Herbage Response to Sagebrush Spraying

DONALD N. HYDER AND FORREST A. SNEVA

Range Conservationists, Squaw Butte-Harney Experiment Station[1], Burns, Oregon

Information that is presently available makes chemical control of sagebrush (*Artemisia tridentata*) a practical operation. Yet additional information is needed regarding ecological responses to assure that the practice of spraying for sagebrush control will be used wisely.

The economy of brush control must be determined by the amount of forage and meat products gained; however, the principal objective in brush control should be an upgrade in range condition. An evaluation of returns consistent with this management objective will require a long period of study, but the practical application of chemical control methods will not wait for such extensive experimentation. Therefore, sagebrush control measures must be undertaken in a manner consistent with present knowledge.

Information from previous work and experience has been evaluated in terms of how, when, why, and where to control sagebrush in a recent bulletin by Pechanec and others (1954). Preliminary details of herbage response to chemical sagebrush control, and its relation to site selection, will contribute to this back-log of information.

The present paper presents three years of results in herbage response to sagebrush spraying. The amount of forage and meat products resulting from sagebrush control, and the range condition at the time of spraying will be of interest to others contemplating control of big sagebrush by spraying. Perhaps the information most new to the sagebrush-bunchgrass range is the apparent source of herbage response, and the implications it proposes regarding range ecology.

Experimental Methods

One-tenth acre plots were established in 1951 to compare herbage response following sagebrush control by spraying 1 pound per acre of 2,4,5-T butyl ester with that following sagebrush eradication by grubbing and on untreated areas. The experiment was in randomized blocks with two replications. Ten permanent 9.6 square-foot samples were established on each plot from which herbage yields by species were obtained. Five permanent 100-foot lines were established on each plot to obtain basal intercept measures on the bunchgrasses and crown intercept measures on big sagebrush. Plaster of Paris blocks were planted at five locations on each plot at depths of 6 to 18 inches to obtain resistance readings of available soil moisture (Bouyoucos, 1950).

The 40-acre range pasture in which the plots were located was sprayed for sagebrush control in 1952 with two pounds per acre of 2,4-D butyl ester. Herbage response and trends on the entire area are of interest as verification of results on the plots. Grazing by yearlings was permitted on the pasture in August each year. Herbage production was sampled before grazing, and the yearlings were weighed on and off to obtain animal performance.

Pre-treatment inventory results as presented in the following tables appear to justify a range condition rating of fair with respect to bunchgrass density and composition. Average annual precipitation is nearly 11 inches, with over half of that amount received in the form of snow.

Results

Herbage Yields

In the three years following sagebrush treatments, sprayed plots have produced 882 pounds per acre more grass and 1,226 pounds per acre more total herbage than untreated plots (Table 1). Grubbed plots responded differently insofar as weeds were concerned. Those plots have produced, in the three years following treatment, 841 pounds per acre more grass and 1,507 pounds per acre more total herbage than untreated plots.

Spraying restricted the growth of weeds (mostly *Lupinus caudatus*) in the spraying year, but complete kill was not observed for any of the weed species. In the year after spraying the yield of weeds was slightly higher on sprayed plots than on untreated plots, but was considerably lower than that on grubbed plots. An enormous increase in weed herbage occurred in 1953 (Figure 1), which was a very wet year with total precipitation of 15.68 inches and a growing season (April, May, and June) precipitation of 6.60 inches. Beginning in 1953 the weeds were divided into legume and non-legume herbage. Weed yields were down in 1954, which was abnormally dry with a total precipitation of 6.77 inches and a growing season precipitation of 2.74 inches.

