES

Study sites within the Priest River Experimental Forest (PREF) in northern Idaho are at elevations ranging from 2500 to 3800 feet. Several habitat types are represented on these southwest-facing slopes and they include Douglas-fir, grand fir, and western redcedar (Thuja plicata) (Cooper 1987). Over this elevational range annual precipitation averages from about 32 to 35 inches.

Before harvesting, the overstory consisted of about 120 trees per acre with a basal area of about 200 square feet per acre. Ponderosa pine accounted for 33 percent of the overstory, Douglas-fir about 51 percent, and the remaining 16 percent was a mixture of western larch (Larix occidentalis), western redcedar, and western white pine (Pinus monticola). The understory was dominated by a mixture of Douglas-fir, redcedar, and grand fir along with several species of tall shrubs.

The study sites on the Payette National Forest (PNF) are at elevations from 4200 to 4500 feet. These southwest-facing sites varied between moist Douglas-fir to dry grand fir habitat types. Exact stand structure before harvesting was not measured, but it was dominated by 150 to 200 year-old ponderosa pine with a smaller amount of mature Douglas-fir and larch. Douglas-fir and grand fir saplings and tall shrubs dominated the understory.

METHODS

Field Sampling

Downed woody fuels were measured (Brown et al. 1981) before and after fire treatment to relate their consumption to fire impact. In addition, duff reduction and mineral soil exposure were measured to determine burn severity. Basal area and number of trees by species before and after logging treatments were determined. Tree damage, survival, and causal agents were quantified or estimated to determine posttreatment stand dynamics. The percentage of cover for shrubs, grasses, and forbs were measured pretreatment and for several years posttreatment. The emergence and survival of conifer seedlings from sown seed were monitored during the first postburn year. All vegetation including overstory, understory, and conifer regeneration will be monitored in successive years. Weather data were monitored during burning and will be collected through the life of the study.

Shelterwood Treatments

At PREF, all treatment units were harvested and two shelterwood prescriptions were tested, one leaving a moderate overstory of about 40 square feet of basal area per acre and another leaving a heavy overstory of about 80 square feet per acre. The favored retention species was ponderosa pine, which averaged 63 percent of the residual stand but was unevenly distributed. To reach the prescribed basal area levels, mature Douglas-fir (29 percent) and larch (8 percent) were also left. Average diameters for these three species were similar, ranging from 18.5 inches for Douglas-fir to 20.9 inches for ponderosa pine. The affects of the two cutting levels are not apparent at this time and therefore not addressed further in this paper.

At the PNF sites, only the moderate shelterwood prescription was tested. Ponderosa pine was favored, but many Douglas-fir were left to reach the appropriate basal area. Also, understory saplings and small poles were left to determine their response to the burning treatments.

Fire Treatments

At PREF, fire prescriptions called for contrasting but realistic burn treatments to test different levels of fire intensity and resulting fuel consumption on site responses. These contrasts were realized with a no-burn treatment and two burn treatments at different fuel moisture conditions, primarily moist and dry duff. The moist burns were conducted during the warmest, driest period of the day on June 1, 1989, and the dry burns were conducted during the evening, night, and morning of September 13 and 14, 1989 (fig. 1). Strip headfire ignition with propane torches was used to control fire intensity.

Flame lengths in the slash of the moist burns ranged from 1 to 6 feet but were less than 1 foot in natural litter fuels. Flaming duration varied from 15 seconds to several minutes in natural litter fuels and from 5 to 30 minutes in slash fuels. No rain fell on the burns for 14 days so smoldering continued in the duff until mop-up. Fuel moistures during burning are shown in table 1.

In the dry burns much less ignition was needed as the fire backed down the slopes quite readily under these dry conditions (table 1). Flame lengths ranged from 2 to 7 feet in the slash but averaged about 1 foot in litter fuels. Flaming combustion in the slash fuels frequently lasted for many hours. Smoldering, along with infrequent flaming continued for 2 days after ignition at which time 0.4 inch of rain extinguished the fire.

