Selective Herbicides for Improving California Forest Ranges

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THIS paper reports some preliminary tests with selective herbicides for control of weeds and brush on forest ranges in northeastern California. The results are encouraging. Herbicides were sprayed on depleted range areas dominated by big sagebrush (*Artemisia tridentata*), black sagebrush (*A. arbuscula*), silver sagebrush (*A. cana*), green manzanita (*Arctostaphylos patula*), and buttercup (*Ranunculus alismaefolius* and *R. occidentalis*). Control of undesirable plants was most successful on areas with big sagebrush and buttercup, where the spraying accelerated growth of bunchgrasses by two to four times. Spraying also showed promise as a relatively inexpensive method of site preparation in advance of seeding.

Kind of Range Land Treated

The areas selected for experimental spraying were representative of the meadow and sagebrush grazing types, and of manzanita brushfields that have replaced or occur in the open timber type in some localities; all were in the pine forest zone at an elevation of about 5600 feet, on the Lassen National Forest.

Meadow.—Semi-wet meadows on the floors of mountain valleys are key grazing areas because they have relatively level topography, desirable plants for grazing, and watering places for livestock. Most meadows have drainage channels, but as the gradient is usually slight, the soil remains moist until mid-summer or longer. Many meadows, however, have deteriorated. Native grasses of high forage value have decreased and unpalatable species increased; buttercup and other weeds now dominate the cover. If a suitable plant cover could be established, forage production from these meadows could be materially increased.

Sagebrush.—Silver sagebrush dominates some of the land next to the meadows. These areas may be under water from 3 to 10 weeks after snow melts because surface drainage is slight and the soil has such heavy texture that seepage is very slow. By mid-summer the areas become dry and the soil cracks. Little soil moisture is available for plant growth in late summer, and a droughty condition prevails in autumn.

Big sagebrush thrives on the well-drained slopes where the soil is deep and porous, and black sagebrush grows on the slopes or flats below the big sagebrush where the soil is heavier and has less depth.

The three species vary in growth habit and resistance to control. Big sagebrush on the study areas was from 2 feet to 3.5 feet high, being at least twice the height of silver sagebrush. Big sagebrush plants usually have single stems that are brittle and non-sprouting. Silver sagebrush plants have several small, willowy stems which sprout freely following damage to the top. Black sagebrush is smaller than big sagebrush but similar in growth form

[1] Maintained by the Forest Service, U. S. Dept. of Agriculture, at Berkeley, in cooperation with the University of California. The Sherwin-Williams Company furnished the chemicals used.

and in control by herbicides, therefore results are discussed only for big sagebrush and silver sagebrush.

Manzanita brush.—Green manzanita is found in the ponderosa and Jeffrey pine forest on slopes above the meadows. This shrub often dominates local areas of these sites to the exclusion of both timber reproduction and livestock forage. On the experimental areas manzanita had a crown density of 48 percent.

Improvement of Mountain Meadows by Spraying

Procedure.—The semi-wet meadow selected for the test was fenced 13 years ago, and has been grazed only lightly and intermittently since then. Some recovery could be noticed inside the protected area, which had a thicker sod and more vigorous plants than the surrounding area, but weedy species such as buttercup were still dominant. On June 26, 1948, when buttercup was in full flower, two plots were sprayed at the rate of 3.3 pounds of the butyl ester of 2,4-D in 10 gallons of diesel oil per acre. The area was sprayed by use of a 10-foot boom and sprayer mounted on a pickup truck bed. This combination could easily be used on large-scale operations. Actual kill of the plants was determined in the summer of 1949.

Change in vegetative composition.—Spraying greatly diminished the amount of buttercup and aster (*Aster foliaceous*). Other weedy herbaceous species occurring in the meadow included knotweed (*Polygonum bistortoides*), camassia (*Camassia quamash*), and cinquefoil (*Potentilla gracilis*). Results for these three species were inconclusive. The undesirable grasslike plants, coarse rush (*Juncus balticus*) and sedge (*Carex douglasii*), decreased in amount on the sprayed plots (Table 1).

Grasses increased in density as the competing weedy herbaceous plants died out. Nevada bluegrass (*Poa nevadensis*), spike redtop (*Agrostis exserata*), mat muhly (*Muhlenbergia squarrosa*), and California oatgrass (*Danthonia californica*), were the most numerous grasses of the meadow. Tufted hairgrass (*Deschampsia caespitosa*), and nodding barley (*Hordeum nodosum*) were present in lesser amount but were conspicuous because of their size.

