Effects on Associated Species of Burning, Rotobeating, Spraying, and Railing Sagebrush

WALTER F. MUEGGLER AND JAMES P. BLAISDELL

Range Conservationists, Intermountain Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, Ogden, Utah.

Control of big sagebrush (*Artemisia tridentata*) on heavily infested areas has long been recognized as an effective range improvement practice. By killing this one undesirable species the grazing capacity of rangelands can often be increased manyfold.

During the past 20 years several methods have been developed to reduce sagebrush numbers and bring about such range improvement (Pechanec *et al.*, 1954). Generally these methods can be divided into two main categories: those that destroy all existing vegetation, and selective methods that destroy sagebrush without complete destruction of the herbaceous understory. When there are few plants of desirable species, consideration in the selection of a control method generally need be given only to effectiveness of sagebrush removal, relative cost, and development of a satisfactory seedbed. Establishment of forage species will be dependent upon artificial seeding. On the other hand, if a good stand of desirable species is present, it is upon these that increased production should depend; selection of the eradication method should not only consider degree of sagebrush kill and cost but also the effect of treatment upon these associated plants. It is with this question of the effect of treatment on associated forage species that this paper is concerned.

Considerable information has already been obtained on the effect of various selective methods of sagebrush control. Blaisdell (1953) reported in detail the effect of sagebrush burning on residual vegetation on the Upper Snake River Plains of Idaho. Bohmont (1954), Hyder and Sneva (1956), and Blaisdell and Mueggler (1956) are among those who have studied the effect of the sagebrush-killing 2,4-D sprays on associated vegetation. Burning, spraying, rotobeating, and railing as well as other methods were described by Pechanec *et al.* (1954), but only general information was presented on the relative effects of these methods on associated vegetation. Evidently little information is available on direct comparisions of various methods of sagebrush removal under carefully controlled conditions.

A comparison of four methods of sagebrush control that maintained the native herbaceous understory—burning, rotobeating, railing, and spraying with 2, 4-D—was started in 1952 on the Upper Snake River Plains in southeastern Idaho. The study area is in a fairly homogeneous, dense stand of big sagebrush between 2 and 3 feet in height, on the spring-fall range of the U. S. Sheep Experiment Station near Dubois, Idaho. The topography has only slight relief with little surface drainage; the sandy-loam soil is underlain by basaltic lava. Precipiation averages about 13 inches annually.

A good understory of native perennial species was present throughout. This herbaceous understory consisted predominantly of bluebunch wheatgrass (*Agropyron spicatum*), thickspike wheatgrass (*A. dasystachyum*), Idaho fescue (*Festuca idahoensis*), plains reedgrass (*Calamagrostis montanensis*), subalpine needlegrass (*Stipa columbiana*), blue grasses (*Poa* spp.), threadleaf sedge (*Carex filifolia*), fleabane (*Erigeron corymbosus*), lupines (*Lupinus* spp.), and minor amounts of other grasses and forbs. Besides the dominant big sagebrush, the shrubby vegetation included spineless gray horsebrush (*Tetradymia canescens*), downy rabbitbrush (*Chrysothamnus puberulus*), and antelope bitterbrush (*Purshia tridentata*). A more detailed listing of species and relative amounts can be found in Table 2.

Methods

A 54-acre area was divided roughly into quarters, and a different treatment was imposed upon each. An untreated check was reserved adjacent to the treated areas. Field-scale treatments were used and cost data were kept.

One-quarter was sprayed in early June 1952 using a ground spray unit with a 16-foot boom mounted on a truck. The 2,4-D ethyl ester (Weedone 48) was applied in a water carrier at the rate of 2 pounds of acid and approximately 20 gallons of water per acre. Unfortunately it was necessary to spray the area when winds were fairly high. Spray drift, combined with unexpected rockiness of the area, resulted in poor spray coverage with the ground vehicle. For this reason the sagebrush kill on the experimental area was much lower than would ordinarily be expected. Similar treatments on nearby areas have caused almost complete eradication of big sagebrush.

One of the areas was rotobeaten in early August 1952. A standard Case rotobeater with chain flails was run over the area only once to shred the brush. The machine was adjusted so that the flails just cleared the ground surface. Ample power was supplied by a wheeled tractor.

Railing was also done in early August. The rail used was constructed of three 11-foot sections of heavy railroad rail loosely bolted together at the ends to make a semiflexible 33-foot length of rail. The center section was of double weight. Drags were attached to the rear to keep the rails upright. A deisel motor patrol pulled this rail over the area twice, once each way.