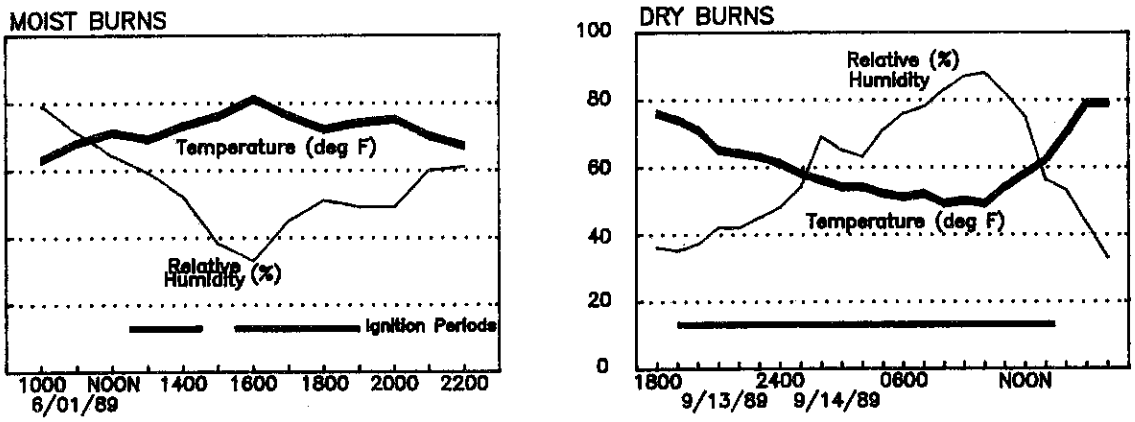

Figure 1. Temperature and relative humidity during ignition periods for moist and dry burns at PREF.

As with the PREF sites, contrasting burn treatments were prescribed on the PNF sites to compare with each other and with an unburned treatment. Burns again were conducted primarily in the spring and fall, although one was performed in midsummer. In general, spring and fall burning corresponds, respectively, with moist and dry conditions, but one spring burn had fuels with moisture contents as dry as those in the fall burns. Weather and average fuel moisture for the burn treatments are found in table 1. Strip headfires were used to control intensity and rate of fire spread. Flame lengths in natural litter fuels were generally less than 1 foot but were quite variable in the slash fuels of all treatments, with maximums up to 10 feet.

Table 1. Environmental conditions during the burns and fuel moistures just prior to the burns at both PREF and PNF.

Location	Burn Type	N	Air Temps	Relative Humidity	Wind	Moisture Content Woody Fuel Size Class 0-1 in	1-3 in	3+ in	Duff
Priest			deg F	%	mph	----------	%	----------	
River	Moist	6	69-76	43-50	1-8	14	20	74	88
	Dry	6	54-77	39-66	1-5	11	12	59	41
Central									
Idaho	Moist	1	64-66	31-33	2-6	10	*	*	91
	Dry	4	63-72	22-39	0-5	11	*	*	35

* Data not collected

RESULTS AND DISCUSSION

Fuel Reduction

A distinct contrast in fuel reduction resulted between the moist and dry prescribed burns in all fuel categories in both research areas (table 2). As expected, the percentage of woody fuel reduction decreased with increasing fuel size. Three times as much duff was consumed in the dry burns as in the moist burns at both locations and twice as much was consumed at PREF as on the PNF sites. Reduction of large woody fuels for the moist and dry burns at PREF was 2.1 and 9.1 tons per acre, respectively, while at the PNF sites, reduction was only 0.9 and 3.4 tons per acre for the moist and dry burns. This difference in the amount of large woody fuels consumed may help explain the duff consumption difference at the two locations.

Table 2. Preburn and postburn fuel loadings and duff depths with cooresponding percentage loss at PREF and PNF.

		Woody Fuel Size Class											
	Burn	0-1 in			1-3 in			3+ in			Duff Depth		
Location	Type	Pre	Post	Loss	Pre	Post	Loss	Pre	Post	Loss	Pre	Post	Loss
Priest		-- t/a --		%	-- t/a --		%	-- t/a --		%	inches		%
River	Moist	3.9	1.2	69	4.7	2.9	38	16.6	14.5	13	1.0	0.7	30
	Dry	5.2	0.4	92	5.2	0.8	85	22.4	13.3	41	1.0	0.1	90
Central													
Idaho	Moist	4.2	1.4	67	6.1	3.7	33	5.2	4.3	17	1.2	1.0	15
	Dry	3.9	0.9	77	5.2	1.7	67	7.8	4.4	43	1.4	0.8	43

