STATION PAPER NO. 9 JUNE 1952

CHEMICAL CONTROL OF BIG SAGEBRUSH IN CENTRAL WYOMING

By

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FOREST SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE
FORT COLLINS, COLORADO

*Maintained in cooperation with Colorado A & M College

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INTRODUCTION

Much of central Wyoming is open sagebrush-grassland. Here, big sagebrush (*Artemisia tridentata*) seldom averages more than 12 inches in height and the plants grow from 1 to 5 feet apart. In some areas the shrubs are more robust and form dense thickets which provide an effective barrier to livestock. Throughout the type, competition from the shrubs results in decreased grass production.

Although big sagebrush is an important source of forage for both domestic livestock and big game animals, and is a means of reducing erosion on steep slopes, there are thousands of acres on which a reduction of the sagebrush cover would provide a severalfold increase in yield of valuable forage grasses. Control measures are feasible where topography is level or rolling, where erosion is not an important problem, and where big sagebrush is not an essential browse plant for domestic livestock or game animals.

Since World War II, control of undesirable plants has been greatly advanced by the development of new herbicides including 2,4-D and 2,4,5-T.

1/ Maintained by the Forest Service, U. S. Department of Agriculture, in cooperation with Colorado A & M College at Fort Collins, Colorado, and with Research Center headquarters at Laramie, Wyoming, in cooperation with the University of Wyoming.

Spraying with these chemicals promises sagebrush control at lower cost than mechanical methods and, in addition, spraying does not disturb the soil or uproot desirable plants. Organic matter is not destroyed as when burning is practiced, nor is there present the hazard to life and property.

Chemical control of big sagebrush is being investigated in the Beaver Rim area near Lander, Wyoming, as part of the Forest Service and Bureau of Land Management cooperative research program in range land improvement. This paper reports the results of the 1950 herbicide treatments on big sagebrush along with the response of the herbaceous vegetation to removal of the sagebrush competition in the 1949 studies. The studies were begun in 1949, enlarged in 1950 and 1951, and will be continued in 1952. The 1949 results were reported by Hull and Vaughn (4). Similar studies conducted by Colorado A & M College and the Rocky Mountain Forest and Range Experiment Station in Colorado were reported by Hervey and Doran (2).

EXPERIMENTAL AREA

The Beaver Rim area is within the Sweetwater River drainage and about 35 miles southeast of Lander, Wyoming. Elevation is nearly 7,000 feet and the growing season extends from early May to about the middle of September. The annual precipitation is approximately 14 inches and comes largely in two distinct periods -- March through June, and during September and October (5). Soil is a fine sandy loam with a lime-accumulation layer 13 to 16 inches below the surface. Soil depth is at least 30 inches, but occasional rock outcrops are present.

Big sagebrush forms an uneven-aged stand of from 25 to 30 plants per 100 square feet. The mature plants are approximately 50 years of age, average 12 inches tall, and make up nearly 40 percent of the stand. Vigorous, flexible plants in the 10- to 45-year age group make up about 35 percent of the stand. The remaining 25 percent consists of younger plants and seedlings, many of which are under 1 inch in height.

Scattered plants of small rabbitbrush (*Chrysothamnus* spp.) and spineless horsebrush (*Tetradymia canescens inermis*) occur throughout the area. On the 1950 study area there was an average of 6.5 rabbitbrush plants and a trace of spineless horsebrush per 100 square feet.

The herbaceous understory covers only 8 to 10 percent of the ground and consists largely of thickspike wheatgrass (*Agropyron dasystachum*) and streambank wheatgrass (*A. riparium*) with minor amounts of bluebunch wheatgrass (*A. spicatum*), plains reedgrass (*Calamagrostis montanensis*), prairie junegrass (*Koeleria cristata*), Cusick bluegrass (*Poa cusickii*), Sandberg bluegrass (*P. secunda*), and needle-and-thread (*Stipa comata*).

Forbs make up a very minor part of the understory. They include milkvetch (*Astragalus* sp.), lupine (*Lupinus* sp.), phlox (*Phlox* sp.), and clover (*Trifolium* sp.).

