Sagebrush Control with 2,4-D

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Sagebrush covers about 95 million acres of rangeland in the western United States. In northeastern California alone, 5 million acres are in this vegetative type, largely dominated by one of three species: big sagebrush *(Artemisia tridentata)*, black sagebrush *(A. arbuscula)*, or silver sagebrush *(A. cana)*. These three kinds of sagebrush have very low palatability for livestock on this rangeland, which is valued for summer grazing. The sagebrush competes strongly with forage plants, thereby reducing forage production and grazing capacity of the range. Field scale experiments conducted from 1946 to 1954 have shown that sagebrush is effectively controlled by use of selective herbicides.

All three species of sagebrush proved highly susceptible to 2,4-D (2,4 dichlorophenoxyacetic acid). The best spray solution was 2 pounds acid equivalent butyl ester of 2,4-D in an oil-water emulsion at 10 gallons per acre. Spraying was most effective when new twigs were 3 to 4 inches in length—between late May and mid-June on the areas selected for the experiments. Airplane, helicopter, and ground-rig spraying gave highly satisfactory kill of sagebrush if care was taken to obtain complete coverage of the foliage at the optimum growth stage with the recommended spray material.

[1] *Maintained at Berkeley, California by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California.*

Previous Tests and Chemicals

The earliest spraying of sagebrush with hormone sprays in northeastern California was conducted in 1946 by R. K. Blanchard in fire control research and A. L. Hormay in range-management research, both of the California Forest and Range Experiment Station. Heavy rates of application were employed; the sodium salt of 2,4-D was applied at rates of 12.5, 25.0 and 37.5 pounds acid equivalent in 1,600 gallons of water per acre. The important finding from these early experiments was that sagebrush was susceptible to 2,4-D, and the results pointed to the desirability of developing practical field methods to use in chemical control of sagebrush.

Control of big sagebrush by use of chemicals has been reported by other workers, including Hyder (1954) in eastern Oregon, Hull and Vaughn (1951) and Bohmont (1954) in Wyoming, and Hervey (1951) in Colorado. Their findings are in close accord with the results reported in this paper.

Methods and Results of Field-scale Spraying

To determine the best time to apply hormone sprays, a series of large plots was sprayed at monthly intervals beginning in May 1949. A motor-driven sprayer, which was placed in the bed of a pickup truck, and a 20-foot boom were used. The work was centered on the Lassen National Forest at an elevation of 5,600 feet. In this area most of the precipitation comes as snow in the winter. The soil was well supplied with moisture after snow melted in April and on through May. As the temperature climbed during this period, conditions became favorable for rapid vegetative growth.

The highest percentage kill of sagebrush was obtained from spraying in May and June (Table 1), when the new twig growth was in early stages of development. The optimum stage for spraying came when 3 to 4

Table 1. Control of sagebrush sprayed in 1949 with 1 pound of butyl ester of 2,4-D per acre at monthly intervals and with 2 pounds in June.

Type of sagebrush	Sagebrush kill, when date and rate of spraying were—			
	May 20	June 20		July 20
	1 lb.	1 lb.	2 lbs.	1 lb.
	Percent			
Big sagebrush	77	75	98	60
Black sagebrush	92	89	94	35
Silver sagebrush	70	81	96	38

inches of new twig growth had been produced. During the course of these studies, this stage occurred between May 20 and June 15, varying from year to year.

The three species of sagebrush did not differ significantly in susceptibility to 2,4-D when sprayed at the optimum time and rate—in June with 2 pounds of the butyl ester (Table 1). In another test, solution was applied by airplane at the same growth stage and gave big sagebrush kill of 100 percent; black sagebrush, 98.3 percent; and silver sagebrush, 98.8 percent. Big sagebrush was more susceptible than black or silver sagebrush when sprayed in July (Table 1). Black sagebrush proved more susceptible than big sagebrush in May, and at the 1-pound rate of 2,4-D, in June.

Silver sagebrush was the only species that showed a tendency to sprout from the base after the tops had been killed by spray. This resprouting was not sufficient to present a serious problem of re-invasion.

Several formulations of 2,4-D were tested[2] during the years 1948 to 1954 (Table 2). Butyl ester of 2,4-D proved the most effective and economical of all forms used. The sodium salt, alkanolamine, and isopropyl ester forms did not give such consistently good results as the butyl ester. Two low volatile esters of 2,4-D—butoxy ethanol ester and propylene glycol butyl ether ester—were slightly more effective than the butyl ester but were not as economical, considering cost per pound in relation to percentage kill.