Overstory Mortality

Total overstory mortality 1 year after burning and 2 years after harvesting at the PREF site was similar among species with ponderosa pine and larch losing 7.1 percent and Douglas-fir losing 9.3 percent of all trees. It was difficult in many cases to determine specific causes of tree mortality because frequently more than one agent was suspected. One obvious agent was more prevalent in ponderosa pine than the other species. Wind damage, either uprooting or bole breakage, killed 4 percent of the pines and caused 58 percent of the total pine mortality. In Douglas-fir, wind resulted in less than 1 percent loss of total trees or about 7 percent of total mortality. The relatively high wind damage in ponderosa pine appeared to be associated with lack of wind-firmness of trees formerly growing in a dense stand that was suddenly opened up. Wind damage at this stage of the study was not related to the fire treatments because most of the trees were impacted by wind before burning occurred.

A mortality category called background mortality was assigned to the trees in the no-burn treatments, which succumbed to stress-related agents. These agents include several species of bark beetles, root rot and stem pathogens, and perhaps, logging damage. Prior to logging, prolonged effects of severe competition with understory shrubs and other overstory trees apparently added to the general stress level. Radial tree growth had greatly declined in the past 20 to 30 years.

Nonwind mortality increased from the no-burn treatment to the moist-burn treatment and again to the dry-burn treatment, therefore the fire was considered a key agent in tree losses (fig. 2). However, the other stress factors were likely working with fire impacts to ultimately cause tree death.

Figure 2 shows an incremental increase in total mortality of Douglas-fir and larch from no-burn to moist-burn to dry-burn. This was not the case with ponderosa pine because of the variable wind damage. However, looking at the mortality from agents other than wind, this incremental increase as burn severity increases is also apparent in ponderosa pine.

Ponderosa pine, with only 1 percent background mortality in the no-burn treatment, appeared to be in a less stressed state than Douglas-fir with 7 percent mortality in that treatment (fig. 2). However, if this background, nonfire mortality is removed from the mortality in the burn treatments, then the residual fire-related mortality was quite similar in the two species. Larch losses from

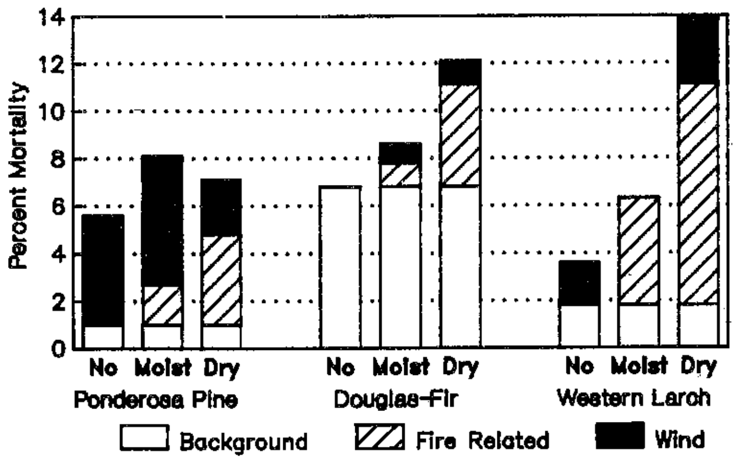

Figure 2. Percentage mortality by cause for three tree species in the no-burn, moist-burn and dry-burn treatments at PREF.

fire injury appeared relatively high, but because of the small sample size, mortality may not have been accurately represented.

For comparison with the findings at PREF, tree mortality data from the PNF areas is shown in figure 3. These results contrast mortality of ponderosa pine and Douglas-fir in two broad size classes and two growing seasons after prescribed underburning in the spring (early May) and the fall (early October). All tree losses were assumed to be caused by direct or indirect fire impacts and not by other agents alone such as wind.

Small ponderosa pine mortality was quite high following fire in both seasons, exceeding that of Douglas-fir (fig. 3). These ponderosa saplings and poles, being in an understory position, were likely under significant stress because of their inherent shade-intolerant nature, and thus may have been predisposed to mortality from fire injury. Douglas-fir saplings and poles, being more shade-tolerant, were likely under less stress and, therefore, death was primarily the result of fire effects alone.