METHODS

In 1950 as in 1949 (4) several commercial herbicides were sprayed on big sagebrush with airplane and ground-spraying equipment to determine their effectiveness in killing big sagebrush. Treatments were made on three dates to determine the time of maximum susceptibility.

Chemical treatments

A total of 59 different combinations of chemicals and carriers was tested in 1950. Isopropyl esters of 2,4-D and 2,4,5-T were used in the majority of treatments. More complex compounds -- butoxy ethanol esters and propylene glycol butyl ether esters of 2,4-D and 2,4,5-T -- were tried on a limited scale on one date. Limited tests were also made with maleic hydrazide, two of the dinitro weed killers, and with ethyl amine of 2,4,5-T.

All chemicals were mixed with one of three carriers and applied as foliage sprays. Water at rates of 3, 5, 10, and 25 gallons per acre, diesel oil at rates of 3 and 5 gallons per acre, and an emulsion of 4 gallons of water and 1 gallon of diesel oil were used as carriers. 2,4-D and 2,4,5-T were applied in these carriers at rates of ½, 1, and 2 pounds acid equivalent per acre.

Time of treatment

The stage of growth of big sagebrush at the time of treatment appears to be a very important factor in its susceptibility to selective herbicides. Past work indicates that maximum susceptibility occurs during the period of most active growth in spring or early summer (1). To determine the period when treatments are most effective, 24 of the 59 herbicide and carrier mixtures were applied on three different dates: May 15, June 5 to 10, and June 25. The remainder were tested only during the expected optimum period June 5 to 10.

Spraying equipment

Two types of equipment were used in applying the chemicals. The majority of treatments were made with a model 23 Enparco sprayer attachment on a D-2 Caterpillar tractor (fig. 1). Eight treatments were duplicated on June 25 using a Piper Special airplane (fig. 2). The aerial sprayings were planned for June 5, but bad flying weather in the study area prevented their application until the later date.

Study design

One-acre plots (60 by 726 feet) were used for ground sprayings. Aerial sprayings were made on 5-acre plots (100 by 2,178 feet). Check strips of 20 feet were left unsprayed between ground-spray plots and 100-foot strips were left between aerial-spray plots. The time and expense involved in making 109 ground and 8 aerial spray applications prohibited use of replicate plots. Single-plot treatments were considered adequate to separate the most promising from numerous chemical and carrier mixtures. These promising mixtures could then be tested intensively without the experiment becoming impractically large.

Data collected

At the time of spraying, two soil-moisture samples were taken on the study area at 6-inch intervals to a depth of 2 feet.

Before spraying, an inventory was made of the vegetation on the study area. Sagebrush was counted by age classes -- seedling, young flexible, mature, and dead plants -- on one 50-square-foot permanent plot within each treatment. Also recorded were numbers of other shrubby species as well as the presence and growth stage of the herbaceous plants. Big sagebrush twigs were measured to provide data on current growth. One year after spraying the 50-square-foot permanent plots were reinventoried. In this way the kill of sagebrush by age class was obtained as well as indications of the susceptibility of other shrubby and herbaceous plants. The percent of sagebrush plants killed was tallied for each treatment by examining 200 additional big sagebrush plants chosen by the pace-transect or step-point method. The kill recorded for the treatment was the percent of plants that were completely defoliated. Any live foliage on a plant caused it to be classified as living.

Grass yields were obtained in July 1951 by clipping sample plots inside exclosures on six 1949 ground-sprayed plots and adjacent unsprayed strips, and on three 1949 aerial-sprayed plots and adjacent unsprayed strips. The exclosures were not fenced until after the 1950 grazing season and as a result the experimental plots were grazed by cattle and to some extent by sheep in 1949 and 1950. The increased grass production, therefore, was due only to reducing the sagebrush competition and was not aided by 2 seasons' protection from grazing.

On several occasions cattle in the experimental area were observed concentrating on sprayed plots. In order to determine the difference in utilization, if any, herbage samples were clipped outside the exclosures on both sprayed and unsprayed plots and compared with yields inside the exclosures.

RESULTS AND CONCLUSIONS

The percent kill appearing in tables 1 and 2 refers only to sagebrush plants which were completely defoliated 1 year after treatment. Since the extent to which partially defoliated plants will continue to compete with the herbaceous understory is not definitely known, it was considered desirable to make this distinction.

