WILEY

THE WILDLIFE SOCIETY

Sprouting of Northern Idaho Shrubs after Prescribed Burning

Author(s): Thomas A. Leege and William O. Hickey

Source: *The Journal of Wildlife Management*, Vol. 35, No. 3 (Jul., 1971), pp. 508-515
Published by: Wiley on behalf of the Wildlife Society
Stable URL: https://www.jstor.org/stable/3799705
Accessed: 17-03-2020 17:19 UTC

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.

Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use, available at https://about.jstor.org/terms

JSTOR

Wiley, Wildlife Society are collaborating with JSTOR to digitize, preserve and extend access to *The Journal of Wildlife Management*

This content downloaded from 166.7.122.202 on Tue, 17 Mar 2020 17:19:13 UTC
All use subject to https://about.jstor.org/terms

SPROUTING OF NORTHERN IDAHO SHRUBS AFTER PRESCRIBED BURNING[1]

THOMAS A. LEEGE, Idaho Fish and Game Department, Kamiah
WILLIAM O. HICKEY, Idaho Fish and Game Department, Kamiah

Abstract: Most of the elk (*Cervus canadensis*) herds in northern Idaho depend upon seral brush fields created many years ago by wildfires in mature timber. Browse produced in the brush fields has decreased because of advancing plant succession and palatable shrubs growing too tall to be effectively utilized. We initiated a study in 1965 to evaluate the effectiveness of spring and fall burning in reducing the height of browse. Individuals of all shrub species usually sprouted prolifically after both spring and fall burns. More sprouts generally resulted after spring burning, but the sprouts grew taller on the fall-burned plants. The physical and chemical characteristics of the sprouts are discussed. Multiple regression components are listed for predicting numbers of basal sprouts after the burn from preburn crown measurements.

Wildfires in the early 1900's created most of the elk winter ranges in northern Idaho, especially in the St. Joe and Clearwater river drainages. Seral shrub fields replaced conifers, and the quantity of forage increased dramatically. However, with the passing of time, several of the most palatable browse species grew beyond the reach of elk and at the same time shaded out browse in the understory. This problem was recognized as early as 1950, when cutting was attempted to reduce the height of overgrown shrubs and promote sprouting (Clearwater National Forest files, Orofino, Idaho). The technique was successful, but the estimated cost of $50–60 per acre on a large-scale basis was prohibitive. The herbicides 2,4–D, 2,4,5–T, and a 50–50 mixture of the two were used experimentally in 1960 to increase forage production by killing back the tall crowns and inducing basal sprouting (Mueggler 1966, Lyon and Mueggler 1968). Results varied with species, time, mixture, and concentration, but it was recommended that none of the chemicals be used where redstem ceanothus (*Ceanothus sanguineus*) was abundant. Personnel of the St. Joe National Forest tried prescribed burning in the early 1960's. They found that willow (*Salix* sp.), redstem ceanothus, shiny-leaf ceanothus (*C. velutinus*), mountain maple (*Acer* sp.), alder (*Alnus* sp.), serviceberry (*Amelanchier alnifolia*), and ocean spray (*Holodiscus discolor*) sprouted prolifically after burning in late September (Brown 1966).

In 1965, we began to study the use of fire to rejuvenate brush fields in cooperation with the Clearwater National Forest. In this paper we document the initial sprouting response of 11 shrub species to spring and fall burning. An evaluation of the ecological effects and application of prescribed burning in northern Idaho has been reported (Leege 1968, 1969).

We are grateful to Dr. R. Knight of the University of Idaho for statistical assistance and for reviewing the manuscript. D. Jenni, B. Holman, and other employees of the U. S. Forest Service helped select study areas and conduct the burn treatments. Employees of the Idaho Fish and Game Department, J. Gifford, G. Power, and T. Meske, assisted with collection and analysis of data.

THE STUDY AREA AND METHODS

We chose study areas on Otterslide and Sherman creeks, tributaries of the Lochsa

[1] A contribution from Idaho Federal Aid Project W–139–R.