Larger trees of both species were minimally impacted by the spring fire. However, Douglas-fir mortality from fall burns was three times greater than that of ponderosa pine, implicating the superior fire resistance of mature pines. This distinction was not apparent in the more moist habitats in the PREF study.

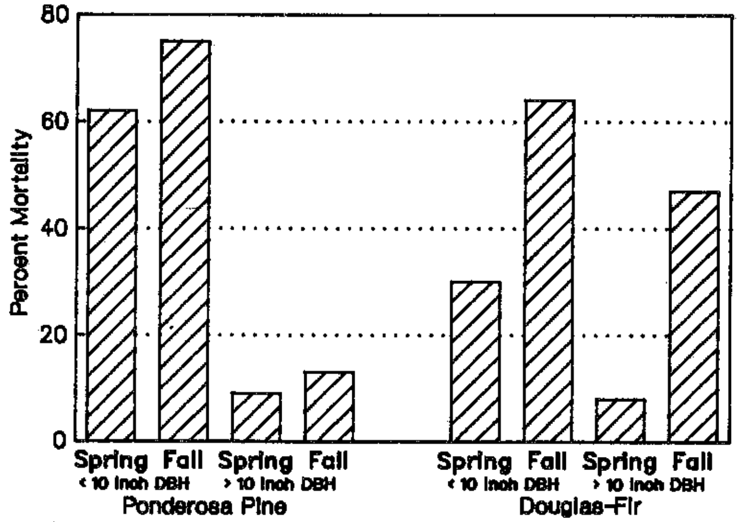

Figure 3. Percentage tree mortality, of contrasting spring to fall burning and two size classes on the PNF site.

An interesting observation (fig. 3) is that ponderosa pine mortality from spring and fall burning was similar, within size classes, but Douglas- fir mortality from fall burning was significantly greater than from spring burning. The overstory pines had a high tolerance for the range of fire conditions produced by both the spring and fall fires. However, the difference between fire conditions and impacts produced by the spring and fall burns was apparently enough to cause varied levels of mortal injury to the Douglas-fir. Therefore, a narrower range of fire tolerance for Douglas-fir is suggested. This differential response could have implications for species management using varied fire characteristics.

First-Year Natural Conifer Regeneration

At PREF, ponderosa pine and western larch seeds were sown in the fall of the same year as burning. Seedling emergence and mortality were monitored during the first growing season.

Burned seedbeds produced 6 to 12 times more ponderosa pine and 3 to 7 times more western larch seedling germinates than unburned seedbeds. Dry-burn treatment seedbeds produced twice the seedling germinates for both ponderosa pine and western larch as did the moist-burn treatment seedbeds.

At the end of the first growing season initial establishment of ponderosa pine in the burn treatments was 9 times greater than the unburned, with overall first year survival of seedlings at 50 to 60 percent. There were treatment differences in the percentage survival for larch with 63 percent on the dry burn compared to 45 percent for the no-burn. Seedling emergence and survival during the first season are generally the most critical in the establishment of tree regeneration (Shearer 1975). As trees age, they become less sensitive to environmental extremes and are better able to avoid physiological stress (Foiles and Curtis 1973). In this study, the benefit of burned seedbeds seems clear for the initial establishment of ponderosa pine and western larch.

Understory Vegetation Response

The percentage canopy coverage was estimated for each vascular plant species in seven coverage classes (Brown et al. 1981). The pretreatment cover estimates were made during the summer before the logging began. Posttreatment coverages were estimated for both burn and no-burn units, in summer, the year after the burns. The no-burn, moist-burn, and dry-burn treatments generally represent a progression of increasing heat treatments on the soil and surface vegetation. This progression is illustrated by consumption of woody fuels (all size classes), which was obviously zero in no-burn, and averaged 24 percent in wet burn, and 57 percent in dry burn units at PREF (table 3) and by posttreatment mineral soil exposure, which averaged, respectively, 2, 10, and 38 percent (table 3).

Table 3. Percentage cover for selected plant species, mineral soil exposure and woody fuel consumption at PREF.