TABLE 1

Basal density of three classes of meadow vegetation on sprayed and unsprayed plots

Class of vegetation	Percentage basal area	
	Sprayed plots	Unsprayed plots
Grass	6.55	4.88
Grasslike	1.17	3.76
Weeds	.41	3.19
Total	8.13	11.83

Nevada bluegrass made the greatest increase in spread of any grass on sprayed plots. An increase of 155 percent was found to have occurred 14 months after the spray was applied. The increase in basal density of grasses did not equal the decrease in area formerly occupied by herbaceous weeds. Consequently, the basal area for all vegetation was less on sprayed than on unsprayed plots.

Influence on seed and forage production.—The desirable native grasses produced seed much more abundantly on the sprayed than on unsprayed plots. Seventeen seed stalks of the principal grasses developed per square foot of sprayed meadow. Unsprayed plots averaged only 0.5 seed stalk per square foot. The height of seed stalks averaged 13 inches on sprayed and 9 inches on unsprayed plots.

Upon control of the competition from undesirable weeds, the Nevada bluegrass and other native grasses produced more than four times as much dry weight as

the same grasses gave on the unsprayed plot (Table 2). Total production was not significantly different for sprayed versus unsprayed plots when weedy species were included.

TABLE 2

Yield in 1949 on sprayed and unsprayed meadow plots

SPECIES GROUP	SPRAYED	UNSPRAYED
	lbs. per acre	*lbs. per acre*
Grass	1028	242
Herbaceous weeds	9	488
Grasslike (rushes-sedges)	8	350
Total	1045	1080

Improvement of Sagebrush Range by Spraying

Procedure.—Sagebrush had been shown to be susceptible to the sodium salt of 2,4-D in 1946 and 1947. From 5 to 16 pounds of acid equivalent of 2,4-D in 1600 gallons of water per acre were used in these early tests. In 1948 an attempt was made to develop a procedure that would be practical for range improvement uses. Different amounts of the butyl ester of 2,4-D were applied with 20 gallons of water per acre as a carrier. Spraying was done with the truck-mounted boom and sprayer.

Susceptibility of sagebrush.—Big sagebrush proved highly susceptible or hypersensitive to 2,4-D (Table 3). A satisfactory kill of big sagebrush was attained by applying 1 pound of the butyl ester per acre in late June. Higher rates per acre gave a slightly higher percentage kill but not enough higher to warrant the greater expense. Increasing the rate of application above 5 pounds per acre did not significantly increase or decrease the percentage kill of either species of sagebrush.

Untreated big sagebrush grew actively from May 1 to August 1 in 1948. When the spray was applied (June 30), 7 inches of new twig growth had been produced, approximately half of the vegetative growth for the year. All twig growth on unsprayed big sagebrush ceased after August 15, having attained a maximum length of 12 inches. The peak of flowering for big sagebrush occurred about September 15. Black sagebrush had approximately the same period of active growth but the peak of flowering came one month earlier. From the results shown in Table 3 and from observation of adjacent plots sprayed at monthly intervals during the summer of 1949, we conclude that the best time to spray is during the period of most active growth. This period was between May 15 and June 30 in 1948. If allowance is made for the lateness of plant development in 1948, the average period of most active growth may be expected between May 1 and June 10.

TABLE 3

Kill of two species of sagebrush sprayed with butyl ester of 2,4-D

TIME AND RATE OF TREATMENT	BIG SAGEBRUSH		SILVER SAGEBRUSH	
	Plants killed	Crown area killed	Plants killed	Crown area killed
	pct.	*pct.*	*pct.*	*pct.*
June 30, 1948				
1 lb. per acre	85	95	4	18
5 lbs. per acre	100	100	29	66
10 lbs. per acre	94	96	26	71
July 30, 1948				
1 lb. per acre	81	95	30	89
5 lbs. per acre	92	99	51	97

Silver sagebrush was much less effectively controlled than big sagebrush. Considerable sprouting occurred from the silver sagebrush stems. A fairly high kill of crown area resulted from the late July application. Silver sagebrush produced

vegetative growth from June 1 to September 1 in 1948, and the peak of flowering came September 10. The period of most active growth for silver sagebrush comes approximately one month later than for big sagebrush. The influence of this later period of active growth upon susceptibility of the plant to 2,4-D is shown in Table 3; July 30 application gave higher percentage kill than the June 30 application.

