SHRUB RESPONSES AFTER FIRE IN AN IDAHO PONDEROSA PINE COMMUNITY[1]

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Buring at 10–15-year intervals has been recommended in the warm, grand fir (*Abies grandis*)-myrtle pachistima (*Pachistima myrsinites*) communities on the Lochsa River of northern Idaho (Leege 1979). Spring and autumn burning generally promote sprouting of most shrub species in this community and produce valuable browse (Leege and Hickey 1971, Wright 1978). Fire is also a valuable tool in shrub and timber management in the more xeric ponderosa pine (*Pinus ponderosa*)-common snowberry (*Symphoricarpos albus*) communities (Davis et al. 1980). Effects of fire on production and mineral content of shrubs in this community have not been documented.

The objectives of this study were to measure changes in shrub density, biomass, production, and mineral concentrations for several years after a fire and to compare these values with those mea-

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sured for shrubs growing on adjacent unburned sites.

STUDY AREA

A fire caused by lightning in a warm, dry ponderosa pine-snowberry habitat type and adjacent montane grassland on 10 August 1973 in the Upper Selway River (White Cap Creek) area of northern Idaho, provided the opportunity to assess shrub responses to burning. The 1,100-ha area, which burned for 43 days (Mutch 1974), is part of a fire-management zone in the Selway-Bitterroot Wilderness Area where fires are allowed to burn under most natural conditions.

The burned area ranged in elevation from 935 to 1,830 m. All study plots were on south-facing slopes at 1,000–1,300 m above sea level. Soils were formed from parent material consisting of decomposed granite, gneiss, and rhyolite on the Idaho Batholith (Greenwood and Morrison 1967). Habeck (1972) characterized these soils as having low fertility and water holding capacity and weak structure. Average annual precipitation was 76 cm which peaked during November–January and again in April–June (Finklin 1977).

The fire occurred under extremely dry conditions, with relative humidity as low as 11%, maximum temperatures of 32 C, and winds gusting to 45 km/hour. Herbaceous cover was sparse and unevenly distributed on south-exposed slopes. The major shrubs, common snowberry, Saskatoon serviceberry (*Amelanchier alnifolia*), birchleaf spirea (*Spirea betulifolia*), baldhip rose (*Rosa gymnocarpa*), mallow ninebark (*Physocarpus malvaceus*), and redstem ceanothus (*Ceanothus sanguineus*) were sporadically located across the slopes increasing in abundance in draws and southeasterly aspects. Other shrubs encountered at low densities included scouler willow (*Salix scouleriana*), dwarf blueberry (*Vaccinium caespitosum*), common chokecherry (*Prunus virginiana*), creeping barberry (*Berberis repens*), and creambush rockspirea (*Holodiscus discolor*).

Adjacent unburned slopes that were topographically similar were used for comparisons with areas burned in 1973. One unburned ridge had burned in 1962, 11 years prior to the burn under study. A reconnaissance prior to plot selection indicated effects of the 1962 burn on parameters we measured were gone by the time of our investigation.

Elk (*Cervus elaphus*) and deer (*Odocoileus hemionus, O. virginianus*) use these areas as winter–spring range. McCulloch (1955) reported heavy browsing by elk on shrub winter ranges near the present study site. Livestock grazing was discontinued entirely in 1972, except for occasional fall use by outfitter pack horses.

METHODS

Shrub unions dominated by snowberry and/or ninebark were examined starting in 1974. Six study sites were randomly located on aspects of 110–265° within the burned area and 7 sites were established on comparable adjacent unburned sites on aspects of 75–245°. No unburned sites within the burn perimeter were found to serve as comparisons.

Twenty 4-m² microplots were systematically located starting at random within each study site. Rooted stem numbers per unit area and stem heights of the 6 major species were measured each August on each microplot. Thirty to 50 plants of each species were harvested on each study site outside the microplots and air dried. Shrub heights and twig numbers were recorded. Plants were oven dried at 70 C for 48 hours. Current annual growth (CAG) was separated into twigs and leaves before weighing. CAG and the remaining above ground material was aggregated and weighed to estimate total stem biomass.

