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Postburn Regrowth of Shrubs Related to Canopy Mortality

Abstract

An experimental fall burn was conducted in a northern Idaho seral shrub field on a Douglas-fir/ninebark habitat type. Production of current annual twig growth (CAG) of redstem ceanothus, oceanspray, ninebark, and Scouler willow was correlated with the amount of canopy mortality following burning. Postburn shrub productivity, measured as lengths and weights of CAG, was found to increase directly with the degree of canopy mortality.

Introduction

Knowledge of shrub response to different intensities of fire is needed to assess effects of burning for wildlife habitat improvement. DeWitt and Derby (1955) stated that the duration of the increased nutritive quality of browse caused by burning was directly related to burn intensity, but they failed to discuss the mechanism by which this result came about. This paper describes the regrowth response of four shrub species—redstem ceanothus (*Ceanothus sanguineus*), oceanspray (*Holodiscus discolor*), ninebark (*Physocarpus malvaceus*), and Scouler willow (*Salix scouleriana*) (Hitchcock and Cronquist, 1973)—to different degrees of fire-induced canopy mortality.

Study Area

The study area was a 16 ha prescribed burn on a 30° south exposed slope in the Douglas-fir/ninebark (*Pseudotsuga menziesii*/*Physocarpus malvaceus*) habitat type (Daubenmire and Daubenmire, 1968). The burn was located on Basalt Hill within the 324 ha Hatter Creek enclosure of the University of Idaho Experimental Forest, six miles south of Princeton, Latah County, Idaho. The burn area encompassed two cover types: an upland midshrub type in which ninebark and snowberry (*Symphoricarpos albus*) predominated, and a more mesic tall shrub complex in which Scouler willow was dominant. Redstem ceanothus, oceanspray, birchleaf spirea (*Spiraea betulifolia*), baldhip rose (*Rosa gymnocarpa*), and Oregon grape (*Berberis repens*) were found interspersed among these two types in varying densities.

Methods

Prior to the burn, 50 samples of current annual twig growth (CAG) of redstem, oceanspray, ninebark, and willow were clipped in the fall from each of the cover types,

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measured for length, and weighed after oven drying. The study area was burned on 17 October 1977 when temperature was 23°C, relative humidity 27 percent, and winds 0-5 km/h from the west. The patchy head fire of moderate intensity attained flame heights of 2-100 cm. To determine the effect of differential canopy mortality on productivity of shrub regrowth for each type, at least four individual ninebark, oceanspray, redstem, and willow plants were assigned to one of four mortality classes: 1 = 0 percent; 2 = 1-50 percent; 3 = 51-99 percent; 4 = 100 percent canopy mortality. A minimum of 16 individuals per species per shrub cover type were sampled for CAG productivity. Where possible, at least 20 samples of CAG were clipped, measured, and weighed from each individual shrub. A total of 153 shrubs were assigned to postburn mortality classes, and a total of 3032 twigs were clipped, measured, and weighed.

Canopy Mortality and CAG Response

Analysis of variance and Duncan's multiple range tests of CAG length and weight by mortality class demonstrated that the degree of canopy mortality directly influenced shrub CAG production (Table 1). All four species displayed greater CAG length and weights in shrubs having greater than 50 percent mortality than shrubs subjected to less than 50 percent canopy mortality (Fig. 1). Regrowth response of redstem, ninebark, and willow, whose canopies were completely killed by fire, was more vigorous than that of shrubs whose canopies were only partially killed. Ninebark CAG weights