Growth of bunchgrass.—In the depleted condition of the sagebrush range, grass plants produced very little forage. Upon control of the undesirable competition from big sagebrush, the bunchgrass responded remarkably well (Fig. 1).

sprayed plots averaged 2.5 times the yield that the same grasses produced from unsprayed plots (Table 4).

TABLE 4

Production of bunchgrass in 1949 as influenced by 1948 spraying with 2,4-D to kill big sagebrush

KIND OF FORAGE GRASS	SPRAYED PLOTS	UNSPRAYED PLOTS
	Weight of 25 plants in grams	
Idaho fescue	308	143
Western stipa	202	63
Sitanion	229	27
	Total dry weight in lbs. per acre	
All three grasses	642	285

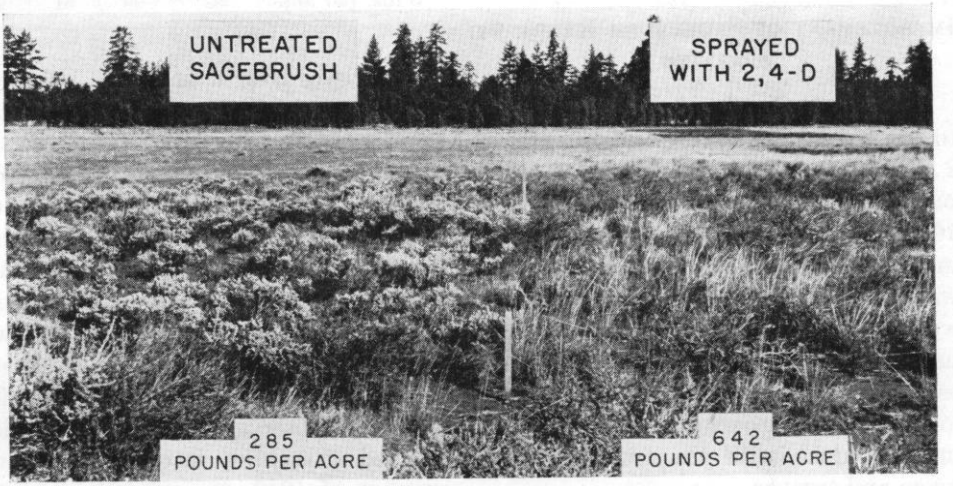

FIG. 1. Spraying sagebrush range with 2,4-D killed big sagebrush plants and released the grasses, more than doubling their yield.

On the big sagebrush area the three principal native grasses were Idaho fescue (*Festuca idahoensis*), western stipa (*Stipa occidentalis*), and sitanion (*Sitanion hystrix*). These grasses averaged 9.6 seed stalks per plant on sprayed and 2.7 on unsprayed plots. Height of seed stalks averaged 16.3 and 12.6 inches, respectively. The production of forage from

Cheatgrass (*Bromus tectorum*) was not abundant on the ranges used in this study. Consequently, the results do not show how native grasses will recover in competition with a thick stand of cheatgrass.

Spraying alone may prove to be of great value in improving sagebrush ranges with a good understory of desirable grasses. However, on most depleted ranges

reseeding by drilling forage species after the spray treatment will be advantageous to speed the recovery. Also, the range manager will need to provide proper grazing management to enable the released grasses and reseeded species to quickly dominate the area opened by killing the sagebrush.

Reaction of Manzanita to Spraying

Procedure—Manzanita brush was sprayed with 2,4-D and 2,4,5-T in late July 1948. The manzanita was beginning to flower and twigs and leaves were growing actively. Because of the rough topography and heavy brush, the truck was parked and the spray applied through a 200-foot hose with a single orifice nozzle. For complete coverage of the manzanita foliage, 10 gallons of diesel oil per acre served as the carrier for the 2,4-D and 20 gallons of water per acre for the 2,4,5-T.

Results.—Top growth of manzanita was killed by 2,4-D and by 2,4,5-T. However, sprouts appeared from the burls at the base of the plants: 100 percent of the plants sprayed with 3.4 pounds of the butyl ester of 2,4,5-T per acre, and 89 percent on those receiving 6.7 pounds of the butyl ester of 2,4-D per acre. Spraying did not control the brush well enough to warrant large-scale use to increase forage production. The fact that top growth was killed by both chemicals and some plants were killed by 2,4-D shows manzanita is susceptible to selective herbicides.