This content downloaded from 166.7.122.202 on Tue, 17 Mar 2020 17:19:13 UTC
All use subject to https://about.jstor.org/terms

River. The Otterslide Creek area had a general aspect of south to southwest and an elevation of about 2,000 feet. Slopes ranged from 60 to 90 percent. On the Sherman Creek area the aspect was primarily west. Slopes ranged from 60 to 100 percent, and the elevation was about 2,200 feet. The soil on both areas originated from granitic parent material and was very coarse, loose, and absorptive.

Wildfires, the most recent ones in 1919 and 1934, have severely influenced vegetation on the Otterslide and Sherman creek areas. Existing species indicate that these areas have a climax vegetation characteristic of the *Abies grandis–Pachistima* habitat type (Daubenmire and Daubenmire 1968). Eight medium-height or tall-growing shrub species were chosen for intensive study: Scouler willow (*Salix scouleriana*), Rocky Mountain maple (*Acer glabrum*), redstem ceanothus, serviceberry, ocean spray, syringa (*Philadelphus lewisii*), bitter cherry (*Prunus emarginata*), and cascara (*Rhamnus purshiana*). Three other less numerous species, ninebark (*Physocarpus malvaceus*), elderberry (*Sambucus coerulea*), and chokecherry (*Prunus virginiana*) were measured when they occurred. Small shrubs common on the areas were snowberry (*Symphoricarpos albus*), birchleaf spiraea (*Spiraea betulifolia*), Oregon grape (*Mahonia repens*), thimbleberry (*Rubus parviflorus*), and wild rose (*Rosa* spp.). The few conifer saplings and seedlings present consisted of ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menziesii*), and grand fir (*Abies grandis*).

Two treatment blocks (spring and fall burn) and a control block were established on each of the two study areas. A rectangular, 1-acre exclosure was constructed across portions of the two treatment blocks on Otterslide Creek. We established two permanently marked, five-plot transects in each block and two additional transects within the exclosure. Plots were spaced 50 feet apart along a preselected transect azimuth. At each plot we located a plant of each of the important shrub species and made the following measurements and estimates before treatment: live-crown diameter (an average of two measurements at right angles to each other), maximum live-crown height, percentage of live crown below 7 feet, percentage of dead crown, number of basal sprouts, and average height of basal sprouts. We attempted to select shrubs representing a variety of sizes for each species. Individual shrubs were marked with metal tags, and the distances and azimuths from the plot stakes were recorded so that the shrubs could be relocated after treatment. Also, a 2.1-ft^2 plot was located with reference to the stake marking each main plot to measure changes in the density of the small, low-growing shrub species.

The Otterslide fall burn was conducted in 1965, and the two spring-burn blocks and the Sherman fall-burn block were treated during 1966. Burning was done in the late March–early April period, and in mid-October. Temperatures during the burns, which were conducted between noon and 4:00 PM, ranged from 67 F to 78 F, and relative humidities ranged from 25 to 48 percent. We broadcast-burned all areas, using headfires started at the bottoms of slopes. Dried forbs and grasses, dead woody twigs, and other light fuels were the main fire carriers. Plants showed little growing activity at the time of burning. During late March and early April the shrubs were still in the winter dormant stage, with the exception that certain individuals showed evidence of swelling buds. When we burned in October, many shrubs had shed their leaves; those remaining exhibited fall colors. Twig growth usually starts in May and ter-

This content downloaded from 166.7.122.202 on Tue, 17 Mar 2020 17:19:13 UTC
All use subject to https://about.jstor.org/terms

Table 1. Measurements of shrub characteristics before burning and one growing season after burning.

