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Effects of a Fall Wildfire on Herbaceous Vegetation on Xeric Sites in the Selway-Bitterroot Wilderness, Idaho

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Abstract

Trends in productivity and mineral content of herbaceous vegetation in Ponderosa pine and montane grassland over a 4-year period are reported. Dry matter production on burned areas was 1.4, 1.3, 2.2 and 1.6 times that on unburned sites in the four successive years following the fire. Annual forbs and annual grasses contributed 56% of total dry matter the first year following fire. Perennial forbs contributed 40, 75, 75, and 77% of dry matter on the burned sites in successive years following the fire, compared with 66% on the unburned site. Herbage mineral concentrations did not change appreciably following fire, although low values for nitrogen and potassium were apparent in the first year.

Responses of herbaceous understories in Ponderosa pine (*Pinus ponderosa*) communities to fire in the northern Rocky Mountains have not been extensively evaluated. Although investigations in Arizona by Pearson et al. (1972), Campbell et al. (1977), and in central Washington (Weaver 1951) have been made, Mueggler (1976) concluded that generalizations are difficult because each combination of climate, vegetation, and soil must be considered separately. Further, none of these investigations evaluated trends in productivity, vegetative composition, and nutrient content simultaneously.

A lightning-caused fire in Ponderosa pine and adjacent montane grassland on August 10, 1973, in the Upper Selway River (White Cap Creek), Idaho, provided opportunities to assess understory responses. It burned for 43 days over an 1,100-ha area, when it was extinguished by rain (Mutch 1974). The area is a portion of a fire management zone in the Selway-Bitterroot Wilderness where fires are allowed to burn under most natural conditions.

Objectives of this study were to follow changes in vegetative production, composition, and mineral content on the burned area and compare with adjacent unburned sites.

Study Area

Elevations on the burn ranged from 935-1,830 m, with all study plots on south-facing slopes at 1,000-1,300 m above sea level. Soils were derived from Idaho batholith parent material consisting of decomposed granite, gneiss, and rhyolite (Greenwood and Morrison 1967). Habeck (1972) characterized these soils as low in fertility, water holding capacity and of weak structure. Average annual precipitation was 76 cm with peaks occurring November-January and April-June (Finklin 1977).

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The fire occurred under extremely dry conditions, with relative humidity as low as 11%, maximum temperatures to 32° C, and winds gusting to 45 km/hr. Ground cover on south-exposed slopes was sparse and unevenly distributed. Burned study sites showed evidence of burned stubble but no litter. The fire burned rapidly over these sites and left little ash. Adjacent unburned slopes of similar topographic characteristics were used for comparisons.

Elk (*Cervus elaphus*) and deer (*Odocoileus hemionus, O. virginianus*) used these areas as winter-spring range. McCulloch (1955) reported heavy utilization of browse by elk on adjacent shrub winter ranges in the early 1950's, and present study sites undoubtedly had received similar heavy use. Limited livestock grazing was discontinued entirely in 1972 except for occasional fall use by outfitter pack horses.

Methods

Fourteen sites were examined starting in June 1974, seven on south slopes within the burn and seven on adjacent unburned slopes of comparable slope and aspect. Canopy cover and frequency of each species in twenty 2× 5 dm permanent plots (Daubenmire 1959) were determined in June 1974 and 1976, when arrowleaf balsamroot (*Balsamorhiza sagittata)*, bluebunch wheatgrass (*Agropyron spicatum*), and cheatgrass (*Bromus tectorum*) were in full flowering stage. Seed stalk heights of at least 50 individual plants of six common species were recorded during mid-June 1974, 1975, and 1976. Ten 2× 5 dm plots on each site but aside from the permanent plots were clipped to ground level in mid-June of each year. Live herbage was composited by site into perennial forb, perennial grass, annual grass, and annual forb categories except that bluebunch wheatgrass and arrowleaf balsomroot comprised separate categories. All clippings were air dried and later oven dried for 24 hours at 70° C and weighed. Samples were grounded and analyzed for N by semimicro Kjeldahl. Calcium, Cu, K, Mg, Mn, Na, and Zn concentrations were quantified by atomic absorption spectrophotometry, and P was determined by the vanodate-molybdate method on plant material digested in a 3:1 mixture of HNO_3:$HClO_4$.