Grass yields have been about the same for spraying and grubbing. Highest yields were obtained in the year following treatment, and have dropped a little in the past two years. It seems peculiar that grass yields dropped in the wet season of 1953 below those of 1952 (which was a little drier than normal with total precipitation of 9.87 inches and a growing season precipitation of 2.73 inches). This suggests that the source of response to sagebrush reduction was something more than release in competition for moisture. The

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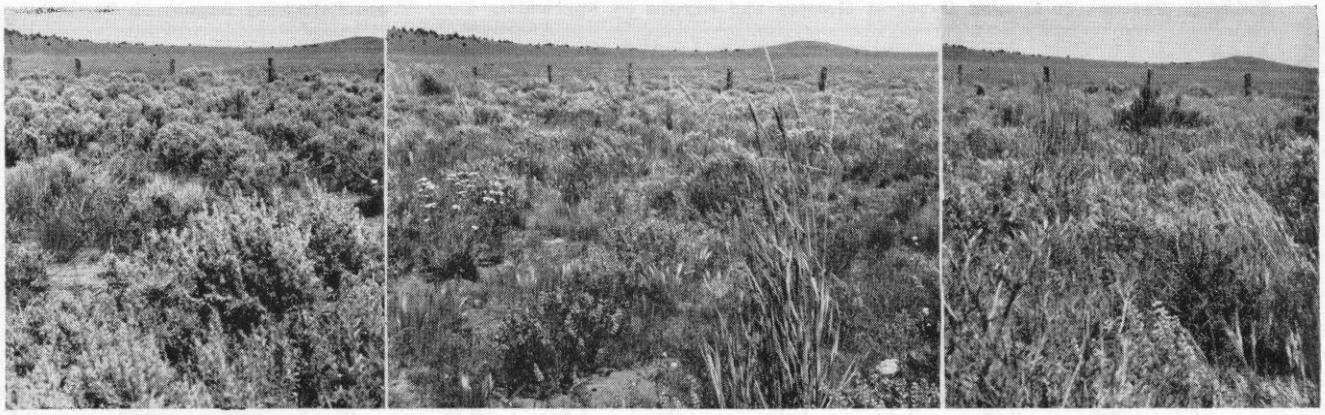

FIGURE 1. Untreated, grubbed and sprayed plots as they appeared in July, 1953, showing response to treatment made in 1951.

suggestion is supported by observation of growth performance. Under the sagebrush the grasses were extremely weak in color, growth, and heading, but on treated plots the grasses were bright green in color, and were strong in growth and heading.

Individual grass species responded differently to sagebrush control measures. Squirreltail (*Sitanion hystrix*) and June grass (*Koeleria cristata*) have responded more than other grasses. Their trends in yields in the past three years are intriguing. Squirreltail was especially strong in the wet season of 1953, while June grass dropped in yield on all plots below 1952 production. In 1954 yields of squirreltail dropped on all plots and June grass increased.

Percentage Ground Cover

Spraying reduced the percentage of ground covered by live sagebrush crown 91 percent (Table 2). In the past three years the portions of crowns not killed by the herbicide have grown some and in 1954 covered 17 percent as much ground area as the original stand. Grubbing removed all the sagebrush, but a few seedlings have become established on those plots. By numbers of plants intercepted, spraying reduced the stand of sagebrush 83 percent.

The percentage basal ground cover of bunchgrasses has increased by about one-third on treated plots, as compared with untreated plots. Most of the increase occurred in the first year; although, smaller increases have been measured in subsequent years.

Percentage ground cover by species parallels closely the trends found in herbage yields. Of particular interest is the increase in squirreltail in 1953 accompanied by a decrease in June grass. In 1954 squirreltail dropped in basal cover to about 65 percent of the comparable measure in 1953, but June grass increased about 25 percent.

The total numbers of bunchgrasses intercepted have increased 7, 30 and 36 percent respectively on untreated, sprayed, and grubbed plots. By individual species the trends in numbers of grasses intercepted have paralleled closely the trends in herbage yields and percentage ground cover. The total number of grasses did not

Table 1. Herbage Yields by Species[1] in Four Years Following Sagebrush Control

Sagebrush Treatment	Year	Grasses								Weeds			Herbage Total
		Asp	Fid	Sth	Shy	Ker	Bte	Other	Total	Legume	Non-Legume	Total	
		(air dry herbage[2] in pounds per acre)											
Untreated	1951	5	3	28	6	40	—	11	93	—	—	26	119
	1952	5	4	40	8	83	—	19	159	—	—	14	173
	1953	4	3	30	18	71	2	1	128	92	0	92	220
	1954	2	4	28	14	107	0	11	166	11	0	11	177
Sprayed	1951	38	10	9	46	55	—	15	173	—	—	4	177
	1952	51	21	13	137	139	—	140	501	—	—	27	528
	1953	53	10	8	137	104	122	8	422	296	60	365	807
	1954	40	9	7	117	131	64	24	392	69	0	69	461
Grubbed	1951	29	0	28	9	72	—	38	174	—	—	62	236
	1952	59	0	60	50	198	—	107	472	—	—	164	636
	1953	48	3	40	102	111	69	34	409	461	81	542	951
	1954	24	3	42	85	151	85	23	413	77	0	77	490