Species and Area	Season of Burn	Sample Size	Crown Diameter (feet)		Crown Height (feet)		Basal Sprouts		
							Number		Height (feet)
			Before	After	Before	After	Before	After	After
Willow									
Sherman	Fall	7	7.4	6.3	13.6	6.9	0.4	45.1	4.9
	Spring	10	8.4	4.9*	15.0	5.5**	1.1	47.8	3.0**
Otterslide	Fall	9	8.9	6.0	20.0	7.3	2.6	45.6	4.6
	Spring	9	8.8	5.6	17.2	6.9	2.7	54.8	4.0
Combined	Fall	16	8.2	6.1	17.2	7.1	1.6	45.3	4.7
	Spring	19	8.6	5.2	16.1	6.1**	1.8	51.1	3.5**
Redstem									
Sherman	Fall	8	4.4	2.1	5.3	2.6	0.9	23.4	1.9
	Spring	10	4.5	2.1	5.5	2.5	3.9	35.3	1.5
Otterslide	Fall	10	4.6	3.3	9.2	3.9	4.6	27.3	2.8
	Spring	13	5.2	3.0	7.9	3.5	4.2	29.8	2.3
Combined	Fall	18	4.5	2.8	7.4	3.3	2.9	25.6	2.4
	Spring	23	4.9	2.6	6.8	3.0	4.1	32.3	2.0*
Mountain maple									
Sherman	Fall	8	9.1	3.8	16.6	4.3	1.8	83.8	2.6
	Spring	10	9.2	3.7	13.9*	4.5	5.3	119.3*	2.3
Otterslide	Fall	11	5.6	3.2	12.6	4.1	3.2	61.8	2.6
	Spring	4	5.4	3.1	13.1	4.8*	7.8	71.5	1.9*
Combined	Fall	19	7.1	3.5	14.3	4.2	2.6	71.1	2.6
	Spring	14	8.1	3.5	13.6	4.5	6.0	105.6	2.2
Serviceberry									
Sherman	Fall	7	9.3	3.9	13.4	4.1	0.4	71.3	2.4
	Spring	9	8.5	4.0	11.6	4.6	1.2	92.3	2.7
Otterslide	Fall	7	8.3	3.7	13.8	4.2	0.9	56.7	2.6
	Spring	5	7.9	3.7	15.0	4.3	2.0	82.0	2.3
Combined	Fall	14	8.8	3.8	13.6	4.2	0.6	64.0	2.5
	Spring	14	8.3	3.9	12.8	4.5	1.5	88.6	2.5
Cascara									
Sherman	Fall	2	4.3	2.8	12.0	3.8	1.5	24.5	2.5
	Spring	4	3.6	2.4	7.0**	3.5	0.5	14.5*	2.5
Otterslide	Fall	9	2.6	1.5	7.6	2.9	0.2	10.5	1.8
	Spring	6	3.3	2.4*	7.3	3.4	0.2	21.3*	2.2
Combined	Fall	11	2.9	1.8	8.4	3.1	0.5	13.3	2.0
	Spring	10	3.5	2.4	7.2	3.5	0.3	18.6	2.3
Bitter cherry									
Sherman	Fall	6	6.7	2.2	15.0	4.2	0.5	16.5	2.6
	Spring	8	5.9	2.1	16.9	3.2*	0.9	26.1	2.1
Otterslide	Fall	7	3.1	2.4	13.0	4.0	0.4	13.8	2.7
	Spring	10	4.4	1.8	13.6	3.5	0.0	11.3	2.0*
Combined	Fall	13	4.7	2.3	13.9	4.1	0.5	15.2	2.6
	Spring	18	5.0	1.9	15.1	3.4	0.4	18.3	2.0*
Syringa									
Sherman	Fall	5	4.9	2.1	8.6	3.8	2.0	37.4	2.2
	Spring	4	5.3	2.4	9.3	3.8	0.8	33.8	2.0
Otterslide	Fall	6	4.5	2.6	8.9	4.3	1.0	38.5	2.5
	Spring	5	4.3	2.0	9.8	3.6	0.4	25.0	2.1
Combined	Fall	11	4.7	2.4	8.8	4.1	1.5	38.0	2.4
	Spring	9	4.7	2.2	9.6	3.7	0.6	28.9	2.1

This content downloaded from 166.7.122.202 on Tue, 17 Mar 2020 17:19:13 UTC
All use subject to https://about.jstor.org/terms

Table 1. (Continued)