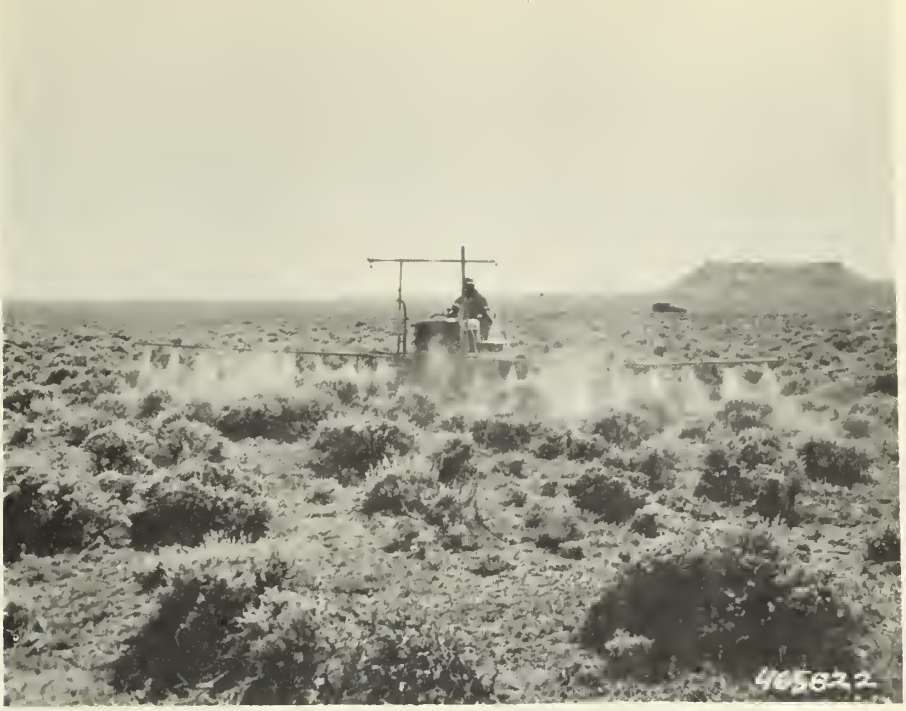

Figure 1.--This tractor-mounted spraying equipment covered a 30-foot swath at 3 miles per hour. The spray tank is behind the operator.

Figure 2.--The airplane equipment sprayed a 50-foot swath at 90 miles per hour. Height of flight was from 2 to 10 feet.

Table 1.--Percent of big sagebrush plants killed by ground spraying on three dates in 1950 with the isopropyl esters of 2,4-D and 2,4,5-T, and the 2,4,5-T ethyl amine.

DATE AND CHEMICAL	POUNDS ACID PER ACRE	PERCENT KILL BY TYPE						
		Gallons of carrier per acre						
		Water				Oil		Emulsion
		3	5	10	25	3	5	4 water-1 oil
MAY 15								
Diesel oil only							13	
2,4-D ester Weedkiller	½	2	4	3	--	5	26	--
(3.5 lbs. isopropyl	1	13	6	29	31	37	26	7
ester per gal.)	2	37	25	19	--	48	49	--
2,4,5-T ester Brushkiller	½	--	--	--	--	--	--	--
(2.66 lbs. isopropyl and	1	59	43	50	--	71	62	--
0.67 lb. amyl ester per	2	--	--	--	--	--	--	--
gal.)								
2,4,5-T amine Brushkiller	½	--	--	--	--	--	--	--
(4.0 lbs. ethyl amine	1	--	--	--	--	--	--	5
per gal.)	2	--	--	--	--	--	--	--
JUNE 5 to 10								
Diesel oil only							0	
2,4-D ester Weedkiller	½	12	45	25	16	65	26	15
(3.5 lbs. isopropyl ester	1	17	35	41	12	69	37	29
per gal.)	2	40	58	41	32	60	74	43
2,4,5-T ester Brushkiller	½	27	49	59	--	68	52	--
(2.66 lbs. isopropyl and	1	53	65	52	66	88	81	--
0.67 lb. amyl ester per	2	51	90	71	--	94	85	--
gal.)								
2,4,5-T amine Brushkiller	½	--	--	--	--	--	--	0
(4.0 lbs. ethyl amine	1	--	--	--	--	--	--	7
per gal.)	2	--	--	--	--	--	--	21
JUNE 25								
Diesel oil only							0	
2,4-D ester Weedkiller	½	10	16	8	--	8	20	--
(3.5 lbs. isopropyl ester	1	42	34	42	12	55	27	--
per gal.)	2	50	39	45	--	66	56	--
2,4,5-T ester Brushkiller	½	--	--	--	--	--	--	--
(2.66 lbs. isopropyl and	1	3	51	49	--	62	76	--
0.67 lb. amyl ester	2	--	--	--	--	--	--	--
per gal.)								
2,4,5-T amine Brushkiller	½	--	--	--	--	--	--	--
(4.0 lbs. ethyl amine	1	--	--	--	--	--	--	35
per gal.)	2	--	--	--	--	--	--	--

