Selective Control of Big Sagebrush Associated with Bitterbrush[1]

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The development of procedures for controlling big sagebrush (*Artemisia tridentata* Nutt.) by spraying with 2,4-dichlorophenoxyacetic acid (2,4-D) causes concern about the possible loss of desirable forbs and shrubs on treated ranges. Blaisdell and Mueggler (1956) studied the effects of 2,4-D sprays on many forbs and shrubs associated with big sagebrush and emphasized the importance of careful range evaluations before spraying. They reported that spraying in eastern Idaho left antelope bitterbrush (*Purshia tridentata* (Pursh) DC.) unharmed or only slightly damaged. However, spraying with 2,4-D in eastern Oregon has caused effects on bitterbrush varying from no apparent damage to severe stand reductions. The importance of this species as fall and winter forage for cattle, sheep, and deer justifies further attention to the nature of susceptibility of bitterbrush to 2,4-D and 2,4,5-trichlorophenoxyacetic acid (2,4, 5-T).

This paper summarizes the results of spraying mixed stands of big sagebrush and bitterbrush on a relatively dry site for bitterbrush. Spray emulsions of 2,4-D and 2,4,5-T were applied at various stages of development in 1958 and 1959. The differenecs among dates of spraying, herbicides, and rates of application provide information that will contribute to moderately successful selective control of big sagebrush associated with bitterbrush on similar sites.

This paper is limited to spraying techniques and does not consider the practical merits for or against selective control of big sagebrush.

Procedure

Two split-plot experiments each including 4 replications and 6 spraying dates randomized by whole plots were established on a deep pumice-pebble deposit having a weakly developed loamy-soil profile. The area is located 2 miles west of Burns, Oregon, at an elevation of 4,300 feet in the foothills adjacent to the Ochoco National Forest. The first experiment was established in September 1957, and sprays were applied on April 30, May 14, June 2, June 13, June 23, and July 9, 1958. The second experiment was established in September 1958, and sprays were applied on April 28, May 6, May 23, May 28, June 3, and June 10, 1959. Individual 1/50-acre plots were sprayed with 2,4-D or 2,4,5-T propylene glycol butyl ether esters[3] at 1.5 or 3.0 lb/A emulsified in water containing 0.2 percent spreader[4] at a total spray volume of 10 gal/A. The spray emulsions were applied with a 4-nozzle (800067 tips), 4-foot, hand-held boom operated from a back-pack compressed-air sprayer at 35 psi (Figure 1).

Precipitation at Burns in crop-year periods (September-June, inclusive) was 13.2 inches in 1957-1958 and 7.1 inches in 1958-1959 as compared with a median amount of 11.6 inches.

The experimental site had a shrub overstory of big sagebrush and bitterbrush and included occasional plants of gray horsebrush (*Tetradymia cancescens* DC.) and wax currant (*Ribes cereum* Dougl.). The herbaceous vegetation included Sandberg bluegrass (*Poa secunda* Presl.), blue bunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. & Smith), thurber needlegrass (*Stipa thurberiana* Piper), Idaho fescue (*Festuca idahoensis* Elmer), bottlebrush squirreltail (*Sitanion hystrix* (Nutt.) J. G. Smith), and foothill deathcamas (*Zygadenus paniculatus* (Nutt.) S. Wats).

Cattle occupied the experimental area during April, May, and June each year. All herbaceous plants were grazed closely by the end of June, but the bitterbrush remained ungrazed during this season.

Bitterbrush and big sagebrush plants were counted before spraying and one year after spraying. Prespraying counts averaged 7 bitterbrush and 44 big sagebrush per plot in 1958, and 15 bitterbrush and 47 big sagebrush in 1959. Reductions in plant counts were expressed in percent of prespraying counts as mortality percentages for analysis and presentation except for bitterbrush on plots sprayed in 1958. In this case, the bitterbrush counts were too small to provide a normal array of mortality percentages; therefore, the counts after spraying were analyzed for treatment differences in an analysis of covariance on prespray-

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[3] *Esteron Ten- Ten and Esteron 245 O. S. were provided for this experiment by the Dow Chemical Company. The trade names given do not constitute preference or recommendation over comparable products.*

[4] *The spreader used was X-77, Colloidal Products Corporation, Sausilito, California.*

FIGURE 1. Spray emulsions were applied with a 4-nozzle, hand-held boom operated from a back-pack compressed-air tank. Sprays were placed in the aluminum tank carried on the chest.

ing counts. To provide uniformity in data presentation, the reductions in bitterbrush counts on 1958 plots are summarized in terms of percent mortality and the source of significant variation identified without a least significant difference.