Species and Area	Season of Burn	Sample Size	Crown Diameter (feet)		Crown Height (feet)		Basal Sprouts		
							Number		Height (feet)
			Before	After	Before	After	Before	After	After
Ocean Spray									
Sherman	Fall	7	5.1	2.7	9.6	3.7	1.0	44.0	2.3
	Spring	8	5.6	2.6	9.2	3.5	0.8	55.4	1.9
Otterslide	Fall	4	6.8	4.1	11.0	4.0	1.8	95.5	2.4
	Spring	6	7.0	3.0**	11.8	3.8	1.5	40.5**	2.2
Combined	Fall	11	5.7	3.2	10.1	3.8	1.3	62.7	2.3
	Spring	14	6.2	2.8	10.3	3.6	1.1	49.0	2.0
Chokecherry									
Combined	Fall	2	5.0	1.8	12.5	3.0	0.5	7.0	2.4
	Spring	3	3.0	1.8	6.3	3.0	0.0	12.3	2.4
Ninebark									
Combined	Fall	2	6.5	4.8	5.8	4.0	6.0	108.0	2.3
	Spring	6	3.3	2.4	5.7	2.9	1.5	28.6	2.4
Elderberry									
Sherman	Fall	2	5.5	6.3	10.8	7.0	0.0	4.0	6.2
	Spring	3	4.3	3.2	7.0	6.0	0.3	11.7	3.9

* Different from fall burn within the same area ($P < 0.05$).
** Different from fall burn within the same area ($P < 0.01$).

minates in late July or early August. The results reported herein were obtained from remeasuring the marked plants after the first growing season after treatment.

Unless indicated otherwise, preburn and postburn measurements were analyzed using a least-squares analysis of variance, with a one-way classification and unequal subclass numbers. Specific differences between individual treatments were tested with a Duncan's multiple range test.

RESULTS AND DISCUSSION

None of the treatment areas burned completely. Only 261 of the 366 marked plants had their aerial portions killed by fire. The tagged plants with aerial portions that were only partially killed or were completely missed by the fires were discarded.

Shrub Mortality

Only 3 of the 11 shrub species listed in Table 1 suffered mortality after the burn treatments. Of the 43 redstem ceanothus shrubs that burned, 2 did not sprout and were presumed dead. Five of 36 burned bitter cherry shrubs did not sprout, and 2 of 23 cascara also died. Fall burning appeared to cause greater mortality, because 7 (5.6 percent) of the 126 marked plants that burned in the fall failed to sprout. Only 2 (1.5 percent) of the 135 spring-burned shrubs (one redstem and one bitter cherry) did not sprout. Of the 136 marked plants on the control areas, 2 bitter cherry and 3 redstem ceanothus (3.7 percent) died during the same period, so we do not assume that burning is solely responsible for shrub mortality on the treatment areas. We suspect that shading and other competition associated with normal plant succession weakened many shrubs to the point that they gradually died. These were probably the individual shrubs that failed to sprout after burning.

This content downloaded from 166.7.122.202 on Tue, 17 Mar 2020 17:19:13 UTC
All use subject to https://about.jstor.org/terms

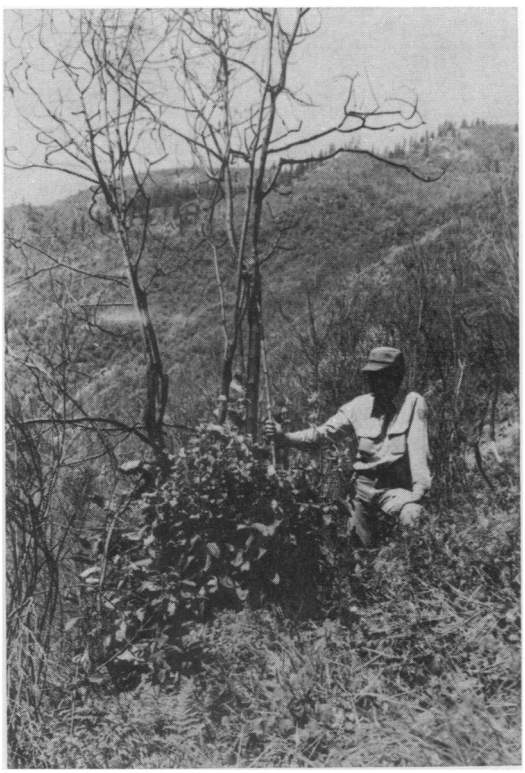

Fig. 1. This typical willow had its aerial portions killed by a spring fire just 4 months before this photo was taken. Available browse has been increased because of prolific sprouting.