Transformation of yield data to the one-quarter power was determined by the method of Box et al. (1978) to stabilize the variance function. The transformed data were tested by the least squares analysis for data with unequal subclasses (Harvey 1960) and by Duncan's multiple range test (Steele and Torrie 1960). Years and sites were considered as random effects resulting in a composite error term for treatments (Scheffe 1959). The significance of these differences was then reported for actual yield data. Mineral concentration data, although not transformed, were tested in this same way. Differences in stalk height between years were tested with a one-way least squares analysis (Harvey 1960) after pooling data from the unburned treatment. Student's T-test was used to test for differences in vegetative parameters between burned and unburned treatments.

Results

Composition and Production

Forty-seven herbaceous species were encountered on the

Table 1. Mean percent canopy coverage and frequency of 20 most frequently encountered herbaceous species in 20 microplots on seven burned and seven unburned plots in 1974 and 1976, lower White Cap Creek, Selway-Bitterroot Wilderness, Idaho.

		1974				1976			
	Plant life	% Cover ± S.D.‡		% Frequency ± S.D.‡		% Cover ± S.D.‡		% Frequency ± S.D.‡	
Component	style†	Burned	Unburned	Burned	Unburned	Burned	Unburned	Burned	Unburned
Bareground		64 ± 22	55 ± 13	--	--	36 ± 15	39 ± 16	--	--
Litter		21 ± 22	42 ± 19	--	--	41 ± 13	40 ± 10	--	--
Agropyron spicatum	PG	2 ± 3	6 ± 4	3 ± 4	8 ± 3	4 ± 2	7 ± 7	4 ± 5	6 ± 6
Bromus tectorum	AG	24 ± 12	9 ± 12	16 ± 3	10 ± 8	10 ± 6	6 ± 9	16 ± 5	6 ± 8
Festuca idahoensis	PG	t ± t	1 ± 1	t ± t	1 ± 2	0 ± --	t ± 4	0 ± --	1 ± 2
Koeleria cristata	PG	1 ± 2	2 ± 5	2 ± 3	2 ± 3	2 ± 3	3 ± 4	4 ± 5	5 ± 6
Poa spp.	PG	t ± t	2 ± 4	t ± 1	1 ± 2	0 ± --	1 ± 2	0 ± --	2 ± 2
Achillea millefolium	PF	2 ± 2	2 ± 2	5 ± 4	5 ± 2	12 ± 12	4 ± 5	11 ± 5	6 ± 12
Balsamorhiza sagittata	PF	12 ± 8	14 ± 6	7 ± 4	9 ± 4	15 ± 5	12 ± 6	7 ± 3	7 ± 4
Calochortis elegans	PF	t ± 7	t ± t	1 ± 1	3 ± 2	t ± 1	t ± t	1 ± 2	1 ± 1
Castilleja lutescens	PF	t ± t	2 ± t	t ± 0	2 ± 2	0 ± --	t ± t	0 ± --	t ± 1
Cerastium arvense	PF	4 ± 10	2 ± 3	7 ± 9	8 ± 6	t ± 1	2 ± 3	1 ± 1	3 ± 5
Collinsia parviflora	AF	1 ± 1	t ± t	1 ± 3	2 ± 3	4 ± 3	2 ± 1	11 ± 5	9 ± 4
Delphinium bicolor	PF	t ± t	t ± t	1 ± 2	2 ± 2	t ± t	0 ± --	t ± 1	0 ± --
Lomatium spp.	PF	t ± t	1 ± 2	2 ± 2	2 ± 4	1 ± 2	1 ± 1	4 ± 4	2 ± 4
Lupinus sericeus	PF	t ± 1	1 ± 1	1 ± 2	3 ± 2	2 ± 2	1 ± 1	1 ± 2	2 ± 2
Montia perfoliata	AF	t ± t	t ± t	t ± t	t ± t	t ± t	t ± t	1 ± 1	t ± t
Myosotis micrantha	AF	1 ± 1	2 ± 3	2 ± 3	5 ± 4	1 ± 1	2 ± 2	6 ± 6	8 ± 6
Rumex acetosella	PF	t ± 1	t ± t	1 ± t	t ± 1	2 ± 3	1 ± 2	2 ± 4	1 ± 2
Tragopogon dubius	PF	2 ± 2	1 ± 1	4 ± 3	1 ± 2	1 ± 1	2 ± 1	16 ± 17	19 ± 17
Vicia americana	PF	1 ± 1	1 ± 1	2 ± 2	2 ± 1	2 ± 4	2 ± 3	4 ± 3	2 ± 2
Zygadenus venenosus	PF	t ± t	t ± --	1 ± 1	3 ± 3	t ± t	t ± t	t ± t	t ± t