Developmental stages of growth were observed on each spraying date and the effects of spraying were observed periodically throughout the season. The effects of spraying on bitterbrush also were evaluated by visual estimates of crown reduction in late summer one and two years after spraying.

Results

The mortality of big sagebrush was greater with 2,4,5-T than with 2,4-D, and acid rates of 3.0 lb/A were more effective than rates of 1.5 lb/A (Table 1). Spraying on different dates introduced significant differences in mortality in 1958 and nonsignificant differences in 1959. Spraying with 2,4-D at 1.5 lb/A in the season extending from the time of head-appearance to green-color-fading of Sandberg bluegrass (Table 2) killed 68 to 94 percent of individual big sagebrush plants. For controlling big sagebrush, rates of 1.5 to 2.0 lb/A of 2,4-D ester have been recommended.

Spraying with 2,4-D was slightly less injurious to bitterbrush than with 2,4,5-T (Table 3). Differences among the four spraying treatments were significant each year, but those among dates of spraying were not significantly different either year. Bitterbrush mortality averaged nearly three times greater in 1959 than in 1958. This difference between years appears to be related to the amounts of precipitation and the proportions of young bitterbrush in the stands. Precipitation was above normal in 1958 and provided better conditions for bitterbrush recovery after spraying than in 1959 when precipitation was below normal. The plots treated in 1959 included more young bitterbrush (plants less than 12 inches tall) than plots treated in 1958. Very few large bitterbrush were killed either year, but plants less than 12 inches tall were killed consistently.

Low mortalities of mature bitterbrush suggested that crown-reduction estimates would evaluate spraying effects on mature plants more completely than mortality counts. Table 4 includes crown-reduction percentages estimated one year after spraying. Dates of spraying and herbicides were sources of significant variation each year. Mid-season spray applications (late May and early June) effect-

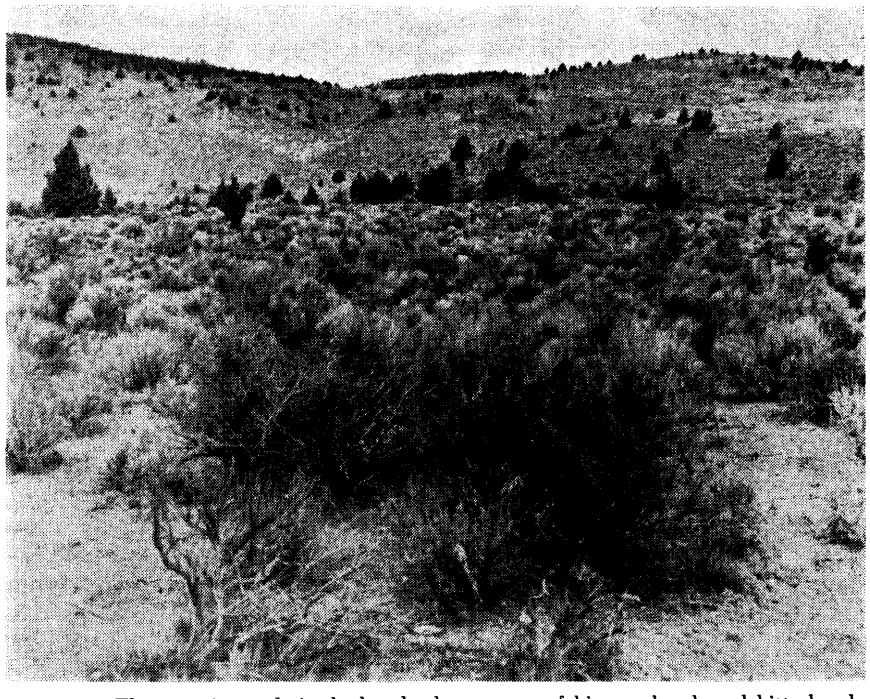

FIGURE 2. The experimental site had a shrub overstory of big sagebrush and bitterbrush.

Table 1. Big sagebrush plants killed by spraying with 2,4-D or 2,4,5-T.

Dates of spraying	2,4-D 1.5 lb/A	2,4-D 3.0 lb/A	2,4,5-T 1.5 lb/A	2,4,5-T 3.0 lb/A	Mean
	(Percent)				
1958					
April 30	69	75	69	85	74[2]
May 14	78	92	90	90	88
June 2	68	90	86	93	84
June 13	84	93	78	94	87
June 23	62	76	69	69	69
July 9	67	82	62	87	74
1958 mean	71[1]	85	76	86	80
1959					
April 28	83	93	90	97	91
May 6	87	97	96	99	95
May 23	88	95	90	100	93
May 28	94	99	93	99	96
June 3	92	96	94	93	94
June 10	88	98	94	98	95
1959 mean	88[3]	96	93	98	94

[1]L.S.D. at 1% among 1958 treatment means = 8%.
[2]L.S.D. at 1% among 1958 date means = 11%.
[3]L.S.D. at 1% among 1959 treatment means = 4%.

ed greater injury than early- or late-season applications. Spraying at any time with either herbicide at either rate killed virtually all leaves and current twig growth of bitterbrush, but spraying before flowering left sufficient time for growth initiation in dormant lateral buds. The amount of dieback in old wood increased as spraying was delayed to later stages of growth (Hyder and Sneva, 1960). As seasonal growth advanced, the amount of sensitive new growth increased, and this development of foliage increased the amount of spray intercepted by the bitterbrush.

