Aerial Application of 2,4-D Plus Picloram for Green Rabbitbrush Control

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Highlight: *An aerially applied mixture of 2,4-D and picloram was more effective than 2,4-D alone in controlling green rabbitbrush and big sagebrush in a very droughty big sagebrush/desert needlegrass community. Herbage production had more than doubled by 5 years after the brush stand was reduced. Needleandthread was the only species to increase in density because of brush control, although considerable seed was produced from other perennial grasses. Modification of the seedbed environment is apparently necessary to establish additional desert needlegrass or Indian ricegrass plants.*

Our purposes were, first, to determine the effectiveness of aerial application of a mixture of 2,4-D [(2,4-dichlorophenoxy)acetic acid] and picloram (4-amino-3,5,6-trichloropicolinic acid) for control of green rabbitbrush (*Chrysothamnus viscidiflorus* subspecies *viscidiflorus*) and big sagebrush (*Artemisia tridentata*), and second, to compare post-treatment plant succession and herbage production to that on areas untreated or sprayed with 2,4-D alone.

Green rabbitbrush is relatively resistant to application of phenoxy herbicides (Hyder et al., 1962). The successful control of green rabbitbrush with 2,4-D depends on careful timing of application in relation to the stage of growth of the shrub and availability of soil moisture. During dry years in the

arid portions of the Great Basin, it is difficult to control rabbitbrush by applying 2,4-D.

Picloram is a much more effective herbicide than 2,4-D for control of green rabbitbrush (Cook et al., 1965; Tueller and Evans, 1969; Evans et al., 1973). Picloram does not control big sagebrush at the rates and timing necessary for control of green rabbitbrush. Tueller and Evans (1969) determined that a mixture of 2,4-D and picloram effectively controlled mixed stands of both species and extended the period when the herbicides could be applied.

In this investigation, we attempted to extend the previous knowledge of mixtures of 2,4-D and picloram for rabbitbrush control by a) applying the mixture aerially, b) applying the mixture to a plant community with species besides big sagebrush and green rabbitbrush, and c) applying the herbicide mixture in one of the most arid environments where green rabbitbrush occurs.

Methods

We selected, in 1968, a 10-hectare area at Medell Flat, which is about 35 km north of Reno, Nev. The area supports big sagebrush plant communities, which contain green rabbitbrush, hop sage (*Grayia spinosa*), green ephedra (*Ephedra viridis*), and a few clumps of desert peach (*Prunus andersonii*). The site was selected because it had, based on information available at the start of the experiment, a perennial grass-dominated understory with sufficient density (2.5 plants/m²) to make use of the environment potential released by controlling the shrubs (Young and Evans, 1974a).

The soils, physiographic position, and relation of the experimental area to other plant communities at Medell Flat are given in detail by Young and Evans (1974a).

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Herbicide Application

A helicopter was used to apply a mixture of 0.42 kg/ha of picloram + 2.5 kg/ha of 2,4-D in 47 liter/ha of water. At the time of herbicide application, the only picloram available in the quantities required was already mixed with 2,4-D as triethylamino salts. The low-volatile esters of 2,4-D are more effective than the amine for control of big sagebrush (Tueller and Evans, 1969). Therefore, the 2,4-D portion of the mixture consisted of 0.84 kg/ha of triethylamine salt and 1.64 kg/ha of low-volatile esters.

Herbicide was applied on May 16, 1968. At that time, the current year's shoot growth of green rabbitbrush had reached from 6.0 to 7.5 cm, and the leaves of desert peach plants were fully developed. The soil profile was dry to a depth of 45 cm. Total precipitation (16.4 cm) and spring precipitation (4.2 cm) were both low in 1967-68. The previous year (1966-67) had had exceptionally high precipitation (28.5 cm), and moisture remained available in the profile below the 45-cm level at the time of spraying.

Next to the experimental area, about 1,000 hectares were aerially sprayed during the same week with 3.36 kg/ha of low-volatile esters of 2,4-D in 28 liter/ha of oil.

Sampling

The 10-hectare experimental area was fenced separately. It was bordered on the west and north by the 1,000-ha area sprayed with 2,4-D. South of the enclosure was a separate pasture, continuously grazed, with no brush control. The eastern enclosure fence was part of the grazing allotment boundary. The adjacent area of the neighboring allotment had been very heavily grazed. We had available a) 10 ha treated with 2,4-D + picloram; b) 1,000 ha treated with 2,4-D; c) several thousand hectares without brush-control treatments, but which had been grazed under the same regime; and d) next to it, an extremely heavily grazed area.