Table 2.--Percent of big sagebrush plants killed by ground spraying on two dates in 1950 with the low-volatile esters of 2,4-D and 2,4,5-T, the dinitro weed killers, and maleic hydrazide.

DATE AND CHEMICAL	POUNDS ACID PER ACRE	PERCENT KILL BY TYPE — Gallons of carrier per acre: Water 5	Water 25	Oil 5	Emulsion 4 water-1 oil
MAY 15					
Maleic hydrazide (2.4 lbs. diethanolamine salt per gal.)	2.4	-	2	-	-
	4.8	-	2	-	-
JUNE 5 to 10					
Brushkiller #32 (2.0 lbs. butoxy ethanol ester per gal. 2/3 lb. 2,4,5-T and 1-1/3 lb. 2,4-D)	1	-	-	24	-
	2	-	-	24	-
ACP 926 (same chemicals as Brushkiller #32)	1	-	-	9	-
	2	-	-	12	-
ACP 903 (3.0 lbs. butoxy ethanol ester of 2,4-D per gal.)	1	-	-	4	-
	2	-	-	6	-
H 10 10 (4.0 lbs. propylene glycol butyl ether ester of 2,4-D per gal.)	1	-	-	20	-
	2	-	-	41	-
Esteron 245 (4.0 lbs. propylene glycol butyl ether ester of 2,4,5-T per gal.)	1	-	-	47	-
	2	-	-	77	-
Esteron Brushkiller (4.0 lbs. propylene glycol butyl ether ester per gal. - 2.0 lbs. 2,4,5-T and 2.0 lbs. 2,4-D)	1	-	-	64	-
	2	-	-	89	-
General Weedkiller (5.0 lbs. dinitro-o-sec-butylphenol per gal.)	3	-	-	-	2
	6	-	-	-	5
Contact Weedkiller (approx. 0.6 lb. dinitro-sec-butyl-phenol and 7.3 lbs. petroleum oil per gal.)	3/8	0	-	-	-
	3/4	2	-	-	-
Maleic hydrazide (2.4 lbs. diethanol amine salt per gal.)	2.4	-	0	-	-
	4.8	-	0	-	-

Date of treatment

Although some variations occurred, highest sagebrush kills were, for the most part, obtained by spraying during the period June 5 to 10. Average sagebrush kills based on all trials with the 1- and 2-pound per acre rates of 2,4-D were 27 percent on May 15, 43 percent on June 5 to 10, and 40 percent on June 25. Corresponding kills with 1 pound of 2,4,5-T per acre averaged 57, 68, and 48 percent, respectively. In general, the results indicate that 2,4,5-T may be effective earlier in the season and maintain its effectiveness just as long as does 2,4-D.