The fourth area was burned in late August. Prior to burning, a standard fire line was constructed, consisting of a double grader line and a 100-foot backfired strip on the leeward sides and a single grader line on the windward. The fire was set simultaneously along both windward edges and a hot, clean burn was obtained.

The entire study area was deferred from grazing the year of treatment and the year following. Moderate grazing by sheep was permitted thereafter.

Each area, including the untreated check, was sampled by 20 permanent, 48-square-foot circular plots spaced in a regular pattern. The weight estimate method (Pechanec and Pickford, 1937) was used to obtain herbage production by species prior to treatment (1952), 1 year after treatment (1953), and 3 years after treatment (1955). Estimates were also made of the percentage of herbage available to sheep, that is, the percentage that was not obstructed by brush.

In order to obtain pretreatment data, the 1952 inventory was of necessity made prior to the early June spraying and consequently before plant maturity. At this time it was difficult to segregate individual grass species rapidly; therefore all grasses were handled as one unit in the 1952 inventory. The 1953 and 1955 inventories were made later in the growing season, and grasses were segregated by individual species with the exception of two pairs, *Agropyron dasystachyum-Calamagrostis montanensis* and *Carex filifolia - Festuca idahoensis*. Because of similarity of vegetative appearances, grouping in these two pairs was necessary for rapid field identification.

Results And Discussion

Effects of Treatments

All four treatments caused sizable reductions in sagebrush and increases in herbaceous species (Fig. 1). Burning and roto-