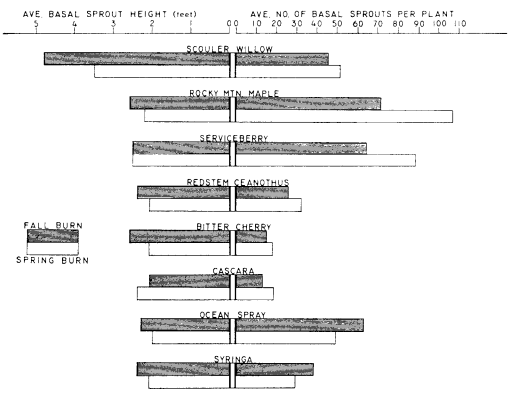

Fig. 2. The number and height of basal sprouts produced during the first growing season after fall and spring burns—combined data for Otterslide and Sherman creeks from Table 1.

Shrub Response to Burning

Plants burned in October did not exhibit any regrowth until the following April, whereas shrubs burned in late March and early April started sprouting within 4 to 8 weeks. This gave spring burning the advantage of providing browse during the winter season after treatment.

A statistical analysis of preburn measurements of crown height and crown diameter showed that we burned similar plants with the spring and fall treatments on each study area. The only exceptions to this were for mountain maple and cascara where, before burning, the mean crown heights on Sherman Creek were significantly different between the fall- and spring-burn areas (Table 1).

Both spring and fall burning satisfactorily reduced the height of out-of-reach browse by killing the aerial portions of shrub crowns and promoting prolific sprouting (Fig. 1). All species produced a larger number of basal sprouts than Mueggler (1966) reported for the same species when they were treated with herbicides. During both burn periods, the shrubs appeared dormant and carbohydrate reserves were at a high level. Had we burned during June, July, or August, when the shrubs were actively growing, it is probable that the sprouting response would have been poorer as Ferguson (1957) found in Texas.

With the exceptions of ocean spray and syringa, more sprouts were produced after spring burning than after fall burning. However, the sprout height was usually greater after fall burns (Fig. 2). Only in a few cases were these differences statistically significant (Table 1). Almost 100 percent of the forage produced during the first growing season after burning was less than 7 feet high and was considered available as

This content downloaded from 166.7.122.202 on Tue, 17 Mar 2020 17:19:13 UTC
All use subject to https://about.jstor.org/terms

Table 2. Physical characteristics of basal sprouts of four main browse species one growing season after spring and fall burning (air-dry specimens).

Measurement	Mountain Maple		Serviceberry		Redstem		Willow	
	Spring (50)[a]	Fall (50)	Spring (50)	Fall (52)	Spring (49)	Fall (50)	Spring (50)	Fall (47)
Diameter of base of main shoot (mm)	5.0	5.1	4.9	5.2	4.0	4.9	10.6	10.2
Sprouts with side shoots (percent)	32.0	26.0	10.0	15.4	12.2	22.0	78.0	87.2
Number of side shoots/sprout[b]	5.1	8.0	3.4	1.9	3.0	5.2	4.5	3.8
Length of main shoot (cm)	97.9	106.1	99.4	106.9	70.1	88.5	167.1	183.7
Sprout length including side shoots (cm)	132.2	146.2	105.6	113.7	71.8	102.5*	361.3	416.4
Weight of main shoot (grams)	7.1	8.1	11.6	13.6	5.0	8.7	34.1	40.6
Sprout weight including side shoots (grams)	7.8	8.8	11.7	13.8	5.1	9.1*	44.2	55.3

[a] Numbers in parentheses are the numbers of basal sprouts in the samples.
[b] Refers only to those sprouts that had side shoots.
* Different from spring burn ($P < 0.05$).

elk browse. Only a few of the extra-long willow sprouts had terminal portions too high to be reached.

There was no definite pattern with respect to crown diameter or heights being larger or smaller after the two treatments (Table 1). Willows were significantly taller and wider after fall burns as compared with spring burns. However, spring burning produced wider and taller serviceberry plants than did fall burning. In most instances, significant differences between the two treatments did not occur.