The crown-reduction of bitterbrush on plots treated in 1958 estimated one and two years after spraying indicates the rate of bitterbrush recovery. Differences among spraying treatments found to be important one year after spraying remained significant two years after spraying. However, crown-reduction two years after spraying was about half as much as one year after spraying. Treated plants had longer, but fewer, actively growing twigs one and two years after spraying and required three or more years to become as productive as untreated plants.

Discussion

Spraying at the time of bitterbrush leaf origin and before the appearance of distinct twig elongation and flowering left only a small amount of dead tissue on large plants. Subsequently, dormant buds initiated growth and in the autumn only slight evidence of spray injury remained. This appearance of slight spray injury was misleading because estimates of crown reduction or suppression of treated plants compared to untreated ones indicated considerable herbicidal effect.

Delaying spraying progressively from the time of leaf appear-

Table 2. Developmental stages of growth of bitterbrush, big sagebrush, and Sandberg bluegrass in 1958 and 1959.

Dates of spraying	Bitterbrush	Big sagebrush	Sandberg bluegrass
1958			
April 30	Leaves half size	New leaves appearing	Heads low in the boot
May 14	Leaves full size	New leaves full size	Heads emerged
June 2	Late flower, flowering began May 21-23, new twigs average 2 inches	New twigs average 2 inches, max. 6 inches	Late anthesis
June 13	Twigs 4 inches, berries turning red	New twigs average 6 inches	Herbage losing green color
June 23	Berries ripe, twigs 4 inches	Twigs 6 inches, max. 10 inches	Herbage cured
July 9	Berries ripe, twigs 4 inches	Twigs 6 inches, flower buds appearing	Herbage cured
1959			
April 28	Leaves half size	New leaves appearing	Heads in the boot
May 6	Leaves full size, flower buds appearing	New leaves full size	Heads emerged
May 23	Early flower	New twigs ½ inch	Early anthesis
May 28	Full flower	New twigs 1 inch	Full anthesis
June 3	Berries forming	New twigs 2 inches	Herbage losing green color
June 10	Berries turning red	New twigs 3 inches, max. 4 inches	Herbage cured

Table 3. Bitterbrush plants killed by spraying with 2,4-D or 2,4,5-T.

Dates of spraying	2,4-D 1.5 lb/A	2,4-D 3.0 lb/A	2,4,5-T 1.5 lb/A	2,4,5-T 3.0 lb/A	Mean
			(Percent)		
1958[1]					
April 30	3	22	42	20	21
May 14	18	12	36	30	24
June 2	6	44	30	46	31
June 13	31	39	11	0	22
June 23	34	0	19	12	16
July 9	4	14	5	22	11
1958 mean	15[2]	21	24	24	21
1959					
April 28	32	58	54	65	52
May 6	42	64	52	40	50
May 23	54	54	58	66	58
May 28	60	53	59	71	60
June 3	62	74	59	69	66
June 10	62	65	43	82	63
1959 mean	52[3]	62	54	66	58

[1]The bitterbrush counts one year after 1958 treatments were analyzed by covariance with prespraying counts because of small numbers of bitterbrush averaging 7 per plot.
[2]Differences among spraying treatments were significant at 1% in the covariance analysis indicated.
[3]L.S.D. at 5% among 1959 treatment means = 8%.

ance until early fruit development increased the crown-reduction of mature bitterbrush. This seasonal pattern in spraying effects was associated with (1) a chronological increase in the amount of foliage, spray interception, and dieback of old wood and (2) a chronological decrease in the duration of favorable growing conditions and opportunity for sprouting from dormant lateral buds. Spraying after the time of flowering on bitterbrush sacrificed essentially a complete season of growth and forage production because all new tissue was killed and the duration of favorable growing conditions was too short for substantial growth from dormant lateral buds. The increase in dieback of old wood associated with delay in date of spraying indicates an increase in spray interception, an increase in downward translocation of herbicide, or both.