†PG = perennial grass, AG = annual grass, PF = perennial forb, and AF = annual forb.
‡ t = trace < ± 0.5 S.D., but not zero.

14 macroplots, but canopy coverage and frequency data are reported for 15 forb and 5 grass species (Table 1). Perennial grasses tended to occur less frequently and constituted a smaller percentage of the canopy cover on burned plots than on unburned plots in both 1974 and 1976. Canopy cover of cheatgrass was approximately twice as great on the burned as on unburned sites in 1974 and 1976. Cover and frequency values of yarrow (*Achillea millifolium*), arrowleaf balsamroot, and American vetch (*Vicia americana*) constituted an equal or lower percentage on the burn in 1974, but by 1976 surpassed quantities on unburned sites.

Total herbaceous dry matter production was 1.4, 1.3, 2.2 and 1.6 times greater on the burned sites than on the unburned sites over the four-year period respectively (Table 2). Total production on the burned sites ranged from 56 to 92 g/m^2 with an average of 75 g/m^2. Total production on the unburned sites ranged from 33 to 65 g/m^2 with an average of 47 g/m^2. Maximum production on both treatments occurred the year after the fire.

Annual forbs and annual grasses contributed 56% of the total dry matter the first year after the fire. Perennial forbs including arrowleaf balsamroot contributed 40, 75, 75 and 77% of the dry matter on the burned sites in successive years following the fire, compared with an average of 66% on the unburned sites. Perennial grass production was low on both treatments providing only 3 and 4 g/m^2 respectively on the burned and unburned sites respectively.

Annual forbs were 1.6 times more productive on the burn than on unburned areas the first year after the burn. By 1975 their production returned to a level comparable to that of unburned areas and was highly variable thereafter. Annual grass production on the burn decreased from a two-fold increase over unburned sites in 1974 to a low in 1975 but remained significantly higher on the burned areas through 1977. Perennial forbs were as productive on the burn as on the unburned sites in 1974, but in 1975 production on the burn doubled and tended to be greater through the following 3 years.

Arrowleaf balsamroot production was consistently

Table 2. Mean yields (g/m^2) of seven vegetation categories for each of four years and four-year mean yields on burned and unburned treatments on Lower Cap Creek, Selway-Bitterroot Wilderness, Idaho. Data have been rounded to nearest whole number.

	Treatment × year means†										
	1974		1975		1976		1977		Treatment means		
Vegetation category	Burned	Unburned	Burned	Unburned	Burned	Unburned	Burned	Unburned	Burned	Unburned	α‡
Annual forbs	30a	18b	4de	3e	10ba	6cd	3e	3e	12	8	.12
Perennial forbs	7d	7d	12bc	7d	13bc	8cd	32a	16b	16	10	.27
Annual grasses	22a	9b	5b	5b	6b	1c	10b	2c	11	4	.03
Perennial grasses	3	2	3	4	1	1	1	1	2	2	ns
Agropyron spicatum§	2	1	2	2	1	3	2	2	1	2	ns
Balsamorhiza sagittata§	30	29	30	22	41	14	29	21	33	21	ns
TOTAL	92ab	65bc	56bcd	43cd	72ab	33d	77ab	45cd	75	47	.014

†Row values followed by different letters are significantly different (α=.05).
‡α is probability level that treatment means are truly different, ns is non significant.
§Species yields are not included in perennial grass and perennial forb categories respectively.