The period of maximum susceptibility of big sagebrush to herbicides has been a major consideration in these studies. All the factors which influence the reaction of plants to organic herbicides are not yet known. For this reason, study on predicting the proper treatment date has been a matter of trial and error. Cornelius and Graham (1) reported that big sagebrush in northern California was most susceptible to 2,4-D when about 7 inches or half of the annual twig growth had been attained. They concluded from their studies that the period of most active twig growth is also the period of maximum susceptibility to selective herbicides. In the Beaver Rim area, total annual twig growth is often less than 3 inches. Furthermore, extreme variation in annual twig growth has been noted between different sites, between plants, and between years. Consequently, the "half-growth" stage could not be reliably determined nor was any other method devised whereby length of new twigs provided an accurate indicator of proper treatment time. An alternative was to use associated vegetation for an index, reasoning that the relative plant development would be the same. Treatments made just prior to or during the early bloom stage of the native bluegrasses gave the highest sagebrush kills. The native wheatgrasses were largely still in the vegetative stage at this time -- an occasional plant being in the early boot stage.

Chemicals

Considering all treatments (table 1) the isopropyl and amyl esters of 2,4,5-T gave consistently highest kills for a given amount of chemical. One pound acid equivalent of 2,4,5-T usually gave somewhat higher kills than 2 pounds acid equivalent per acre of 2,4-D. Table 3 illustrates the comparative performance of commercial ester formulations of 2,4-D and 2,4,5-T where the factors of spraying date and type and rate of carrier were constant. Both 2,4,5-T and mixtures of 2,4,5-T and 2,4-D gave higher kills than did 2,4-D alone. The isopropyl ester formulations were more effective than the propylene glycol butyl ether or the butoxy ethanol esters.

The reason for lower kills with the "low-volatile" propylene glycol butyl ether and butoxy ethanol esters was not readily apparent but can possibly be attributed to rain in the experimental area following treatment. These compounds are more water soluble than the isopropyl esters and this property, though promoting mixing when using water as a carrier, could result in some of the material being washed off the plants in event of rain following treatment. The low-volatile esters do have an advantage

Table 3.--Percent of sagebrush plants killed by different commercial ester formulations of 2,4-D and 2,4,5-T[1/]

Chemical	Pounds of chemical (acid equivalent) per acre		
	½	1	2
	% kill	% kill	% kill
2,4-D			
Isopropyl ester	26	37	74
Propylene glycol butyl ether ester	--	20	41
Butoxy ethanol ester	--	4	6
2,4,5-T			
Isopropyl and amyl ester	52	81	85
Propylene glycol butyl ether ester	--	47	77
2,4-D and 2,4,5-T mixture			
Propylene glycol butyl ether ester (1:1) [2/]	--	64	89
Butoxy ethanol ester (2:1)[2/]	--	16	18

1/ In 5 gallons of diesel oil per acre during the period June 5 to 10.
2/ Ratio of 2,4-D to 2,4,5-T in the mixture.

in that they may be used in agricultural areas with little danger of drift and damage to susceptible crops. For this reason and because they have been used successfully for control of many plants, consumer demand and accordingly manufacture, may swing to more low-volatile and less of the isopropyl and amyl esters. In view of this, it seems desirable to continue study with low-volatile esters in big sagebrush and try to establish more definitely their limits of application with regard to weather or other conditions.

During the optimum period the ethyl amine of 2,4,5-T was even less effective than the esters of 2,4-D. Amines of 2,4-D and sodium salts of the compounds have not been tested at Beaver Rim. Maleic hydrazide and the dinitro weed killers had little herbicidal effect on big sagebrush in these studies. It should be pointed out that the herbicidal properties of the dinitro compounds are somewhat different in that they affect only the area of initial contact whereas 2,4-D and 2,4,5-T are assumed to move into the plant and have a so-called growth-regulating effect. The dinitro compounds were sprayed only during the susceptible period for 2,4-D and 2,4,5-T. This may or may not be the most effective time to treat big sagebrush with chemicals which have a different type of herbicidal action.

Costs

The studies provide a comparison of chemical costs for a given percent sagebrush kill although they do not show the degree of kill which will provide the maximum return on the spraying investment. For example, about 2 pounds acid equivalent per acre of 2,4-D isopropyl ester was required for a 75-percent brush kill. At current jobber prices, this would mean investing about $3.00 per acre in chemical. A slightly higher kill --

81 to 88 percent (table 1) -- was obtained in these studies using 1 pound of 2,4,5-T isopropyl ester. Here again, cost of chemical was approximately $3.00 per acre. The 2,4-D and 2,4,5-T mixture may prove to be the least costly for any desired sagebrush kill. One pound of low-volatile ester of the mixture gave a kill of 64 percent at a cost of only $2.50 per acre for chemical. Since isopropyl esters of 2,4-D and 2,4,5-T when used alone gave higher kills than the corresponding low-volatile esters, a mixture of 2,4-D and 2,4,5-T in the isopropyl ester form may also be superior. These comparisons will be made in the 1952 studies.