[1]The species segregated were as follows:
Asp—*Agropyron spicatum*, bluebunch wheatgrass
Fid—*Festuca idahoensis*, Idaho fescue
Sth—*Stipa thurberiana*, Thurber's needlegrass
Shy—*Sitanion hystrix*, squirreltail
Ker—*Koeleria cristata*, June grass
Bte—*Bromus tectorum*, cheatgrass
Legume—mostly *Lupinus caudatus*

[2]Herbage samples were air dried in 1951 and 1952, but in 1953 and 1954 were oven dried and the herbage weights were converted to 10 percent moisture for reporting as air-dry values.

Table 2. Percentage Ground Cover of Grasses and Shrubs by Species[1] in Four Years Following Sagebrush Control

Sagebrush Treatment	Year	Grasses								Shrubs	
		Asp	Fid	Sth	Shy	Ker	Pse	Other	Total	CHR	Atr
					% basal intercept					*% crown intercept*	
Untreated	1951	0.84	0.04	0.57	0.08	0.75	0.45	0.05	2.79	0	21.20
	1952	0.41	0.13	0.66	0.36	1.23	0.48	0.03	3.30	0	19.73
	1953	0.45	0.05	0.82	0.65	1.30	0.46	0.06	3.79	0	20.24
	1954	0.34	0.08	0.86	0.28	1.51	0.60	0.02	3.69	0	18.06
Sprayed	1951	0.78	0.16	0.09	0.07	0.78	0.21	0.48	2.57	0.30	24.05
	1952	0.69	0.19	0.20	0.78	1.62	0.43	0.43	4.34	0	2.06
	1953	0.99	0.15	0.34	1.17	0.99	0.30	0.77	4.72	0	3.88
	1954	0.73	0.35	0.31	0.74	1.48	0.44	0.96	5.01	0.05	4.03
Grubbed	1951	0.67	0.10	0.18	0.10	0.63	0.57	0.07	2.33	0.35	23.39
	1952	0.64	0.20	0.35	0.49	1.47	0.67	0.06	3.89	0	0.04
	1953	0.76	0.18	0.45	1.05	1.86	0.75	0	5.05	0.18	0.17
	1954	0.84	0.12	0.28	0.73	2.08	0.93	0.10	5.08	0.16	0.25

[1]Species same as in Table 1, and
Pse—*Poa secunda*, Sandberg bluegrass
CHR—*Chrysothamnus spp.*, Rabbitbrush
Atr—*Artemisia tridentata*, Big sagebrush

change much from 1953 to 1954, but the abundance of squirreltail was reduced markedly and that of June grass increased. The average size (intercept) of individual clumps of these two species was uniformly less in 1954 than in 1953.

Available Soil Moisture and Nitrate

The differences in moisture trends among treatments have been especially interesting. In the first year following treatment, soil moisture levels started slightly higher and growing season precipitation was more effective on treated plots; nevertheless, the moisture depletion rate was somewhat faster than on untreated plots. In subsequent years the differences in moisture depletion became more clear. By the third year after treatment, the earlier depletion of soil moisture on treated plots was quite striking (Figure 2).

In part, the differences in soil moisture were due to differences in retention of precipitation. Snow was more effectively held on sprayed and untreated plots than on grubbed plots due to the brush cover; but rain during the growing season was more effective on treated plots due to reduced interception and evaporation, with but little difference between grubbing and spraying in this respect. The over-all retention of precipitation was clearly better on sprayed plots than on plots grubbed or untreated.

There were also differences among treatments in the demand placed upon soil moisture. This difference in demand is visualized in the rates of soil moisture depletion. It seems peculiar that the demand for moisture was stronger on treated plots than on untreated plots which retained all the vegetation.