Table 3 Mean heights (cm) and confidence limits ($\alpha=0.05$) of 5 major grassland species on seven burned plots by year and seven unburned plots over all years. Percentage values are height of plants on the burn expressed as a percent of unburned plants.†

	Burned						Unburned
	1974		1975		1976		1974-1976
Plant species	$\bar{x}$ C.L.	%	$\bar{x}$ C.L.	%	$\bar{x}$ C.L.	%	$\bar{x}$ C.L.
Achillea millefolium	11 ± 5.5^{a}	55	31 ± 1.9^{b}	151	20 ± 2.0^{c}	98	20 ± 2.8
Agropyron spicatum	29 ± 4.1^{a}	86	42 ± 2.0^{b}	127	27 ± 8.0^{a}	82	33 ± 3.2
Balsamorhiza sagittata	47 ± 4.1	122	46 ± 1.9	122	44 ± 4.2	114	38 ± 1.3
Bromus tectorum	27 ± 1.6^{a}	140	27 ± 1.9^{a}	140	21 ± 3.0^{b}	109	20 ± 1.4
Koeleria cristata	36 ± 6.0^{b}	139	29 ± 3.6^{a}	114	29 ± 3.3^{a}	112	26 ± 2.1

†Row values followed by different superscripts indicate significant differences between years on unburned sites ($\alpha=0.05$).

higher on the burn each year, reaching a peak in 1976. Differences, however, were never great enough to be significant due to high variation between plots. No significant differences were found between production of bluebunch wheatgrass or other perennial grasses on the burned and unburned sites, although production also tended to be lower on the burned areas.

The mean heights of three major grass species and two important herbaceous species were used as indices of plant vigor (Table 3). Cheatgrass plants averaged 40% taller on the burn for two years following the fire and then dropped to a height comparable to plants on unburned areas. Junegrass (*Koeleria cristata*) appeared to be more vigorous on the burn than on adjacent areas the first growing season, but no differences were evident a year later. Bluebunch wheatgrass plants were significantly taller the second growing season after the fire, but were of similar height in 1974 and 1976. Arrowleaf balsamroot plants averaged 22% taller than unburned plants through 1977. Yarrow plants on the burned sites reached only 55% of the average height of plants on unburned sites in 1974, but by the second growing season, plants on the burn were 51% taller than those on unburned sites and then dropped to a comparable height in 1976.

Mineral Concentration

The mean concentrations of nine minerals in vegetation from burned and unburned sites are pesented in Figure 1. In general, arrowleaf balsamroot had the highest mineral concentration with greater than 2.0% N, 4.0% K, and 1.3% Ca. The Mn concentration in arrowleaf balsamroot, however, was lower than that found in all other vegetative categories. Annual species tended to have higher Mn concentrations