Oregon grape, wild rose, snowberry, white spiraea, and thimbleberry sprouted after burning and remained at about the same density as prior to treatment. Only 29 of the 50 plots that we established for measuring changes in density burned; therefore our data are too sparse to permit reliable conclusions.

Physical Characteristics of Sprouts

In December 1966, we made a random collection of approximately 50 unbrowsed basal sprouts of each of the four main browse species on the fall and spring burns on Otterslide Creek. Vegetation on both areas had gone through one growing season since treatment. The sprouts were cut at ground level, air-dried until mid-June, and measured (Table 2). Consistencies among the data suggest that sprouts produced after fall burning had more linear growth and were heavier for all four species than sprouts produced after spring burning. However, only redstem showed significant differences when the means were compared using Student's *t*-test. Mountain maple, serviceberry, and redstem grew sprouts that were primarily unbranched for their entire length. For all samples of these three species, the main sprout leader made up over 90 percent of the total weight. Most willow sprouts had side shoots; this factor contributed to the high average weight of sprouts and the relatively low percentage of the total weight in the main shoot (75 percent) in comparison with the other species.

This content downloaded from 166.7.122.202 on Tue, 17 Mar 2020 17:19:13 UTC
All use subject to https://about.jstor.org/terms

Table 3. Chemical characteristics of first-year basal sprouts from burned plants compared with the entire annual-growth leaders from unburned plants (control).[a]

Species and Area	Season of Burn	Protein	Fat	Crude Fiber	N.F.E.[b]	Ash	Ca	P
Redstem ceanothus								
Sherman	Control	5.83	1.16	35.07	55.27	2.67	0.82	0.08
	Spring 1966	5.45	0.82	36.89	54.75	2.09**	0.65**	0.08
Otterslide	Control	5.49	0.89	38.10	52.97	2.55	0.77	0.07
	Fall 1965	4.80*	1.09	45.47**	46.95**	1.77**	0.64*	0.07
	Spring 1966	5.35†	0.89	44.50*	47.01**	2.26††	0.67*	0.08
Serviceberry								
Sherman	Control	3.37	1.00	41.46	52.11	2.08	0.57	0.11
	Spring 1966	3.89	0.67**	45.22**	48.59**	1.63*	0.52	0.09
Otterslide	Control	3.90	1.49	43.76	48.52	2.34	0.61	0.11
	Fall 1965	4.01	0.90**	45.68	47.81	1.61**	0.53	0.09
	Spring 1966	4.07	0.73**	45.41	47.99	1.82**	0.57	0.09

[a] Samples were collected on February 14–15, 1967. All measurements are expressed in percentage of ovendry weight.
[b] Nitrogen-free extract.
* Different from control ($P < 0.05$).
** Different from control ($P < 0.01$).
† Different from fall burn ($P < 0.05$).
†† Different from fall burn ($P < 0.01$).

Chemical Characteristics of Sprouts

Three samples of annual growth, approximately 2 pounds each, were randomly collected from redstem and serviceberry plants on each of the treatment and control areas on Sherman and Otterslide creeks. The collection, made on February 14 and 15, 1967, did not include sprouts from the Sherman fall burn since no growth occurred there during the 4 months after treatment. These samples consisted of sprouts collected after the first growing season on the burned areas; they were cut at ground level. Annual twig growth was collected on the adjacent unburned control areas. All samples were analyzed in duplicate; each percentage in Table 3 represents an average of three samples and three subsamples.

Crude fiber was the only nutrient that increased in the new growth after the burning treatments. Fat, nitrogen-free extract, ash, and calcium were usually lower on the burned areas than on the controls. Protein decreased after burning in the redstem samples but remained about the same or increased slightly for serviceberry (Table 3). These data are presented only to document the chemical contents of entire sprouts; they should not be used to make judgments as to the effects of burning on browse nutrients. We also made a collection of the terminal 2 inches of the sprouts and compared them with the terminal 2 inches of annual growth on unburned plants. We believed that this collection more nearly represented the portions that elk usually eat. In analyses of the terminal 2 inches, we found a higher protein content in burned plants than in controls (Leege 1969). If we use protein as the yardstick of browse quality, the analyses indicate that burning may increase the food value of the usable portion of the annual growth.