Where no susceptible agricultural crops grow near the sagebrush to be sprayed, the high volatile butyl ester is recommended. Where near-by crops may be injured by volatilization and drift of the selective herbicide, low volatile ester should be used. Comparisons of 2,4-D and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) revealed that the latter gave no higher kill of the sagebrush species than 2,4-D. Since the 2,4,5-T is more costly, it is not recommended.

The kind and rate of the carrier for the selective herbicidal sprays is important. The amount cannot be great or the cost of treatment will be too high; yet the gallonage per acre must be sufficient to give good coverage of all the foliage and to penetrate and permit movement of the selective herbicide in the plant. Adequate coverage for sagebrush control requires several small droplets for each leaf. Spray should cover at least 30 percent of the foliage area as described by Graham (1953). Nine gallons of water and ½ gallon of diesel oil per acre as an oil-water emulsion gave the best results. Addition of the selective herbicide at about ½-gallon

Table 2. Comparison of selective herbicides for control of sagebrush in experiments conducted during 1949, 1951, 1952, and 1953. Lassen National Forest, California.

Formulation	Rate acid equivalent per acre	Control of sagebrush
	Lbs.	*Percent*
	—1949—	
Butyl ester 2,4-D	2	96
Butyl ester 2,4-D	1	82
Butyl ester 2,4-,5-T	1	41
Butyl ester 2,4-D and 2,4,5-T mixed	2	83
	—1951—	
Butyl ester 2,4-D	2	99
Butoxy ethanol ester 2,4-D	2	99
Butyl ester 2,4,5-T	2	96
Butyl ester 2,4-D	1	83
Butoxy ethanol ester 2,4-D	1	97
Isopropyl ester 2,4-D	1	87
	—1952—	
Butyl ester 2,4-D	2	100
Butoxy ethanol ester 2,4-D	2	98
Alkanolamine 2,4-D	2	95
Isopropyl ester 2,4-D	2	82
Butoxy ethanol ester 2,4-D	1	87
	—1953—	
Butyl ester 2,4-D	1	81
Alkanolamine 2,4-D	1	75
Butoxy ethanol ester 2,4-D	1	94
Propylene glycol butyl ether ester 2,4-D	1	96
Propylene glycol butyl ether ester 2,4-D	2	100

[2] *Selective herbicides were furnished for testing by American Chemical Paint Company, Dow Chemical Company, and Thompson Chemicals Corporation.*

Table 3. Helicopter and ground sprayer results in controlling sagebrush: 1950 application, Lassen National Forest.

Method	Treatment				Kill of sagebrush
	Form of 2,4-D ester	Rate per acre: Acid equivalent	Rate per acre: Oil-water emulsion carrier	Speed of application	
		Lbs.	*Gal.*	*M.p.h.*	*Percent*
Air by helicopter	Butyl	2	10	30	92
	Butyl	1	10	30	76
	Butyl	1	5	30	44
	Butyl	1	5	60	24
	Butyl	1	2½	60	27
Ground by 10-foot boom sprayer	Butyl	1	10	4	96
	Isopropyl	1	10	4	65

makes a total volume of 10 gallons per acre.

Spraying by helicopter was tested in 1950 on 200 acres in the Lassen National Forest. As a part of this operation, the helicopter was used to apply different rates of active herbicide and of carrier per acre. These experimental applications were compared with others made at the same time by ground rig (Table 3). For aircraft application, the 2-pound rate of 2,4-D was superior to the 1-pound rate. Also, 10 gallons of carrier and 2,4-D per acre gave a higher percentage kill than either 5 or 2½ gallons per acre. Applying the same form and rate of 2,4-D by ground sprayer gave a better distribution of spray over the foliage, hence a higher percentage of kill than application by helicopter. Although the 1-pound rate gave high percentage kill when applied by ground sprayer in this test, through the years ground application at the 2-pound rate has proved more consistently effective.

An airplane was used in 1951 to spray more than 3,000 acres of sagebrush on the Lassen and Modoc National Forests. Also, a 200-acre area of sagebrush at 5,800-feet elevation was sprayed on Bureau of Land Management rangeland near Cedarville, California. Two pounds acid equivalent of butyl ester of 2,4-D was applied in 9½ gallons of oil-water emulsion per acre.