Natural Seeding on Sprayed Areas

Seedlings of native forage plants were not found in 1949 on any of the sprayed areas, even though the season of 1948 presented exceptionally favorable conditions for native grasses to produce seed on the ranges in northeastern California. The experimental areas were not grazed in either year, another condition favoring production of seed.

Observations on other experimental areas of depleted range in the vicinity of the sprayed areas show that natural thickening of the native bunchgrasses is extremely slow. Thickening occurs primarily by tillering of the plants. New seedlings contribute very little toward increasing the density of the forage cover even under total protection from grazing for several years. Therefore, artificial revegetation may be required to obtain recovery of much of the depleted meadow and sagebrush range in a reasonable length of time.

Reseeding on Sprayed Areas

That herbicides may be useful in revegetation projects was shown by early results from reseeding trials on sprayed areas. Plots were prepared adjacent to the sprayed plots by plowing and discing. A mixture of forage species including smooth bromegrass (*Bromus inermis*), crested wheatgrass (*Agropyron cristatum*), timothy (*Phleum pratense*), western wheatgrass (*Agropyron smithii*), alfalfa (*Medicago sativa*), and birdsfoot trefoil (*Lotus corniculatus*) was drilled across the sprayed and the plowed plots in sagebrush and in meadow. As of September 1949, the number of seedlings established per square foot was:

	Autumn 1948 sowing	*Spring 1949 sowing*
Big sagebrush		
Sprayed with 2,4-D and drilled	8.8	6.2
Plowed and drilled	10.2	5.0
Meadow		
Sprayed with 2,4-D and drilled	10.4	0.0
Plowed and drilled	11.6	2.8

A few more seedlings per square foot were obtained on plowed plots than on sprayed, but the difference is not signifi-

cant. Plowing destroyed all of the native grasses. Spraying did not destroy any of the grasses, but discing and drilling reduced the density by approximately one-half. Nevertheless, there remained on the sprayed plots an average of 0.5 to 1.0 native grass plants per square foot on the sagebrush type. On the sprayed meadow remaining native grass plants averaged 1.8 per square foot with autumn discing and drilling and 5.2 plants per square foot with spring discing and drilling.

Autumn sowing, which produced a satisfactory stand on all plots, proved significantly better than spring sowing. Spring seedbed preparation and planting were especially unsatisfactory on the meadow. The meadow remained wet and equipment could not be efficiently operated at the time spring seeding should be done.

Spraying has some distinct advantages over plowing. Some areas that are too rocky to be plowed can be sprayed. Where soil erosion presents a hazard, spraying is better conservation practice, since it leaves much of the protective cover intact and does not destroy soil structure. Also, the method promises some economies in reseeding.

Need for Additional Information and Precaution

Greater efficiency and more consistent results may be expected from further study of selective herbicides. The various chemicals and methods for their use seem almost innumerable and will require many years for full study and evaluation. Meanwhile a few precautions in their use should be remembered.

Some desirable native legumes and browse plants are susceptible to the herbicides now in use. Where these desirable plants occur the range manager will need to decide whether control of the undesirable brush and weeds will be worth more than the loss of desirable plants. Also, some agricultural crops are susceptible to 2,4-D and care must be taken to avoid drift of spray materials if such crops are growing near the range to be treated.

There has been some indication, on other kinds of sagebrush, that below-normal precipitation may decrease the effectiveness of 2,4-D. The spraying for the experiment reported on in this paper was done in a year of above-normal precipitation. Some large-scale projects aimed at control of big sagebrush by use of 2,4-D applied by airplane have been reported as a failure. The details of the projects have not been published, but the failure is mentioned here as a warning that not all spraying with the chemicals has been successful.

Summary

The butyl ester of 2,4-D was sprayed on mountain meadow, big sagebrush, silver sagebrush, and manzanita brush ranges in northeastern California. Buttercup and some other meadow weeds were satisfactorily killed. Big sagebrush proved highly susceptible, the kill being 85 percent. On silver sagebrush and green manzanita, sprouting occurred so control of these two species cannot be considered satisfactory although much of the crown was killed. Grasses in the meadow and big sagebrush range exhibited greatly accelerated growth as a result of spraying to control the competing weeds and brush.

Spraying with selective herbicides offers a method of eradicating undesirable vegetation less expensive than plowing. Spraying may be used on areas too rocky or rough for plowing. Spraying keeps the erosion hazard at a minimum because much of the vegetative cover and soil structure remains intact.

A satisfactory emergence of desirable forage grasses and legumes resulted from autumn seeding with a grain drill on sprayed sagebrush range and meadow.