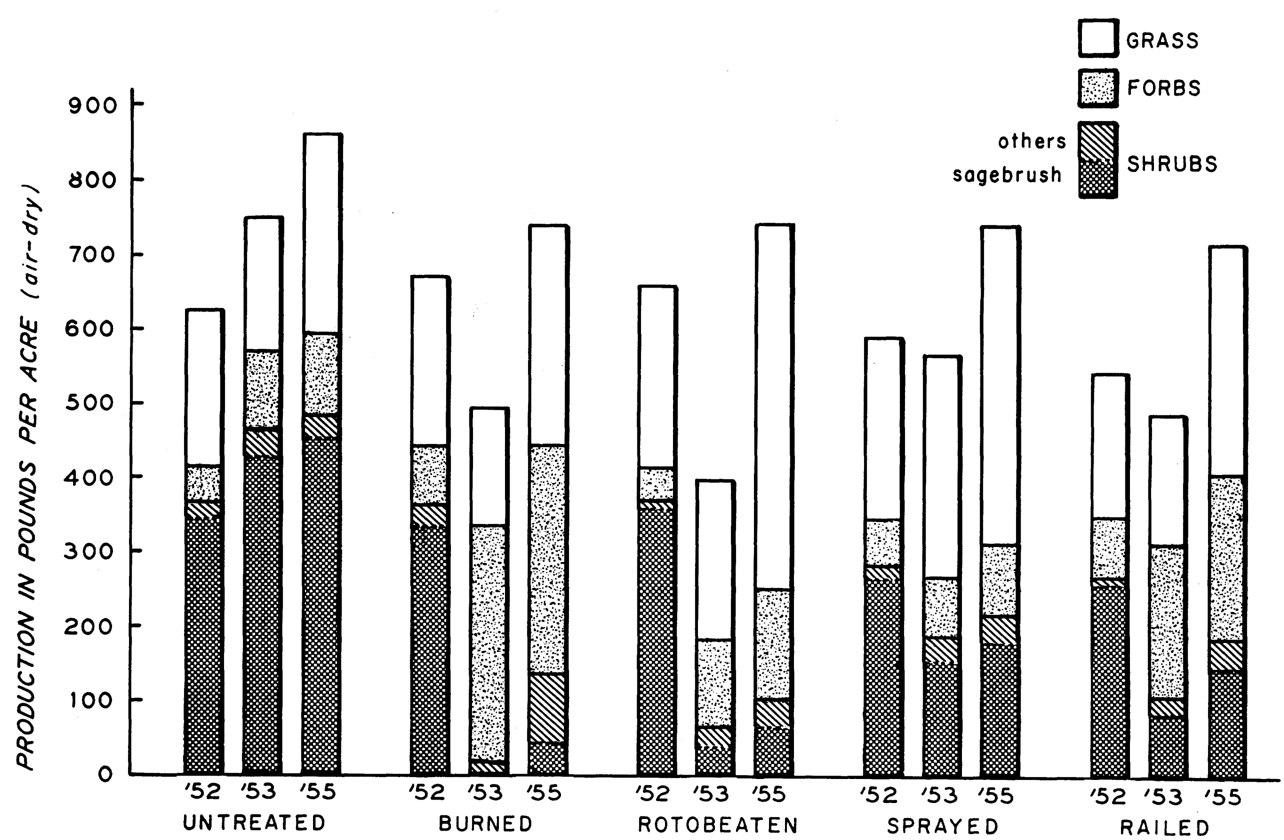

FIGURE 1. Grass, forb, and shrub herbage production prior to treatment (1952), and 1 year (1953) and 3 years afterward (1955), as compared to production on untreated range.

beating reduced sagebrush considerably more than spraying and railing. Burning brought about a much greater increase in forbs than any of the other treatments, and rotobeating and spraying a greater increase in grasses. Railing caused intermediate increases in both grasses and forbs. Despite general increases in grasses, forbs, and shrubs other than sagebrush on all treated areas, total vegetal production 3 years after treatment was still considerably less than on the untreated area. The inability of a predominantly herbaceous cover to produce as much foliage dry matter as a shrub-herb complex has been previously observed by Blaisdell (1953).

It should be noted that there were differences in herbage production on the various areas prior to treatment as well as natural year-to-year fluctuations on the untreated area (Fig. 1). Therefore, to determine accurately the effect of treatment upon vegetation it is necessary to compare relative rather than absolute vegetal changes over the 3-year period.

As compared with production on the untreated area, grasses decreased slightly on the burn the first year, remained about the same on the rotobeaten and railed areas, and increased markedly on the sprayed area. Three years after treatment the deleterious effect of burning on total grass production had been overcome, but there still had been no increase attributable to burning. Blaisdell (1953) found similar injury to grasses the first year after burning, but reported that rhizomatous species generally recover fully within 3 years after burning, and that losses incurred by most other grasses are recovered in 12 to 15 years. Rotobeating resulted in a 50-percent gain in grass production over what it would have been by the end of the third year had there been no treatment, spraying caused better than a one-third increase, and railing resulted in approximately a one-fifth increase of grass. Apparently burning was the only treatment that actually injured the grasses.

Although other treatments caused no injury, only on the sprayed area were grasses able to take immediate advantage of the release from sagebrush competition. During the first growing season after treatment grasses were noticeably more vigorous on the sprayed range than on adjacent areas, and herbage production was greatly increased. Substantial gains in grass production the first year after spraying with 2,4-D is apparently the rule (Bohmont, 1954; Hurd, 1955; Hyder and Sneva, 1956). However, the reason for such increase on the sprayed area and not on the rotobeaten or railed area is not clear. This may have resulted from reduced evaporation and a greater accumulation of snow among sagebrush skeletons. A comparison of March 1 snow accumulation showed 0.9 inch more moisture in the form of snow on the sprayed than on the rotobeaten area, about 7 percent of the average annual precipitation. It is also possible that the vigorous grass production may have resulted from an actual stimulus by the 2,4-D.

Production of forbs increased on the burned, rotobeaten, and railed areas during the first season, but decreased on the sprayed area in relation to the untreated area. By the third year relative forb production on all treated areas was slightly less than the first year after treatment. However, burning was still considered responsible for a 61-percent increase in total forb production, rotobeating a 50-percent increase, and railing a 20-percent increase, and railing it would have been with no treatment. During this same period spraying had caused a 39-percent loss in forbs. Such forb damage from 2,4-D is common (Bohmont, 1954; Hurd, 1955; Blaisdell and Mueggler, 1956).

Very pronounced reductions of shrubs occurred with all treatments. This reduction reflects the effect of treatment upon sagebrush which composed almost 95 percent of before-treatment shrub production. Greatest reductions in sagebrush were apparent the first year after treatment; thereafter production increased slightly. After 3 years sagebrush production on the burned area was still only 11 percent and on the rotobeaten area only 14 percent of what it would have been with no treatment; production on the sprayed and railed areas was 50 and 43 percent, respectively. Production of the shrub group excluding sagebrush was increased by all treatments with the exception of an initial reduction on the burn. By the third year production of associated shrubs, as a group, had doubled and tripled on treated areas. Such increases are attributed to the sprouting habit of most of these species.