	SHELTERWOOD					
	NO BURN		MOIST BURN		DRY BURN	
GENUS SPECIES	PRE	POST	PRE	POST	PRE	POST
	PERCENT COVER					
SHRUBS						
ACER GLABRUM	4.2	1.3	5.1	1.4	5.0	0.5
AMELANCHIER ALNIFOLIA	1.1	1.3	1.5	0.9	0.7	0.1
CEANOTHUS SANGUINEUS	0	0.4	0	1.8	0	10.6
HOLODISCUS DISCOLOR	6.8	4.4	5.8	1.9	5.5	0.9
PHYSOCARPUS MALVACEUS	19.4	15.2	26.3	16.2	16.2	4.7
ROSA GYMNOCARPA	3.9	3.6	4.1	3.3	3.9	3.0
RUBUS PARVIFLORUS	4.2	4.5	1.3	1.5	1.2	2.6
SPIRAEA BETULIFOLIA	3.7	3.3	4.3	4.4	2.7	2.8
SYMPHORICARPOS ALBUS	4.6	4.7	2.7	2.2	3.1	2.2
VACCINIUM GLOBULARE	1.6	1.0	2.3	0.6	1.4	0.1
LOW WOODY PLANTS						
BERBER REPENS	4.6	4.0	3.8	3.7	3.9	1.3
LINNAEA BOREALIS	4.3	2.6	4.5	2.3	1.0	0.2
LONICERA CILIOSA	1.5	1.3	0.9	0.6	0.7	0.1
FERNS						
PTERIDIUM AQUILINUM	3.1	3.1	2.2	2.1	0.8	1.7
GRASS						
BROMUS CARINATUS	0.7	1.4	0.4	1.6	0.3	0.3
BROMUS VULGARIS	1.9	0.2	1.7	0.2	1.5	0.1
CALAMAGROSTIS RUBESCENS	16.1	15.4	16.4	18.5	9.7	10.4
CAREX CONCINNOIDES	2.1	1.4	1.2	0.6	0.7	0.4
CAREX ROSSII	0.7	1.3	0.5	2.5	0.7	3.9
ELYMUS GLAUCUS	0.3	0.8	0.3	0.6	0.1	0
FESTUCA OCCIDENTALIS	0.4	1.6	0.8	1.7	0.3	0.6
PERENIAL HERBS						
ADENOCAULON BICOLOR	2.4	2.3	1.7	1.5	2.0	1.0
APOCYNUM ANDROSAEMIFOLIU	0.5	0.9	1.0	2.6	0.5	1.4
ARENARIA MACROPHYLLA	1.1	1.1	0.9	1.0	1.0	1.8
CLINTONIA UNIFLORA	3.6	2.7	3.0	1.4	2.4	0.3
DISPORUM HOOKERI	2.0	1.2	1.0	0.4	1.6	0.8
EPILOBIUM ANGUSTIFOLIUM	0	0.2	0	0.2	0	5.5
FRAGARIA VESCA	1.1	1.2	1.3	0.9	1.1	0.4
GALIUM TRIFLORUM	1.4	3.2	0.9	0.7	1.6	0.8
HIERACIUM ALBIFLORUM	1.6	1.8	1.5	1.3	1.6	0.5
MONTIA PERFOLIATA	0	0	0	0	0	1.1
SMILACINA STELLATA	3.7	2.3	3.0	1.1	3.2	0.2
INTRODUCED HERBS						
CIRSIUM VULGARE	0	0.2	0	2.4	0	0.9
TOTAL COVER BY VEGETATION TYPE						
SHRUBS	50.2	40.9	54.0	34.3	39.2	27.6
LOW WOODY PLANTS	10.4	7.9	9.2	6.6	5.6	1.6
GRASSES	22.9	22.5	22.5	27.5	14.4	17.1
FORBS (INCL. PTERIDIUM)	23.9	25.9	25.6	23.4	21.0	23.9
TOTAL VASCULAR PLANT COVER	107.4	97.2	111.3	91.8	80.2	70.2
MINERAL SOIL COVERAGE AFTER TREATMENT		2%		10%		38%
BURN CONSUMPTION OF ALL WOODY FUELS		0		24%		57%

One year after treatment, total vascular plant cover was only slightly below pretreatment levels on all treatments at PREF, although the percentage reductions were somewhat greater in the burn treatments (table 3). There were, however, substantial changes in species composition related to treatment type. In the no-burn units, the tall shrubs Acer, Holodiscus, and Physocarpus decreased slightly, probably because of mechanical damage during logging. The small shrub Vaccinium globulare (huckleberry) and the low woody plant Linnaea also decreased in the no-burn units, which is consistent with their response in logged/no burn stands in other studies (Arno et al. 1985). Coverage changes in herbaceous species were generally minor or subtle in the no-burn units.