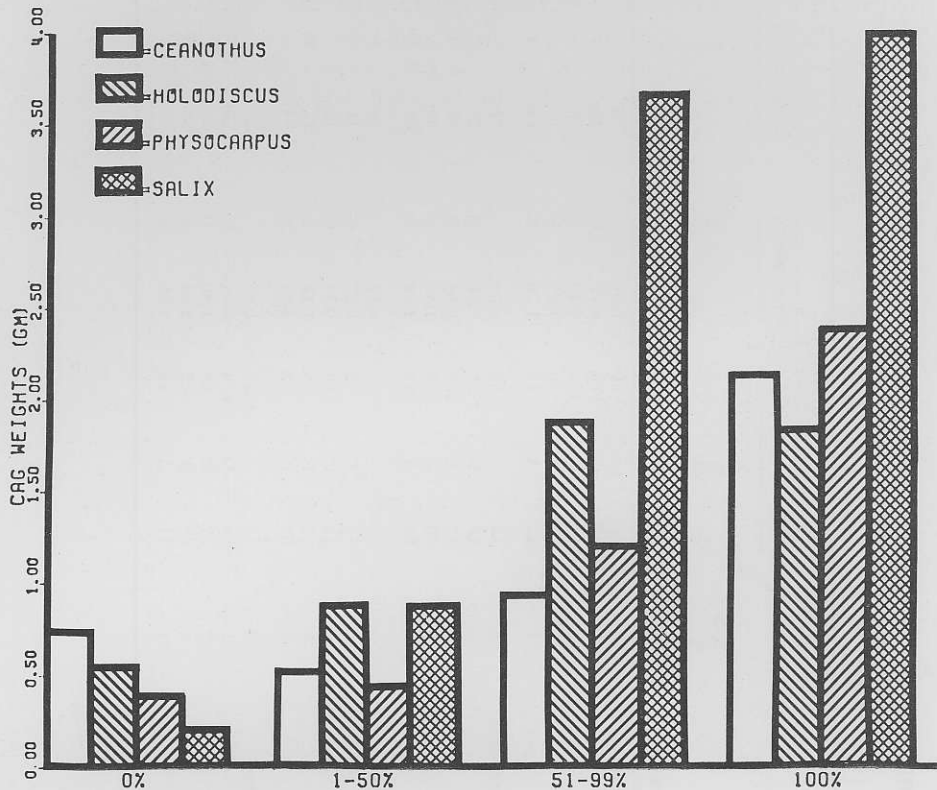


Figure 1. Twig weight relationships to canopy mortality classes.

TABLE 1. Twig weight and length relationships to canopy mortality classes as determined by Duncan's multiple range test. Canopy mortality classes are: 0 = preburn; 1 = 0 percent; 2 = 0-50 percent; 3 = 51-99 percent; 4 = 100 percent burned. Postburn means with same letters are not significantly different ($\alpha = .05$).

Species	Mortality Class No.	MIDSHRUB				TALL SHRUB				TOTALS				
		Twig length		Twig weight		Twig length		Twig weight		Twig length		Twig weight		
		K (mm)	Grouping	Sample Size	K (gm)	Grouping	K (mm)	Grouping	Sample Size	K (mm)	Grouping	Sample Size	K (gm)	Grouping
Redstem	0	9	C	50	0.09	C	6	B	50	0.04	7	B,C	100	0.07
	1	18	C	115	0.72	C	22	B	64	0.78	19	B,C	179	0.74
	2	14	C	129	0.40	D	23	B	83	0.82	17	C	233	0.53
	3	26	B	70	1.22	B	19	B	66	0.67	23	B	136	0.95
Oceanspray	4	42	A	68	1.70	A	62	A	53	2.72	51	A	121	2.15
	0	10	B	50	0.08	B	12	C	50	0.14	11	B	100	0.11
	1	22	B	72	0.56	B	20	C	74	0.46	21	B	146	0.51
	2	19	B	205	0.64	B	45	B	51	2.20	24	B	276	0.93
Ninebark	3	30	A	89	1.18	A	65	A	86	2.70	47	A	175	1.93
	4	32	A	84	1.58	A	68	A	57	2.88	43	A	161	1.87
	0	9	C	50	0.12	C	11	C	50	0.12	10	C	100	0.12
	1	10	C	72	0.27	C	16	C	77	0.57	13	C	149	0.42
Willow	2	12	C	169	0.47	B	12	C	21	0.30	12	C	190	0.45
	3	26	B	85	1.42	B	25	B	76	0.93	25	B	161	1.18
	4	52	A	72	2.81	A	44	A	71	2.03	48	A	143	2.42
	0	8	C	50	0.05	C	16	C	50	0.20	12	D	100	0.12
Willow	1	16	B	109	0.24	B	10	C	85	0.16	13	D	194	0.20
	2	37	B	65	1.40	A	22	C	84	0.56	29	C	149	0.93
	3	68	A	47	2.50	A	83	B	60	4.61	76	B	107	3.68
	4	71	A	85	2.99	A	168	A	27	7.07	94	A	112	3.98