Additional information on effectiveness of the various treatments for sagebrush control is supplied by plant counts (Table 1). Before treatment the number of sagebrush plants per 48-square-foot plot ranged from 9.8 on the area to be burned to 11.6 on the untreated area, or an average of approximately 11 plants per plot. The greatest reduction in numbers was obtained by burning, which killed all the old plants. The first year after treatment the burned area had only 1.5 plants per plot (all seedlings) and by the third year after treatment only 2.8 plants per plot, or an over-all reduction in numbers of 72 percent. Railing was the least effective method for reducing sagebrush numbers, as there were 3.8 plants per plot the first year after treatment and 6.2 by the third year, or a reduction of only 42 percent. Despite the rather

Table 1. Average numbers of sagebrush plants per 48-square-foot sample plot on five different areas before, 1 year after, and 3 years after using different methods to kill sagebrush.

	1952 prior to treatment	1953 First year after treatment	1955 Third year after treatment
Untreated	11.6	10.4	11.9
Burned	9.8	1.5*	2.8
Rotobeaten	10.7	2.0	3.6
Sprayed	11.1	3.5	4.3
Railed	10.7	3.8	6.2

*Seedlings

low kills of sagebrush from the 2,4-D treatment in this test, it should be recognized that spraying is an effective method for sagebrush eradication; kills of more than 90 percent are not uncommon (Blaisdell and Mueggler, 1956).

Species Herbage Yields

Herbage yields of individual species prior to treatment and 3 years afterward are shown in Table 2. The data are grouped into arbitrary desirability classes for sheep in order to obtain a better understanding of changes in amount and type of forage. The classification is based upon sheep preferences in this particular spring-fall range area; the same species may of course be rated differently elsewhere. Although pretreatment estimates were not made for individual grasses, the effect of each treatment is indicated by comparison of subsequent yields with those on the other areas. Caution must be exercised in deducing treatment effects by direct comparison with the untreated area. This is especially true in the case of the grasses where no before-treatment figures are available for individual species. An attempt has been made to avoid erroneous interpretations by utilizing supplementary information to indicate inequalities in original production.

Of all the treatments, burning caused some of the most pronounced changes in individual species. Species other than sagebrush that were harmed by burning were *Agropyron spicatum, Antennaria microphylla, Penstemon radicosus,* and especially *Carex-Festuca* and *Purshia.* Although *Stipa comata* may have suffered a loss, it was probably not as severe as the figures indicate; frequency data suggest that there was less of this species on the burned area originally than on the untreated. Burning appeared to benefit most *Agropyron-Calamogrostis, Stipa columbiana, Astragalus convallarius, Lupinus, Erigeron, Chrysothamnus,* and *Tetradymia.* These observations agree essentially with long-term observations by Blaisdell (1953), who found, however, that initial decreases in many of these species, with the exception of *Festuca* and *Purshia,* were only temporary and that they eventually regained or exceeded their original production.

None of the species on the rotobeaten area, other than sagebrush, was seriously injured by this treatment; all appear to have responded favorably. The apparent decrease in *Agropyron spicatum* is deceptive, for frequency data indicate a markedly greater occurrence of this species in 1953 on the untreated area than on any of the treated plots, suggesting an inequality of original production. What seems a slight decrease on the rotobeaten area, and on the sprayed and railed areas as well, may actually be a slight increase. As pointed out previously, there was a lag in response of grasses to release by rotobeating the first year as compared to the forbs. This is illustrated by relative production figures between the two groups over the entire period (Fig. 1). Before treatment production of grasses was almost six times that of the forbs; 1 year after it was less than twice as great; and in 3 years, by which time grasses had taken advantage of reduced brush competition, it was over three times as great as the forbs.

The most pronounced effects of spraying were reductions in *Lupinus* and *Erigeron,* besides sagebrush, and increases in most grasses, especially *Stipa columbiana.* The indicated increase of *Stipa comata* is of doubtful validity because of the erratic occurrence of this species on the sample plots. Both *Purshia* and *Tetradymia* benefited by spraying. Production of other species was not appreciably changed.

With greater sagebrush kill from spraying, which might ordinarily be expected, grasses that increased under this limited reduction in competition would probably show greater gains, and forbs would probably be damaged more severely. Blaisdell and Mueggler (1956) found that such species as *Penstemon, Arnica fulgens, Comandra umbellata, Eriogonum heracleoides,* and *Chrysothamnus,* not obviously affected in this study, were lightly damaged by spraying with 2,4-D.