Carriers

Compounds used as carriers or diluents serve one major function: To dilute the herbicide so that the spraying equipment can disperse it efficiently and accordingly achieve maximum coverage of the plant being treated. As shown in table 4, highest average sagebrush kills were obtained on all dates when diesel oil was used as a carrier. Although a 90-percent kill was obtained with 2 pounds of 2,4,5-T in 5 gallons of water per acre during the optimum period (table 1) the majority of the higher kills were with oil and in no case did results with 3 gallons of water per acre compare favorably to 3 gallons of oil.

Table 4.--Comparison of the average of all rates of carriers on three spraying dates using isopropyl esters of 2,4-D and 2,4,5-T.

Chemical	Pounds acid equiv. per acre	Average percent of sagebrush plants killed								
		Carrier			Carrier			Carrier		
		Oil	Water	Emuls.	Oil	Water	Emuls.	Oil	Water	Emuls.
2,4-D	1 and 2	40	23	7	60	35	42	51	38	16
2,4,5-T	1	67	50	-	85	59	--	68	50	--

There was no obvious reason why 3 gallons of oil per acre gave better results than 5 gallons of oil in several instances. These unexpected reactions seem to occur frequently in chemical plant control and may be a product of any one or a number of factors such as wind-drift, clogged nozzles, or lower sensitivity in some plants of a species than in others. The water-oil emulsions were used only in a few tests but do show some promise.

Although oil gave best results in these studies, water should not be excluded as a carrier where it is available in large amounts. In many big sagebrush areas, however, ample supplies of clean water are relatively infrequent. The extra transportation involved as well as the need for more frequent stops to fill spraying equipment may more than offset the cost of 3 gallons of diesel oil per acre as compared to 5 or more gallons of water.

Soil moisture

In both 1949 (4) and 1950 treatments, highest sagebrush kills were obtained at the time of highest soil moisture in the upper 18 inches within the year of application (table 5).

Table 5.--Average soil moisture to a depth of 2 feet on three dates in 1950 and two dates in 1949.

Depth	Soil moisture in percent of dry weight				
	1949		1950		
	May 25*	June 15	May 15	June 5*	June 25
in.	%	%	%	%	%
0 - 6	15	14	18	22	9
6 -12	18	16	21	28	17
12 -18	19	18	27	28	18
18 -24	9	20	22	26	17

* Date of highest sagebrush kills

The range of soil moisture encountered in the studies has been very narrow and the results may be only coincidental. Soil moisture could, however, be expected to have at least an indirect effect on herbicide effectiveness since it is one of several factors that influence the growth condition of the sagebrush.

Relative susceptibility of different age classes

Kill within the individual age classes of big sagebrush was not sampled intensively. The available data do indicate that seedlings were less susceptible to both 2,4-D and 2,4,5-T on May 15 than were older plants. The reverse was true on June 25. During the June 5 to 10 period there was no apparent difference in the susceptibility of different age classes. In no case was the difference between chemicals confined to any particular age class.

Effect of herbicides on other vegetation

Small rabbitbrush showed definite resistance to the herbicide treatments which gave highest kills of big sagebrush. Many rabbitbrush plants were killed back to the root crown in the same year they were sprayed. The majority grew new shoots the following year and showed no evidence of permanent damage. The data indicate that rabbitbrush is somewhat more susceptible to 2,4-D than to 2,4,5-T. The highest top and root kill, up to 50 percent of the plants, was with 2,4-D treatments made June 25, indicating also that rabbitbrush may be more susceptible later in the season than is big sagebrush.

Spineless horsebrush was not injured by any of the herbicide treatments. Phlox was usually damaged and often killed by both 2,4-D and 2,4,5-T in openings where it was not protected by the sagebrush foliage.