and willow CAG length and weights demonstrated this relationship well, as these measures of productivity increased directly with the degree of canopy mortality. The CAG lengths of ninebark and the lengths and weights of redstem followed a similar pattern, but in these species, unburned shrubs were more productive than those with less than 50 percent canopy mortality. Only the oceanspray data indicated superior productivity at the level of greater than 50 percent canopy mortality as opposed to the 100 percent mortality class.

Mean lengths and weights of CAG were generally greater for those shrubs in the more mesic tall shrub type (Table 2). An exception to this trend was ninebark. Ninebark regrowth in the midshrub and tall shrub types was not significantly different for mortality classes 2 and 3; for mortality classes 3 and 4, the regrowth of ninebark was actually greater for the drier site. All species measured had significantly greater ($\alpha = .05$) CAG lengths and weights after the fire except willow (Table 3).

Discussion

The different response of redstem and oceanspray may have been due to specific differences in burn tolerance. The superior productivity of redstem's unburned plants over lightly burned plants have indicated that low levels of canopy mortality may not have caused sufficient damage to the plant to simulate vigorous basal sprouting, yet the canopy may have been sufficiently damaged to decrease CAG productivity. The superior productivity of oceanspray in mortality class 3 over mortality class 4 may have been caused by inadvertent sampling of plants which burn so intensely as to sustain root crown damage, or these results may indicate lower fire tolerance.

The response variability was obscured when data from both transects were combined (Table 1). The same trends as previously discussed were still evident. Differentiation among mortality classes was more distinct for all shrubs in the midshrub type, the more xeric site. The higher soil moisture of the tall shrub type allowed for greater response for all mortality classes, obscuring some of the partial canopy mortality effects. In the more xeric sites, the limited soil moisture may have curtailed the vigor of post-

TABLE 2. Relationship of twig lengths and weights of regrowth of four species in two cover types related to mortality class following burning, as determined by an unpaired t-test; a = significantly different at $\alpha = .01$; b at $\alpha = .05$; c at $\alpha = .10$; and NS = no significant difference between cover types.

Species	Mortality class no.	Mean twig lengths (mm)			Mean twig weights (gm)		
		Midshrub	Tall shrub	t-test	Midshrub	Tall shrub	t-test
Redstem	1	17.9	22.1	b	0.72	0.78	NS
	2	14.3	22.5	a	0.40	0.82	a
	3	26.4	18.9	b	1.21	0.64	b
	4	41.5	62.4	a	1.70	2.71	a
Oceanspray	1	22.3	19.6	b	0.58	0.45	NS
	2	18.8	44.6	a	0.63	2.20	a
	3	30.0	65.0	a	1.18	2.70	a
	4	32.0	68.0	a	1.57	2.87	a
Ninebark	1	10.0	16.0	a	0.26	0.57	c
	2	11.7	12.0	NS	0.46	0.30	NS
	3	26.0	24.8	NS	1.42	0.91	NS
	4	51.6	44.3	c	2.80	2.03	c
Willow	1	15.7	9.8	a	0.23	0.16	a
	2	37.0	22.0	a	1.40	0.56	c
	3	68.0	83.0	NS	2.50	4.60	b
	4	71.0	168.0	a	2.99	7.07	a

TABLE 3. Mean lengths and weights of current-annual-growth of four shrubs in two cover types for two years. a = Means significantly different from midshrub ($\alpha = .01$); b = Means of mid- and tall shrub types not significantly different; c = Means significantly different from preburn means ($\alpha = .01$); d = Means not significantly different from preburn means.