Changes induced by railing were not as pronounced as with other treatments; no species were greatly favored and none aside from sagebrush was noticeably damaged. The effects of railing were similar to those of rotobeating, but to a lesser degree because of lower sagebrush kill. Species that appear to have benefited most are *Carex-Festuca, Poa, Lupinus, Chrysothamnus,* and *Tetradymia.* The

Table 2. Herbage production before treatment (1952) and 3 years after (1955) on comparable areas subjected to different methods of sagebrush removal.

	Untreated		Burned		Rotobeaten		Sprayed		Railed	
	1952	1955	1952	1955	1952	1955	1952	1955	1952	1955
	(Air-dry pounds per acre)									
Total Grass	207	268	229	295	250	490	245	430	200	310
Total Forbs	49	114	82	307	43	150	65	92	80	223
Total Shrubs	367	481	361	137	368	102	281	219	267	184
Desirable Species										
Agropyron spicatum		41		18		33		29		30
Agropyron dasystachyum-Calamagrostis montanensis		31		68		68		46		30
Carex filifolia-Festuca idahoensis	*	106	*	36	*	204	*	146	*	143
Koeleria cristata		3		8		7		5		9
Poa spp.		18		35		66		25		34
Stipa comata		13		4		20		40		1
Stipa columbiana		51		123		91		138		63
Astragalus miser	1	7	—	3	1	8	Trace	4	1	6
Astragalus convallarius	—	1	—	10	—	5	—	2	—	4
Lupinus spp.	—	1	41	148	3	26	15	4	6	51
Penstemon radicosus	3	6	5	3	2	4	5	7	5	9
Purshia tridentata	8	8	14	Trace	—	—	5	13	—	—
Others	1	8	6	26	—	Trace	2	2	5	8
Total Desirable	220	294	295	482	256	532	272	461	217	388
Moderately Desirable										
Achillea lanulosa	1	2	3	9	1	1	—	Trace	—	1
Antennaria microphylla	4	18	4	4	1	17	5	18	7	39
Arnica fulgens	8	9	1	2	4	7	5	6	23	20
Comandra umbellata	Trace	1	3	2	1	3	5	3	1	1
Erigeron corymbosus	26	40	9	38	21	49	14	13	21	44
Eriogonum heracleoides	3	7	8	13	4	14	8	17	2	10
Chrysothamnus puberulus	4	11	5	68	4	16	3	12	3	20
Others	6	3	2	3	4	4	4	3	5	4
Total Mod. Desirable	52	91	35	139	40	111	44	72	62	139
Undesirable Species										
Artemisia tridentata	346	452	337	47	360	67	269	178	257	144
Tetradymia canescens	5	8	5	21	4	20	4	17	6	20
Others	Trace	18	—	50	1	12	2	13	5	26
Total Undesirable	351	478	342	118	365	99	275	208	268	190
Total Production	623	863	672	739	661	742	591	741	547	717

*1952 production for total grasses given above.

remaining species showed little change that can be directly attributed to railing. The apparent reduction in *Stipa comata* is probably not real, since frequency data suggest very erratic distribution of this species.

Changes in amount and type of forage are indicated by class totals of desirable and moderately desirable species in Table 2. Three years after treatment total air-dry production of desirable and moderately desirable species was 621, 643, 533, and 527 pounds per acre on burned, rotobeaten, sprayed, and railed areas, respectively, as compared to 385 pounds per acre on the untreated range. Production of the desirable class alone was 482, 532, 461, and 388 pounds per acre for the respective treatments, while that for the untreated range was only 294 pounds. Such changes were not immediate but occurred gradually over the 3-year period. The rotobeaten area especially was slow to respond with an increase in forage production.

Only 75 percent of the herbage on the untreated range was considered available to livestock, whereas 98, 98, 88, and 90 percent was available on the burned, rotobeaten, sprayed, and railed areas, respectively. It is apparent, then, that all treatments produced sizable increases in available forage and that increases were greatest on burned and rotobeaten range. It can be expected that availability of forage on the sprayed area will increase as the sagebrush skeletons decay.