Spraying equipment

Airplane and ground-spraying equipment have so far given very similar results. In the June 25 treatments, where there was direct comparison, the airplane spraying gave an average sagebrush kill of 33.7 percent. The same treatments with the tractor equipment gave an average sagebrush kill of 34.5 percent. No aerial sprayings were made in the June 5 to 10 period when kills were higher.

The airplane equipment is noticeably freer from clogged nozzles than the tractor equipment because of the larger nozzle openings necessary for any given rate of application per acre at the airplane's higher speed. Where large areas are to be sprayed, lower cost of application is another distinct advantage of using the airplane equipment.

Grass production increases from sagebrush control

Grass production may be increased two to three times by chemical control of big sagebrush in the Beaver Rim area (table 6; figs. 3 and 4). These increases are, to some degree, proportional to the percent of sagebrush plants killed. A fair grass stand was, of course, present before treatment, else the increased production would not have occurred.

Table 6.--Average air-dry herbage production of perennial grasses in 1951 on experimental sagebrush-control plots sprayed in 1949.

Species	Average sagebrush kills				
	Untreated	58%	66%	78%	97%
	Lbs/A	Lbs/A	Lbs/A	Lbs/A	Lbs/A
Total grass	222	490	553	559	645
Thickspike and streambank wheatgrasses	189	318	420	449	493
Bunchgrasses (all)	33	172	133	110	152

Thickspike and streambank wheatgrasses are the most abundant grasses in the study area and accordingly produced the greatest amount of air-dry herbage. These species reproduce largely by means of underground rootstalks or rhizomes (3). They rapidly formed an open sod in the openings following sagebrush kill. Bluegrasses, bluebunch wheatgrass, and needle-and-thread are the principal bunchgrasses. The increased production of these species probably followed an increase in vigor of the original plants rather than the establishment of new plants from seed.

Figure 3.--Typical unsprayed area on Beaver Rim. The suppressed grass produces only about 222 pounds of air-dry herbage per acre.

Figure 4.--On this area 97 percent of the sagebrush plants were killed by spraying in 1949. Air-dry grass production in 1951 was 645 pounds per acre.

Cautions to observe in sagebrush control

The concentrations of cattle on the sprayed plots was probably due only to the increased supply of available forage. On July 25 the grasses in the sprayed plots had been grazed nearly twice as heavily as those in the unsprayed check plots. This suggests that some provision should be made in the sagebrush-spraying program to control grazing where only a small part of the range can be sprayed in any 1 year as may often be the case. Concentration of cattle on sprayed areas may result in damage to the non-shrubby species and encourage a reinvasion of the sagebrush or other undesirable plants.

Herbicides should be used with caution where palatable browse or broadleaved herbaceous plants grow in association with the sagebrush and produce substantial amounts of feed. Although not encountered in these studies, many desirable as well as undesirable plants are susceptible to 2,4-D and 2,4,5-T. A list of desirable plants that are sensitive to these herbicides can usually be obtained from local State or Federal weed-control workers.

SUMMARY

Valuable forage plants on many Wyoming ranges are being suppressed and held in low productivity by dominant stands of big sagebrush. Under these conditions range improvement often can be accomplished merely by controlling the brush. Organic herbicides show promise as an improved tool for reducing sagebrush competition.

Studies in the Beaver Rim area near Lander, Wyoming, reveal that 75 percent and higher kills of big sagebrush can be obtained with as little as 1 pound of 2,4,5-T ester per acre, or 2 pounds of 2,4-D ester per acre. These herbicides were most effective in this area when applied in 3 to 5 gallons of diesel oil carrier about the time the native bluegrasses started blooming. Herbicide treatments which gave best control of big sagebrush did not result in severe damage to other shrubby species or to perennial grasses.

So far, airplane- and ground-spraying equipment have given similar results. The airplane equipment is cheaper and more may be accomplished when spraying large areas.

Native grass production was increased from two to three times by killing from 60 to 97 percent of the sagebrush. The increased forage supply apparently attracted concentrations of cattle and the forage species on sprayed areas were utilized almost double the amount that they were on unsprayed areas. This suggests that grazing should be controlled following sagebrush spraying to avoid damage to the desirable plants.

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