Twig numbers were estimated from mean number of twigs per plant or from regression analysis of twig numbers on plant height. CAG and plant biomass were estimated from regression analysis of twig weight on plant weight and plant weight on plant height, respectively. Weight estimates were multiplied by shrub densities in microplots to determine annual production and biomass per unit area.

Samples for nutrient concentrations in twigs and leaves were collected from plants on burned and unburned sites in June of the first 3 years. The upper one-third of each twig was ground to pass through a 2-mm sieve. Samples were analyzed for N by semimicro Kjeldahl. Calcium, Cu, K, Mg, Mn, Na, and Zn concentrations were determined by the vanodate-molybdate method on material digested in a 3:1 mixture of HNO_3:HClO.

Differences in plant parameters between years were tested on burned and unburned sites separately by least square analysis of variance for data with unequal subclasses (Harvey 1960) and Duncan's multiple range test (Steel and Torrie 1960). Since plant parameters on unburned sites did not differ ($P < 0.05$) over the 4-year period, these data were pooled for comparisons with burned plots. Student's t test was used to test for differences between plant parameters on burned and unburned sites.

Mineral data from all 3 years were pooled and treatment means were tested with a Mann-Whitney U test (Siegel 1956). Differences in mineral concentrations between species were tested by least square analysis of variance and Duncan's multiple range test (Steel and Torrie 1960).

RESULTS

Shrub Densities

Mean stem densities of the 6 major shrub species were greater on burned than on unburned sites. Common snowberry constituted over 40% of the total number of stems present on both burned and control sites. Mallow ninebark and birchleaf spirea were more abundant ($P < 0.05$) on burned than unburned sites. Variation in density of other species between sites was great enough to override the comparisons between unburned and burned sites. Redstem ceanothus occurred only as seedlings on the burn, increasing the 2nd growing season after the fire and remaining constant thereafter.

Twig densities (Table 1) were the equivalent of stem densities on burned sites during the first growing season. Twig density in 4 of the 6 shrubs did not increase after the 2nd year. Mallow ninebark and redstem ceanothus twig densities continued to increase until the 3rd and 4th years, respectively.

Shrub Biomass

Common snowberry, mallow ninebark, and redstem ceanothus comprised 90% of the total shrub biomass on unburned sites (Table 1). Total shrub biomass on the burned area the first growing season was about 50% of the shrub biomass on unburned sites. By the 3rd growing season, total shrub biomass on burned sites exceeded that on unburned sites and by the 4th growing season was 35% greater. Biomass of all species except spirea on the burned area, increased during the 4 years, but only the biomass of the taller shrubs (Saskatoon serviceberry, redstem ceanothus, mallow ninebark) increased significantly.

Table 1. Mean number of rooted stems and twigs per m², aboveground biomass (g/m²), current annual growth (g/m²), and mean heights (cm) of 6 shrubs on burned and unburned sites, 1974–77, on White Cap Creek, Selway-Bitterroot Wilderness, Idaho.