Eradication Methods

Cost of the various eradication methods may vary considerably, depending upon size of area to be treated, equipment used, etc. The following figures may be considered indicative of comparative costs. The cost of burning, which includes construction of adequate fire lines, actual burning, and the loss of grazing because of 1-year mandatory deferment, is about $0.70 per acre. Rotobeating costs vary from $3.00 to $6.00, spraying with 2 pounds acid equivalent 2,4-D, $2.50 to $3.00, and railing twice over, $2.00 to $2.50 per acre. It is readily apparent that despite the 1-year grazing deferment, burning is by far the least expensive method of sagebrush eradication. More specific information on burning procedure and costs is given by Pechanec, *et al.* (1954a).

When selecting a method best suited for a particular area, it is necessary to consider not only effect upon existing vegetation and cost but also adaptability of the method to the site and effect upon erosion hazard. Rotobeating and railing leave a good litter cover and do not increase the erosion hazard, but both methods are restricted to fairly rock-free areas. Rotobeating should not be attempted where rocks protrude more than 3 inches above the soil surface or excessive equipment breakage may result. Spraying does not increase the erosion hazard appreciably and is suitable for any terrain where airplanes can be used, but may be highly undesirable on sheep ranges which have a high percentage of susceptible forbs. Burning is suited to any terrain where the fire can be kept under control; however this method should not be used on readily erodible soils or on slopes steeper than about 30 percent, for burning destroys all litter and exposes the soil to erosion.

Summary

Four different methods of selective sagebrush control were studied on sagebrush-bunchgrass range at the U. S. Sheep Experiment Station near Dubois, Idaho. Burning, rotobeating, spraying with 2,4-D, and railing were compared on adjacent areas to obtain a better understanding of relative effects upon associated native species and forage production.

Burning was the only treatment that injured any grasses. The *Carex filifolia-Festuca idahoensis* group was most severely reduced by burning. Other grasses, though set back temporarily, soon recovered. Grasses as a group were greatly favored by the other treatments. There was a lag in increased grass production the first year after rotobeating and railing, but grass production increased immediately with spraying.

Although burning brought about the greatest increase in total forbs, *Antennaria microphylla* and *Penstemon radicosus* were injured; *Astragalus convallarius, Erigeron corymbosus,* and *Lupinus* spp. were most benefited. Rotobeating and railing tended to favor all forbs, perhaps *Lupinus* spp. more than the others. Spraying caused a pronounced reduction in forbs, with *Lupinus* spp. and *Erigeron corymbosus* being most severely affected.

Sagebrush was greatly reduced by all treatments. By the third year after treatment sagebrush production on the burned area was only 11 percent of what it would have been with no treatment, 14 percent on the rotobeaten area, 50 percent on the sprayed area, and 43 percent on the railed area. Sagebrush plants were reduced to 28, 33, 39, and 58 percent of their former numbers under the respective treatments. *Purshia tridentata* was severely injured by burning; it was favored by spraying. *Chrysothamnus puberulus* and *Tetradymnia canescens,* which sprout readily, increased under all treatments.

All treatments produced sizable increases in available forage. Three years after treatment total production of desirable and moderately desirable species was approximately two-thirds greater on the burned and rotobeaten areas, and better than one-third greater on the sprayed and railed areas, than on the untreated range. Only 75 percent of the grass and forbs was available to livestock on the untreated range, but 98, 98, 88, and 90 percent was available on the burned, rotobeaten, sprayed, and railed areas, respectively.

LITERATURE CITED

BLAISDELL, JAMES P. 1953. Ecological effects of planned burning of sagebrush-grass range on the Upper Snake River Plains. U. S. Dept. Agr. Tech. Bull. 1075, 39 pp.

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

BOHMONT, DALE W. 1954. Chemical sagebrush control—good and bad. Wyoming Agr. Exp. Sta. Cir. 54, 7 pp.

HURD, RICHARD M. 1955. Effect of 2,4-D on some herbaceous range plants. Jour. Range Mangt. 8: 126-128.

HYDER, D. N. AND F. A. SNEVA. 1956. Herbage response to sagebrush spraying. Jour. Range Mangt. 9: 34-38.

PECHANEC, J. F. AND G. D. PICKFORD. 1937. A weight estimate method for the determination of range or pasture production. Jour. Amer. Soc. Agron. 29: 894-904.

———, *et al.* 1954. Controlling sagebrush on range lands. U. S. Dept. Agr. Farmers' Bull. 2072, 36 pp.

———, *et al.* 1954a. Sagebrush burning — good and bad. U. S. Dept. Agr. Farmers' Bull. 1948, 34 pp.