In 1954 determinations were made of soil nitrate in the surface six inches of soil using a LaMotte quick-test kit. Available soil nitrate in the surface six inches of soil on untreated plots dropped from six parts per million on June 8 to 3 p.p.m. on July 5, while soils from treated plots increased in nitrate content from 5 to 10 p.p.m. It appears that big sagebrush is a strong competitor for soil nitrogen.

Production and Trends on 40-Acre Sprayed Range

In the past two years this pasture has produced a total of about 650 pounds more forage per acre, and over twenty pounds more beef per acre than was obtained before spraying (Table 3).

With the value of increased yearling gains rated at 18 cents per pound, the return has been over $4 per acre in two years. After suitable deductions for operating expenses, the increased beef production should redeem the cost of spraying (about $3 per acre) within five years.

In 1953, the first year after spraying, the aspect of mature herbage was predominantly squirreltail. In 1954 squirreltail did not dominate the aspect and appeared to be dropping out, but June grass increased in composition by weight from 28 percent in 1953 to 36 percent in 1954.

Discussion

Sagebrush control on sagebrush-bunchgrass range in fair condition gave about three-fold increase in herbage production. The higher production was due in part to an increase in numbers of grasses and an increase in basal size, but was primarily due to more vigorous and higher growth. A release in moisture competition was evident in soil moisture levels during the spring of the first year after treatments. Other evidence of im-

Table 3. Herbage and Beef Production on 40-Acre Range Sprayed in 1952

Year	Air-dry herbage	Yearling-days of grazing	Average daily gain	Beef gain
	lbs./acre	*no.*	*lbs.*	*lbs./acre*
1951	280	406	0.58	5.6
1952	305	450	0.74	8.4
1953	723	1146	0.62	17.6
1954	536	640	1.37	21.9

[1]Grazing was allowed only in the month of August. The yearlings were weighed individually on and off the pasture after shrinking off feed and water for 12 hours.

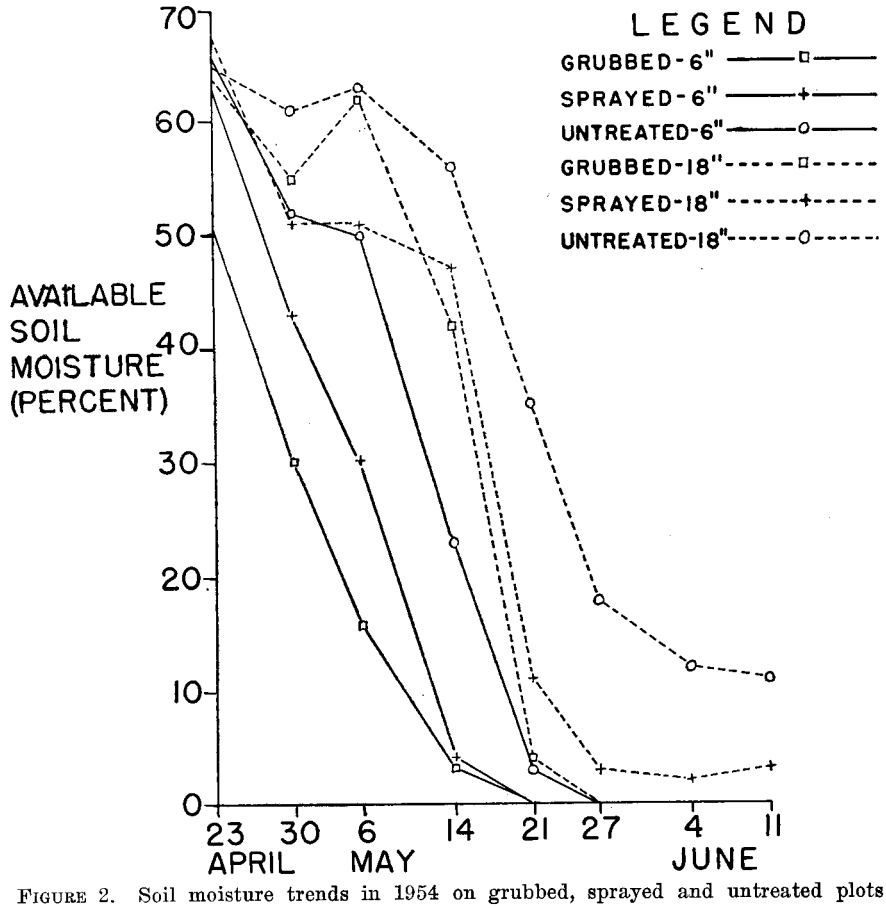

FIGURE 2. Soil moisture trends in 1954 on grubbed, sprayed and untreated plots at depths of 6 and 18 inches.