		Burned				Unburned
Species		1974	1975	1976	1977	Mean of 1974–77
Saskatoon serviceberry	stems	0.4	0.4	0.4	0.4	0.2
	twigs	0.4^{a}	1.1^{b}	1.2^{b*}	1.3^{b*}	0.3
	biomass	0.4^{a}	1.1^{b}	2.0^{c}	2.1^{c}	1.3
	CAG	0.4^{a}	0.5^{a}	0.7^{b*}	0.7^{b*}	0.2
	height	24^{a}	29^{ab}	33^{bc*}	35^{c*}	26
Redstem ceanothus	stems	0.02^{a}	0.1^{b}	0.1^{b}	0.1^{b}	0.4
	twigs	0.02^{a}	0.2^{b}	0.2^{bc}	0.3^{c}	1.7
	biomass	0.01^{a*}	0.1^{a*}	0.5^{b*}	0.5^{b*}	7.4
	CAG	0.01^{a*}	0.1^{b*}	0.1^{b*}	0.1^{b*}	3.6
	height		12^{*}	15^{*}	18^{*}	44
Mallow ninebark	stems	0.7^{*}	0.7^{*}	0.7^{*}	0.7^{*}	0.2
	twigs	0.7^{a}	6.5^{ab}	8.1^{bc}	13.9^{c}	4.0
	biomass	1.2^{a}	1.8^{a}	2.2^{a}	3.3^{b}	5.1
	CAG	1.2	0.8	0.9	1.2	1.9
	height	27^{a}	32^{ab*}	36^{abc*}	45^{c}	45
Baldhip rose	stems	0.6	0.6	0.6	0.6	0.4
	twigs	0.6^{a*}	2.0^{b}	2.0^{b}	2.2^{b}	1.3
	biomass	0.5	1.4	1.7	1.9	0.9
	CAG	0.5	0.8	0.9	1.1	0.6
	height	20	25	25	27	22
Birchleaf spirea	stems	2.8^{*}	2.8^{*}	2.8^{*}	2.8^{*}	1.0
	twigs	2.8^{a}	3.5^{ab}	3.9^{b}	3.9^{b}	3.6
	biomass	2.1^{*}	2.1^{*}	1.9^{*}	2.0^{*}	0.5
	CAG	2.1^{a*}	1.1^{b}	1.1^{b}	1.0^{b}	0.3
	height	19	20	20	20	17
Common snowberry	stems	3.4	3.4	3.4	3.4	2.3
	twigs	3.8^{a*}	36.2^{b}	36.2^{b}	36.2^{b}	21.3
	biomass	8.1	12.5	16.4	21.4	8.1
	CAG	8.1	5.0	5.9	7.1	2.8
	height	26	27	29	33	33
All shrubs	stems	8.0	8.1	8.1	8.1	4.4
	twigs	8.2	49.5	51.6	57.6	32.1
	biomass	12.3	19.1	24.5	31.3	23.2
	CAG	12.3	8.2	9.6	11.2	9.5

[a] Row mean within burned sites followed by different letters differ from each other ($P < 0.05$).
[b] Asterisks indicate differences between burned sites and overall mean of unburned sites ($P < 0.10$).
[c] Column totals subject to rounding errors.

Current Annual Growth

Total CAG did not vary between burned and unburned sites over the 4 years (Table 1). Redstem ceanothus accounted for 38%; snowberry, 30%; and ninebark, 20% on unburned sites. Common snowberry consistently contributed the greatest proportion of CAG on burned sites.

Saskatoon serviceberry was most productive on burned sites in 1976 and 1977. Redstem ceanothus production increased ($P < 0.05$) after the first growing season but remained well below that on un-

Table 2. Mean mineral concentration values of the upper one-third of current annual growth of 6 shrubs harvested during 3 years from burned (B) and unburned (UB) sites on White Cap Creek, Selway-Bitterroot Wilderness, Idaho, 1974–76.