In contrast, there were major compositional changes after the dry-burn treatment. The coverage of tall shrubs Acer, Holodiscus, and Physocarpus was greatly reduced (table 3), although long term postburn studies suggest that these shrubs will approach or surpass their pretreatment coverages in several years (Arno et al. 1985). The sensitive V. globulare shrub and the low woody plants were also greatly reduced after the dry burns, whereas most small shrubs (i.e., Rosa, Spiraea, and Symphoricarpos) had approximately regained their pretreatment levels in 1 year and Rubus had increased. Ceanothus spp. are shade-intolerant shrubs that often regenerate abundantly on a freshly burned site as a result of large quantities of soil-stored seed that survives the fire and are induced to germinate by a heat treatment (Reed 1974). Stickney (1990) classifies these fire species as "residual colonizers." At PREF Ceanothus was rare in the pretreatment communities and after the no-burn treatment but became the most abundant shrub after the dry burns. The average number of Ceanothus seedlings per acre was 450 after the no-burn treatments, 26,700 on the wet burns, and 144,400 on the dry burns. In general, as fire severity increased, the amount of shrub sprout cover decreased and the amount of shrub seedling cover increased.

Among herbaceous species at PREF, the rhizomatous pinegrass Calamagrostis rubescens maintained its original cover after all treatments. On the PNF study sites, Calamagrostis also retained its original cover, except following the dry burns at the Steve's Creek site where full recovery took about 3 years (table 4). Grazing by cattle may have been partially responsible for this slight delay in recovery.

The native sedge Carex rossii was a minor component of undisturbed stands, but increased strongly from a combination of seeding and rhizome stimulation after all disturbances at all study areas. Fireweed, Epilobium angustifolium, is an "off-site colonizer" (Stickney 1990) that is established from wind-transported seeds. Although it was rare in the original stands, it became the second most abundant herb after the dry burn at PREF. In general, however, the pretreatment coverage of perennial forbs (broadleaved herbs) was reduced as fire severity increased.

The upland willow Salix scouleriana also increased as a result of wind-transported seeds in the three fall and summer burns in the PNF study (table 4). In the other treatment at the PNF sites, Salix increased from sprouts on surviving shrubs that expanded in response to thinning of the overstory. Other off-site colonizers that increased markedly after burn treatments at PREF and the PNF sites were the annual fireweed Epilobium paniculatum and the introduced thistle Cirsium vulgare. The native bracken fern, Pteridium aquilinum, increased substantially during the 6 years following treatment at all the Secesh River treatment units on the PNF. At PREF Pteridium maintained its initial cover 1 year after no burns and moist burns, but doubled in coverage after the dry burns.

Table 4. Percentage cover for selected plant species and percentage woody fuel consumption on the PNF study sites.