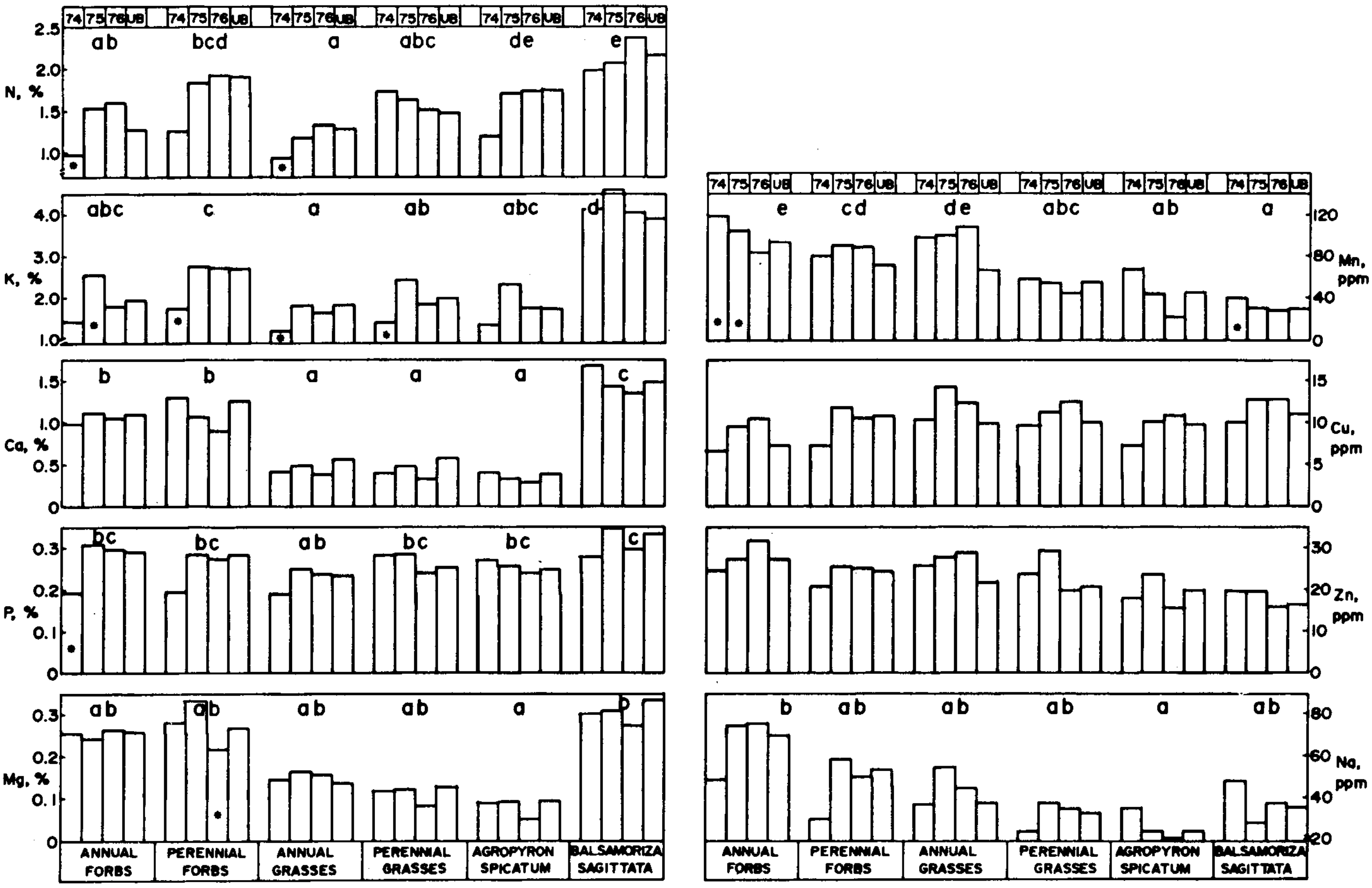

Fig. 1. *Mean mineral concentrations in summer harvested grass and forbs on seven burned sites by year and on unburned sites over 3 years, Selway-Bitterroot Wilderness, Idaho. Dissimilar superscripts above the bar indicate significant ($\alpha<0.05$) differences in mineral concentrations between vegetation types while the asterisk (*) within the bar indicates significant differences ($\alpha<0.10$) between mineral concentration for that year and for the unburned (UB) vegetation.*

than perennial species. Perennial forbs were generally higher in K. Calcium levels in both annual forbs and perennial forbs exceeded those in all grasses.

The N concentration of perennial forbs, annual forbs, and annual grasses tended to be lower the first year after the burn, with the annual species having significantly lower N values in herbage grown on the burned sites compared with that on the unburned sites. Perennial forbs, annual grasses, and perennial grasses, excluding bluebunch wheatgrass, contained less K on the burn than those on unburned sites in 1974 but returned to unburned levels by 1975. Annual forbs on the burn showed an increase in K the second growing season. Annual forbs showed a noticeable decline in P the first year after the fire and an increase in the Mn the first year after burning. Manganese concentration in perennial forbs and annual grasses also tended to be higher on the burn than on unburned areas throughout the study although these differences were not significant. The Cu concentration of annual forbs and perennial forbs showed a drop the first year after the burn that was not exhibited by arrowleaf balsamroot. The Cu level of annual forbs increased on the burn in the third growing season. Grassland vegetation levels of Zn, Na, and Ca did not appear to be affected by burning.