Minerals	Saskatoon serviceberry	Redstem ceanothus	Mallow ninebark	Baldhip rose	Birchleaf spirea	Common snowberry
Nitrogen, %						
B	1.4	2.2	1.3	1.1	1.3	1.4
UB	1.2[b]	1.5	0.9[b]	1.0[b]	1.0[b]	1.1
MRT[a]	a	b	a	a	a	a
Potassium, %						
B	1.5	1.4	1.6	1.3	1.3	2.3
UB	1.2	1.5[b]	1.2[b]	1.1	1.0[b]	2.1
MRT	a	a	a	a	a	b
Manganese, ppm						
B	130	180	40	100	90	130
UB	210	65[b]	60	160	110	200
MRT	b	ab	a	ab	ab	b
Copper, ppm						
B	9.6	6.0	6.5	5.7	5.1	5.4
UB	6.5[b]	5.2	5.8[b]	4.9[b]	4.4	4.4
MRT	b	ab	a	a	a	a
Magnesium, %						
B	0.30	0.23	0.22	0.48	0.35	0.33
UB	0.30	0.20	0.20	0.40	0.41	0.31
MRT	ab	ab	a	c	bc	b
Calcium, %						
B	1.2	1.4	1.2	1.8	0.9	1.1
UB	1.1[b]	1.2	1.0	1.7	1.1	1.0
MRT	a	bc	ab	c	a	a
Phosphorus, %						
B	0.31	0.16	0.30	1.33	0.34	0.30
UB	0.37	0.15	0.28	0.37	0.29[b]	0.32
MRT	b	a	ab	b	b	b
Zinc, ppm						
B	31	18	14	11	29	25
UB	37	16	20	14	36	26
MRT	c	a	a	a	bc	ab
Sodium, ppm						
B	21	47	48	22	32	23
UB	25	22	53[b]	27	28	27
MRT	a	a	a	a	a	a

[a] Shrubs having dissimilar letters for a given mineral differ ($P < 0.1$) from each other, Duncan's Multiple Range Test (MRT).
[b] Indicates difference between burned and unburned sites at $P < 0.05$.

burned sites through 1977. No change due to burning was evident in CAG of mallow ninebark and baldhip rose.

Shrub Heights

Stem heights of Saskatoon serviceberry, baldhip rose, birchleaf spirea, and common snowberry equalled heights on unburned sites after 1 growing season (Table 1). Redstem ceanothus and mallow ninebark heights on the burned sites were comparable to those on the unburned sites after the 4th growing season.

Mineral Concentrations

The greatest changes in mineral concentrations attributable to the fire occurred in the tallest shrubs (serviceberry, ninebark) and the shortest species (spirea), where at least 3 minerals showed significant differences (Table 2). However, minerals which changed were different among species. Mineral concentrations in common snowberry, the most abundant species, did not change. Nitrogen concentrations were affected in 4 species, potassium and copper levels in 3, and zinc and magnesium were not changed. Generally, burning did not appreciably affect mineral concentrations in these shrubs.

DISCUSSION

The shrub union on this burn was not appreciably changed by the fire. Greatest response of all parameters measured for all species combined was in twig and stem densities, but this did not always translate to similar magnitude of responses in weight of biomass or CAG. This pattern varied with individual species. The problem of detecting small changes attributed to burning in shrubs is compounded by high variation in density between and within stands (Lyon 1968). This variation in density may also be expected to occur in related parameters, including twig numbers and weight estimates (Rutherford 1979).

While mineral concentrations in twigs may not be appreciably affected by burning, the actual amount of nutrients available for use by wildlife may still increase because CAG increases. For example, where potassium concentrations in Saskatoon serviceberry were not affected, the numbers of twigs and CAG increased. Conversely, the increase in nitrogen concentration in Saskatoon serviceberry was correlated with increased weight of CAG. These relationships varied considerably between species and minerals. Also, establishment of redstem ceanothus increases mineral availability to ungulates because it is highly preferred. Nevertheless, overall response from burning was lower than found on more mesic sites further north in Idaho (Leege and Hickey 1971). The observed response of shrubs to this burn was similar to the effect on herbaceous species on adjacent xeric sites (Merrill et al. 1980).

We conclude that common snowberry communities on dry sites will not respond as dramatically to fire as will taller shrub communities on more mesic sites (Mueggler 1965, Ohmann and Grigal 1979). Peek et al. (1976) reported that soil moisture greatly affected nutrient quality of plants. Soils on south-facing slopes on this study area would be extremely dry in summer, and burning at this time would tend to increase the desiccation process. Nevertheless, burning at intervals within the natural fire frequency of about 10 years in this community (Arno 1980) will rejuvenate decadent plants and is thus a useful tool.

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