Relationship of Sprouting to Plant Size

Multiple regression and correlation analyses were made of the relationship of preburn crown height, diameter, and volume

This content downloaded from 166.7.122.202 on Tue, 17 Mar 2020 17:19:13 UTC
All use subject to https://about.jstor.org/terms

Table 4. Correlation coefficients (R) and the values of constants used for the prediction of numbers of basal sprouts after the burn from preburn crown measurements.[a]

Species	Season of Burn	Sample Size	Constants				
			R	a	b_1	b_2	b_3
Willow	Fall	15	0.925**	9.798	2.197	0.580	0.010
	Spring	19	0.624	−69.324	14.780	2.828	−0.048
Redstem	Fall	18	0.692*	84.619	−14.777	−5.229	0.364
	Spring	22	0.401	−23.084	10.584	2.837	−0.104
Mountain maple	Fall	19	0.801**	27.481	19.953	−5.619	−0.018
	Spring	14	0.734*	−23.338	17.628	2.743	−0.056
Serviceberry	Fall	14	0.414	120.073	−8.315	−1.697	0.043
	Spring	14	0.536	234.667	−13.202	−9.417	0.109
Cascara	Fall	10	0.802	−15.272	15.717	−1.440	−0.071
	Spring	10	0.628	−7.730	7.365	1.562	−0.111
Bitter cherry	Fall	12	0.472	−15.792	2.841	1.840	−0.018
	Spring	17	0.546	−0.170	4.007	—	−0.005
Syringa	Fall	11	0.772	−56.213	24.744	4.163	−0.337
	Spring	9	0.834	79.648	−11.492	−4.546	0.239
Ocean spray	Fall	11	0.882*	−35.897	27.821	−3.905	−0.065
	Spring	14	0.682*	20.494	19.538	−8.965	—

[a] Multiple regression equation is: Number of basal sprouts $= a + b_1$ (crown diameter in feet) $+ b_2$ (crown height in feet) $+ b_3$ (crown volume in cubic feet).
* $P < 0.05$.
** $P < 0.01$.

to basal sprout numbers after burning. Crown volume was computed as the volume of a cylinder, using the known measurements of height and diameter (Volume $= \pi r^2 h$). For 10 of the 16 cases (eight species, two treatments each), crown diameter was the single measurement that had the best correlation with numbers of basal sprouts produced. Crown volume had the best correlation 5 out of 16 times. Except for bitter cherry and ocean spray on the spring burns, the three measurements used together in a multiple regression gave the best prediction of numbers of basal sprouts (Table 4).

LITERATURE CITED

BROWN, R. L. 1966. Avery face browse rehabilitation study, final report. U. S. Forest Serv., St. Joe National Forest, St. Maries, Idaho. 9pp. Mimeo.

DAUBENMIRE, R., AND JEAN B. DAUBENMIRE. 1968. Forest vegetation of eastern Washington and northern Idaho. Washington State Univ. Agr. Expt. Sta. 104pp.

FERGUSON, E. R. 1957. Stem-kill and sprouting following prescribed fires in a pine–hardwood stand in Texas. J. Forestry 55(6):426–429.

LEEGE, T. A. 1968. Prescribed burning for elk in northern Idaho. Proc. Annual Tall Timbers Fire Ecol. Conf. 8:235–253.

———. 1969. Burning seral brush ranges for big game in northern Idaho. Trans. N. Am. Wildl. and Nat. Resources Conf. 34:429–438.

LYON, L. J., AND W. F. MUEGGLER. 1968. Herbicide treatment of north Idaho browse evaluated six years later. J. Wildl. Mgmt. 32(3): 538–541.

MUEGGLER, W. F. 1966. Herbicide treatment of browse on a big-game winter range in northern Idaho. J. Wildl. Mgmt. 30(1):141–151.

Received for publication January 25, 1971.

This content downloaded from 166.7.122.202 on Tue, 17 Mar 2020 17:19:13 UTC
All use subject to https://about.jstor.org/terms