Discussion

Species composition and the mineral concentration of the understory were not greatly altered by burning; however, an increase in total production and a change in the balance of production among species categories was evident. Increased production on the burn in the first growing season was attributable to greater productivity of annual forbs and annual grasses. Annual forb production after burning appeared to be highly sensitive to environmental conditions while production of annual grasses, comprised primarily of cheatgrass, remained significantly higher on the burn than on adjacent unburned sites for four years following the fire. This prolific response of annuals to burning, particularly cheatgrass, has been previously reported (Countryman and Cornelius 1957). The increase in bluebunch wheatgrass and junegrass production after burning reported elsewhere (Uresk et al. 1976, Weaver 1951, Blaisdell 1953) did not occur. Young and Evans (1978) suggested that cheatgrass which reestablished the first growing season after burning was sufficient to prevent seedling establishment of perennial grasses. By the second season, perennial forbs became well established and probably because of extensive root systems were able to dominate these previously burned sites.

The present vegetation found on these xeric sites, when compared with the *Pinus ponderosa/Agropyron spicatum* habitat type in this area (Pfister et al. 1977), suggests that these sites are in deteriorated condition. A history of heavy big game use in winter and spring, coupled with past livestock use in fall, is probably responsible.

Mineral uptake is the product of biomass and concentration. Concentrations were often not different in herbage grown on burned or unburned sites. However, since production on the burned area was about twice that on the unburned, more minerals were taken up in herbage grown on the burned areas. This may suggest that availability of minerals for plant growth was improved following the fire.

The sometimes reduced mineral concentrations in herbage on the more productive burned, as compared to unburned sites, may represent a simple dry matter dilution. The low N concentrations observed the first year may have resulted from overwinter leaching of soil nitrate. The increased herbage N concentrations in subsequent years may reflect the mineralization of residual ash and of dead roots, as well as increased microbial activity. Because of the darkened surface, soils would have warmed earlier and growth of annuals the first year following the burn may also have been initiated sufficiently earlier than on adjacent unburned sites. This earlier growth likely improved the dry matter production per unit of water. This increased dry matter production may have diluted the herbage N concentrations on burned sites the first year.

The effect of competition on nutrient uptake by competing species is not well understood although Daubenmire (1968) indicated that nutrient concentration of individual plants could be increased as competition decreases. Dominant vegetation on these sites, annual grasses and arrowleaf balsamroot, did not show significantly greater nutrient concentrations than other vegetative categories except in the case of N, K, and Ca and to some extent Mg and Mn in arrowleaf balsamroot. In this case, the differences are consistent on burned and unburned sites, suggesting that any alteration of competitive relationships of mineralization through burning had neglible influence on nutrient concentrations. Additional comparisons in values between vegetative groups are confounded because concentrations of elements are known to change as vegetation matures (Blaisdell et al. 1952, Murray et al. 1978), and some species accumulate nutrients at greater levels than required for metabolic purposes (Larcher 1975). The total mineral mass is not greatly affected by burning. However, mineral availability is temporarily increased because of the release from undecayed litter and standing perennial plant material. Fire on these xeric sites was not of appreciable significance in terms of nutrient change over the long term.

Restoration of fire to a natural role in wilderness areas is an attempt to restore natural conditions. Still, many areas such as the ones in this study have been extensively modified from a natural state through past use. A logical goal for restoration of the native vegetation complex on these sites would be to reduce or eliminate cheatgrass and expedite increases in native perennial bunchgrasses. Productivity of perennial forbs and annual grasses continued to remain high four years following the fire but nutrient changes were generally low and insignificant two years following burning. A comparison of these trends with probable vegetative composition of undisturbed areas (Pfister et al. 1977) suggests that fall burns will not stimulate changes in vegetative composition which would favor perennial grasses, under current conditions. Nevertheless, short-term responses of this work indicate that qualitative and quantitative changes following fire do not adversely affect the vegetative complex on these xeric sites. In the sense that one natural dynamic process is restored, it is concluded that allowing fires to burn on these sites is a useful objective.

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