Species	Preburn Midshrub			Preburn Tall shrub			Preburn Both types			Postburn No canopy mortality		
	Length	Weight	N	Length	Weight	N	Length	Weight	N	Length	Weight	N
Redstem	8.6	0.09	50	5.7 ^a	0.04 ^a	50	7.1 ^b	0.07	100	19.4 ^{b,c}	0.74 ^c	179
Oceanspray	9.7	0.08	50	12.2 ^a	0.14 ^a	50	10.9 ^b	0.11	100	20.9 ^{b,c}	0.52 ^c	146
Ninebark	8.8	0.12	50	10.7 ^a	0.12 ^b	50	9.7 ^b	0.12	100	13.3 ^{b,c}	0.42 ^c	149
Willow	8.0	0.05	50	15.7 ^a	0.20 ^a	50	11.8 ^b	0.12	100	13.1 ^{b,d}	0.20 ^c	194

burn resprouting, especially when canopies were partially damaged. The remaining canopy may have competed for the limited soil moisture, thereby decreasing basal sprout CAG. This trend was further illustrated by a series of unpaired t-tests between sites performed for each mortality class by species (Table 2).

Daubenmire and Daubenmire (1968) suggested that ninebark may be adapted to more xeric sites than oceanspray, redstem, and willow. Mueggler's (1965) shrub species association analysis also demonstrated ecological dissimilarities among ninebark, redstem, and willow. This difference in tolerance of xeric conditions might have best expressed itself after ninebark was stressed by fire-induced canopy kill. These differences in CAG response (lengths and weights) between transects for all species studied tended to obscure the mortality class-CAG response relationships.

T-tests between preburn and postburn mortality class 1 (unburned) CAG lengths and weights for each species indicated that CAG productivity of unburned plants was greater after the fire (Table 3). Some fire induced factors included soil infiltration (Tarrant, 1956; Biswell and Schultz, 1957), greater macronutrient availability (Isaac, 1963; Shearer, 1976; Bollen, 1974), and higher temperatures (Fowells and Stephenson, 1934). Fire independent factors included climatic differences between years.

The growing season in 1978 was more moist than in 1977. The previous 12 months' precipitation (October-September) influencing the CAG for 1977 and 1978 was 42.0 and 75.1 cm, respectively (U.S. Dept. of Commerce, 1976-1978). Thirty-three cm more precipitation were available during the 12 months preceding the postburn shrub data acquisition than were available during the 12 months preceding the preburn shrub data collection. This difference in moisture regimes may have been more influential in creating the CAG length and weight differences of unburned shrubs than were the fire-induced factors previously discussed. While such precipitation differences may have accounted for most, if not all, pre- and postburn differences in unburned shrub production, the comparisons between canopy mortality classes after the fire are not influenced.

CAG of young, vigorously growing plants is more nutritious than that of mature, slow growing plants (Short *et al.*, 1972). The increased postburn nutritive value is probably due to increased macronutrient and soil moisture availability and the vigorous regrowth response stimulated by canopy mortality. The data presented in this study suggest a possible explanation of DeWitt and Derby's (1955) fire intensity/browse quality endurance relationship. These data demonstrate that postburn shrub productivity is directly related to the degree of canopy mortality, which is a function of fire intensity. Plants that experience severe canopy mortality concentrate their nutrients into vigorous regrowth more than shrubs which suffer only light canopy mortality.

In this study, some lightly burned canopies were actually less productive than unburned canopies. In most species, productivity was highest where canopy mortality was greatest. The increased vigor of this regrowth is shortlived and tapers off 3 to 10 years postburn; any increased vigor noted in lightly burned plants often endures for the first postburn growing season only (Cooperrider and Behrend, 1980; Mueggler, 1965; Neuenschwander *et al.*, 1978). The longer lasting increased nutritive value of plants involved in DeWitt and Derby's (1955) high intensity burn was probably due to the increased productivity of completely top-killed plants. Shrub canopies in the low intensity burn probably suffered fractional mortality only. These relationships

suggest a need to reevaluate the effectiveness of prescribed burns conducted for game range improvement. Burns conducted too conservatively often are of insufficient intensity for optimal regrowth. Burning under these conditions wastefully removes ground fuels needed to carry fire while not meeting the objectives of stimulating shrub field productivity.

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