The duration of favorable growing conditions after spraying is an important consideration in timing spray applications. Applying 2,4-D ester as early as big sagebrush exhibits high susceptibility permits a maximum duration of favorable growing conditions after spraying. However, even a maximum duration of favorable growing conditions after spraying can be insufficient in dry seasons, and spraying should be withheld after a winter of below-normal precipitation. Since growing conditions remain favorable for a shorter time on dry sites, the difference in spraying effects between years is extended, by inference, to include site differences. The site selected for these studies is relatively dry for bitterbrush, and the effects of spraying are probably more severe than on wetter sites.

The age (or size) of bitterbrush is an important consideration in spraying for the selective control of big sagebrush because bitterbrush less than 12 inches tall were killed consistently. Spraying is undesirable where young bitterbrush are important components of the vegetation.

An ester of 2,4-D was slightly more selective for big sagebrush than 2,4,5-T ester, and may be recommended for the selective control of big sagebrush under the limitations imposed by the

Table 4. Bitterbrush crown-reduction by spraying with 2,4-D or 2,4,5-T.

Dates of spraying	2,4-D 1.5 lb/A	2,4-D 3.0 lb/A	2,4,5-T 1.5 lb/A	2,4,5-T 3.0 lb/A	Mean
			(Percent)		
1958					
April 30	14	24	39	56	33[2]
May 14	46	55	65	59	56
June 2	14	52	54	72	48
June 13	29	36	38	78	45
June 23	11	19	30	52	28
July 9	11	22	26	42	26
1958 mean	21[1]	35	42	60	39
1959					
April 28	28	58	45	52	46[4]
May 6	48	48	52	62	52
May 23	52	72	85	88	74
May 28	68	70	65	90	73
June 3	58	60	70	88	69
June 10	70	75	78	80	76
1959 mean	54[3]	64	66	77	65

[1]L.S.D. at 1% for 1958 treatment means = 11%.
[2]L.S.D. at 5% for 1958 date means = 14%.
[3]L.S.D. at 1% among 1959 treatment means = 8%.
[4]L.S.D. at 1% among 1959 date means = 17%.

stage of growth development of bitterbrush, the duration of favorable growing conditions after spraying, and the size of bitterbrush plants. Although various phenological stages of development are not always consistent among sites, it appears that the proper timing for spraying mixed stands of big sagebrush and bitterbrush on dry sites is indicated by the appearance of (1) new leaves on big sagebrush and bitterbrush and (2) heads on Sandberg bluegrass (Hyder and Sneva, 1955). Spraying may then continue until bitterbrush is in flower.

Summary

The results of spraying mixed stands of big sagebrush and bitterbrush with 2,4-D and 2,4,5-T provide a guide for moderately successful selective control of big sagebrush on dry sites. These two herbicides were applied at 1.5 and 3.0 lb/A on six dates each in 1958 and 1959. Their effects were evaluated by mortality counts and crown reduction estimates.

An ester of 2,4-D was slightly more selective for big sagebrush than 2,4,5-T ester, and may be applied at recommended rates (1.5 to 2.0 lb/A) for the selective control of big sagebrush under the limitations imposed by (1) the stage of growth development of bitterbrush, (2) the duration of favorable growing conditions after spraying, and (3) the size of bitterbrush plants.

Delaying spraying progressively from the time of leaf appearance until early fruit development of bitterbrush resulted in greater 2,4-D damage. Spraying at any time killed virtually all leaf tissue and current twig growth of bitterbrush; however, spraying at the time of leaf origin and before the appearance of distinct twig elongation or flowers left only a small amount of dead tissue on large plants. Subsequently, dormant buds initiated new growth, and in the autumn only slight evidence of spray injury remained. The amount of growth attained from dormant buds depended upon the duration of favorable growing conditions after spraying. In contrast to large bitterbrush, those less than 12 inches tall were killed consistently.

The proper timing for spraying mixed stands of big sagebrush and bitterbrush on dry sites is indicated by the appearance of (1) new leaves on big sagebrush and bitterbrush and (2) heads on Sandberg bluegrass. Spraying may then continue until bitterbrush is in flower.

LITERATURE CITED

BLAISDELL, JAMES P. AND WALTER F. MUEGGLER. 1956. Effect of 2,4-D on forbs and shrubs associated with big sagebrush. Jour. Range Mangt. 9: 38-40.

HYDER, D. N. AND F. A. SNEVA. 1955. Effect of form and rate of active ingredient, spraying season, solution volume, and type of solvent on mortality of big sagebrush, *Artemisia tridentata*. Oregon Agricultural Exp. Sta. Tech. Bul. 35, 16 pp.

———. 1960. Spraying for big sagebrush in stands of bitterbrush. 1960 Research Progress Report, Western Weed Control Conference.