proved moisture relations on sprayed plots was found in better retention of precipitation. However, the trends in moisture depletion have been faster on treated than on untreated plots.

Those results and observations indicate that release in the competition for soil nitrogen was profoundly important in the response to sagebrush control. Soil nitrate trends in the upper six inches of soils from those plots gave direct evidence of such release. Other evidence is found in the high protein content of big sagebrush and its tremendous response to nitrogen fertilization on other plots (unpublished data).

It is thus concluded that the bunchgrasses have relative advantage over sagebrush in moisture competition (Robertson, 1947), but sagebrush has relative advantage over the grasses in competition for soil nitrogen. With better nitrate relations, the grasses could manifest their advantage. Under those conditions sagebrush reproduction would face more difficulty in establishment than under a stand of sagebrush. When the relative advantage held by the grasses is reduced by too-early grazing in the spring or close grazing at any time in the growing season, the opportunity for sagebrush reproduction increases. Once the sagebrush becomes dense, its relative advantage in nitrogen competition appears to supercede the relative advantage held by the grasses.

The balance in soil moisture and nitrogen may be the primary factor which determines the status of competitive advantage. Thus, there is a basis for appreciation of soil and climatic differences in the competitive relations between grasses and sagebrush. On a climatic basis low growing-season precipitation limits the opportunity for nitrification and should make it easier for the sagebrush advantage in nitrogen competition to supersede the grass advantage in moisture competition. Geographically, the occurrence of big sagebrush is largely in the areas of low growing-season precipitation. Under conditions of high growing-season precipitation, soil nitrogen levels may not become critical, and the competitive relation may depend upon relative advantage in competition for moisture.

In undertaking a program of sagebrush control to gain an upgrade in range condition, grazing should be deferred to grass maturity in the year of treatment, and especially so in the year after treatment. Maximum grass vigor is necessary, if the advantage in competition is to be tipped back to the grasses and the opportunity for sagebrush re-invasion is to be restricted. In subsequent years, grazing management should be planned to prevent too-early grazing, and close grazing at any time during the growing season.

Successful range improvement will depend largely upon the selection of areas which support a sufficient understory of grasses. In general, the deeper-rooted bunchgrasses should be frequent enough that one can walk along stepping from grass to grass without too many misses. It should also be noted that the earliest-growing grasses in the spring made the biggest response initially, then started giving way slowly to the more dominant species. An early closing of the community to sagebrush re-invasion may be obtained with those early-growing grasses, and site selection for their presence may also be important to successful range improvement through sagebrush control.

Summary

1. Herbage response to big sagebrush control measures was evaluated on untreated, sprayed and grubbed plots prepared in May 1951. In 1952-54 inclusive the sprayed plots produced 882 pounds per acre more grass and 1,226 pounds per acre more total herbage than untreated plots. Grubbed plots in the

same three years produced 841 pounds more grass and 1,507 pounds more total herbage than untreated plots.

2. Herbage yields, basal intercepts and numbers of plants by species show that *Sitanion hystrix* and *Koeleria cristata* responded more than other grasses to sagebrush control.
3. Soil moisture was depleted more slowly on untreated plots than on treated plots.
4. A 40-acre pasture sprayed for brush control in May 1952 produced in 1953 and 1954 over twice as much forage and beef as was obtained before spraying.
5. The herbage responses obtained are interpreted as indicative of the importance of soil moisture-soil nitrate balance in the competition between big sagebrush and native bunchgrasses.
6. A sagebrush-bunchgrass range in fair condition, with deep-rooted bunchgrasses yielding about 150 pounds per acre, is suited to profitable improvement by chemical control of big sagebrush.

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