SECECH RIVER STUDY SITE	UNIT 1 SHELTERWOOD/NO BURN				UNIT 3 * SPRING BURN '87		UNIT 2 SPRING BURN '85			UNIT 4 FALL BURN '84			
GENUS SPECIES	PRE	1yr	3yr	6yr	PRE	3yr	PRE	2yr	5yr	PRE	1yr	3yr	6yr
	PERCENT COVER												
AMELANCHIER ALNIFOLIA	3.0	3.0	5.1	9.4	0.3	2.6	2.6	1.3	6.2	0.0	0.0	0.3	1.6
CEANOTHUS VELUTINUS	0.0	0.0	0.1	0.2	0.2	0.7	0.0	1.0	1.3	0.3	3.6	2.8	10.1
SALIX SCOULERIANA	0.3	1.3	5.0	1.3	0.3	4.2	2.9	2.0	4.0	0.0	0.0	3.2	4.3
PTERIDIUM AQUILINUM	4.0	4.5	5.3	10.9	3.3	13.6	1.6	1.7	4.6	2.6	2.4	2.8	11.0
CALAMAGROSTIS RUBESCENS	12.2	18.6	21.8	39.3	5.8	25.4	12.5	9.9	23.6	8.3	7.9	12.1	18.5
CAREX ROSSII	0.0	1.3	3.6	6.8	0.1	8.4	0.0	5.8	16.2	0.3	1.3	6.6	11.2
EPILOBIUM PANICULATUM	0.1	1.1	1.0	0.9	0.0	2.5	0.6	1.8	2.3	0.0	0.8	5.4	2.9
CIRSIUM VULGARE	0.0	0.0	0.3	0.1	0.0	1.6	0.2	3.3	4.4	0.0	0.2	1.8	6.3
TOTAL COVER BY VEGETATION TYPE													
SHRUBS	12.7	18.7	21.9	27.2	6.5	22.7	19.3	20.3	30.6	6.3	8.2	13.4	24.7
GRASSES	14.2	21.3	27.1	49.7	12.9	42.1	15.6	17.5	44.5	11.9	10.6	20.3	33.2
FORBS (INCL. PTERIDIUM)	19.3	26.2	24.8	35.2	15.2	38.8	25.2	31.1	38.1	20.9	18.0	37.6	45.4
TOTAL VASCULAR PLANT COVER	46.2	66.2	73.8	112.1	34.6	103.9	60.1	68.9	113.2	39.1	36.8	71.3	103.3
BURN CONSUMPTION OF ALL WOODY FUELS	0%				39%		58%			59%			

* Unit 3 at Secesh river is the only burn unit with duff moistures similar to the moist burns at PREF.

STEVES CREEK STUDY SITE	UNIT 1 SHELTERWOOD/NO BURN			UNIT 2 FALL BURN '84				UNIT 3 SUMMER BURN '86		
GENUS SPECIES	PRE	3yr	6yr	PRE	1yr	3yr	6yr	PRE	1yr	4yr
	PERCENT COVER									
AMELANCHIER ALNIFOLIA	0.0	1.3	2.0	0.0	0.0	0.3	0.8	0.0	0.0	0.3
SALIX SCOULERIANA	1.3	1.3	3.1	0.0	0.0	0.5	1.3	0.0	0.0	2.3
VACCINIUM GLOBULARE	3.4	2.4	3.6	11.3	5.6	7.2	11.1	13.3	1.6	6.0
CALAMAGROSTIS RUBESCENS	37.7	45.4	63.0	19.2	12.5	18.0	26.9	15.1	5.4	20.8
CAREX ROSSII	0.1	0.1	0.2	0.1	0.0	0.9	1.9	0.0	0.4	1.8
FESTUCA OCCIDENTALIS	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.1	1.1
EPILOBIUM PANICULATUM	0.0	0.0	0.8	0.0	0.1	0.7	3.3	0.0	0.3	6.0
CIRSIUM VULGARE	0.0	0.1	0.2	0.2	0.0	1.9	2.3	0.2	1.1	4.1
TOTAL COVER BY VEGETATION TYPE										
SHRUBS	19.9	16.1	33.8	29.8	16.7	21.6	38.3	30.0	8.4	26.7
GRASSES	41.2	48.5	69.1	22.7	14.1	22.2	34.9	18.7	6.9	26.2
FROBS	23.3	25.0	36.9	14.4	11.6	19.4	35.3	13.2	9.1	34.5
TOTAL VASCULAR PLANT COVER	84.4	89.6	139.8	66.9	42.4	63.2	108.5	61.9	24.4	87.4
BURN CONSUMPTION OF ALL WOODY FUELS	0%			52%				64%		

CONCLUSIONS

Prior to extensive fire control frequent fires served to maintain stands dominated by seral conifers (primarily ponderosa pine) by thinning all species, but primarily by reducing numbers of highly competitive climax species. Proper forest management activities can duplicate and probably improve upon these natural processes. Former ponderosa pine-dominated stands, which have developed dense understories of climax conifers because of fire suppression, can be returned to more open, regenerating pine stands with properly selected cutting schemes and prescribed fire. In shelterwood systems such as reported on here, dry-burn, moist-burn, and no-burn treatments are all possible management options. It is clear that they produce differences in site responses, each of which may apply to specific management objectives. We hope to clarify what these different responses are in the long term and how site values, in addition to timber production, are influenced.

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