The airplane was highly satisfactory for spraying. Excellent coverage of the foliage was obtained on 90 percent of the total area sprayed on the Lassen National Forest at an elevation of 5,600 feet. Where this excellent coverage was obtained, 98.5 percent of the sagebrush was killed. Certain strips were inadequately covered with spray because winds shifted, or swaths were not properly aligned. Also, scattered pine trees occasionally obscured the pilot's view of flagmen, causing a few strips to be missed. The kill on this 10 percent of the area was only 11.8 percent and apparently resulted from spray drifting from adjacent strips. The airplane spraying for the entire area of 1,750 acres on the Lassen National Forest resulted in a sagebrush kill of 88.5 percent. The highest percentage kill, 99 percent, was obtained on the area sprayed in the south Warner Mountains of the Modoc National Forest, at an elevation of about 7,500 feet. Two species, big and silver sagebrush, were equally represented at this location. On the Bureau of Land Management rangeland, sprayed the same season with the same equipment and formulation, the mortality was 92 percent (Fig. 1).

Discussion

Spraying with selective herbicides for sagebrush control has the greatest application on rangeland with enough understory grass present to establish an adequate vegetative cover of palatable forage plants. This treatment provides a method of extending improvement practices into areas that have good soil but are too rocky, sandy, or steep for plowing and reseeding.

Where plowing is required for preparation of a seedbed, or

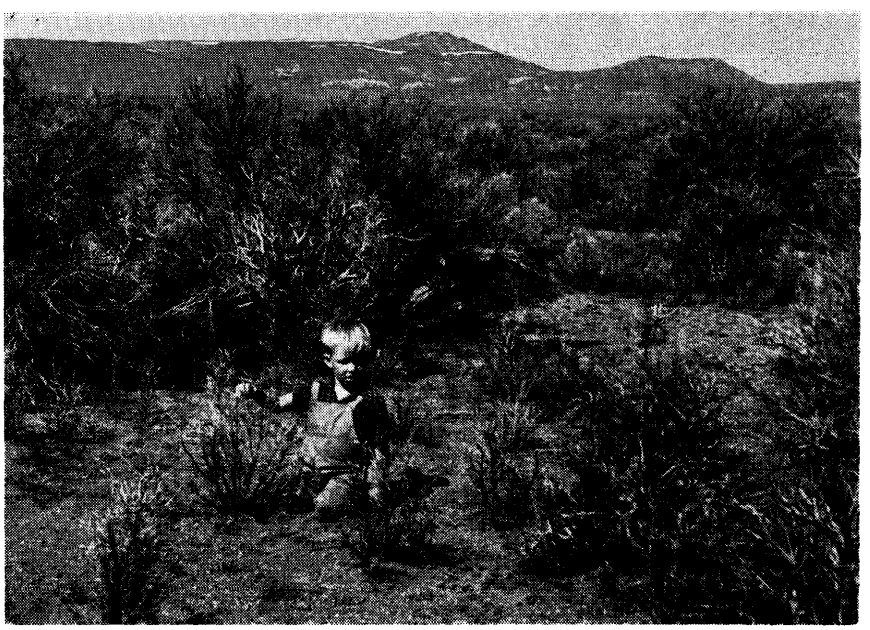

FIGURE 1. Big sagebrush killed by airplane spraying with 2,4-D, June 7, 1951, on Bureau of Land Management rangeland near Cedarville, Calif. Photographed June 17, 1952.

where burning is feasible, it may not be advisable to spray. If seeding of forage plants is required, greater forage production may be realized when the deteriorated rangeland can be plowed or burned. Burning requires a fairly dense brush and understory material for carrying the fire. Where sparseness or patchiness of growth occurs on sagebrush rangeland, then spraying will be superior to burning.

Any attempt to control sagebrush increases the importance of good grazing management. The more palatable plants must be allowed to increase and provide vegetative cover for control of erosion and improvement of the soil. Poor management and excessive grazing may cause greater deterioration of the soil than if the sagebrush cover were permitted to remain.

Summary

Three species of sagebrush (big, black, and silver sagebrush) occur on 5 million acres of rangeland in northeastern California and were found highly susceptible to 2,4-D. The best control was obtained with 2-pounds acid equivalent of butyl ester of 2,4-D in 9 gallons of water and one-half gallon diesel oil per acre. Sagebrush in active stage of growth with new twigs from 3 to 4 inches in length coming between late May and mid-June was more susceptible to spray than earlier or later stages of seasonal growth. Distribution of spray to all of the foliage was necessary for good kill and was accomplished by airplane, helicopter, and ground-rig sprayers.

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