We sampled each of the first three areas in 1968 through 1972 by: a) frequency sampling of herbaceous vegetation, following the procedures of Evans and Love (1957); b) density sampling of perennial grasses with 25 plots, one m² in area; c) density sampling of the woody vegetation with 10 plots 10 by 10 m; and d) clipping twenty 1-m² plots at peak herbage production. The adjacent allotment was sampled in 1972 to compare vegetation under heavy browsing of shrubs.

In 1973, we determined perennial-grass caryopsis production on 50 plots 4 m² in area, randomly located in the area previously treated with picloram and 2,4-D.

Results

Brush Control

The mixture of 2,4-D and picloram was more effective in killing green rabbitbrush than was 2,4-D alone (Table 1). The mixture was also more effective on the other shrub species present, except green ephedra. The relatively poor control of big sagebrush with 2,4-D alone is apparently a result of faulty

Fig. 1. 2,4-D + picloram treated pasture with native perennial grasses and green ephedra (top) compared with brush-infested control pasture (bottom). Meter stick located in the center of photographs is divided into decimeters.

application equipment and technique (Young and Evans, 1974a). In these communities, hop sage is a desirable browse species that is heavily used. Unfortunately, either 2,4-D or the mixture of 2,4-D and picloram completely eliminated this species.

Desert peach often increases on western Nevada ranges sprayed with 2,4-D (Young and Evans, 1974a). It has greatly increased in the area of this study sprayed with 2,4-D in 1968. Control of desert peach with 2,4-D and picloram was slightly better than that with 2,4-D alone, but still unsatisfactory. Desert peach has not assumed dominance in the enclosure treated with the mixture of picloram and 2,4-D, apparently because the initial stand density was very sparse before the 40% reduction resulting from the herbicide treatment (Table 1).

The only shrub remaining in the picloram-2,4-D pasture, of sufficient consequence to characterize the modified plant community, was green ephedra (Table 1). The stand of ephedra was reduced more by 2,4-D than by the mixture of 2,4-D + picloram. The 2,4-D alone, which was applied in oil, caused considerably more necrosis of the green leafless stems of green ephedra plants than did 2,4-D + picloram, which were applied in water. The green ephedra-dominated community is visually refreshing in a generally monochromatic vegetation dominated by sagebrush (Fig. 1). The value of green ephedra as a browse species in these communities is controversial. In the control pasture, it was difficult to detect any use of this

Table 1. Percent control of shrubs in 1969, 1 year after application of 2,4-D, alone or mixed with picloram, and species composition (%) based on cover before herbicides were applied.

Species	2,4-D		2,4-D + picloram		Control
	Species com- position	Control	Species com- position	Control	Species com- position
Green rabbitbrush	30	64	44	95	28
Big sagebrush	27	65	42	96	32
Desert peach	17	15	5	40	22
Green ephedra	21	24	7	14	14
Hop sage	5	100	2	100	4

Table 2. Species composition (% frequency) in 1968 and 1973, and mean composition for 1969 through 1972, in relation to the application of 2,4-D, 2,4-D + picloram, and control.

Species	Control			2,4-D			Picloram + 2,4-D		
	1968	1969-1972	1973	1968	1969-1972	1973	1968	1969-1972	1973
Annual grasses									
Downy brome	17	28	51	20	41	53	22	23	34
Sixweeks fescue	3	9	11	9	3	2	0	1	1
Perennial grasses									
Needleand thread	2	3	1	2	6	9	9	16	18
Desert needlegrass	5	7	5	8	2	3	18	23	22
Thurbers needlegrass	1	1	1	1	2	2	0	2	3
Squirreltail	9	6	7	6	4	5	16	10	9
Indian ricegrass	2	4	4	1	1	1	4	3	1
Sandberg bluegrass	0	0	0	0	0	0	0	1	1
Annual forbs	35	33	3	39	35	24	31	19	8
Perennial forbs									
Spiny skeletonweed	23	19	16	13	6	1	0	2	2
Other	2	1	2	1	0	0	0	0	1

species. However, in the adjacent allotment where grazing pressure had been more intense, all of the current annual growth of green ephedra was used by cattle. The current annual growth of green ephedra plants that survived the 2,4-D + picloram treatment averaged 180% of that measured on the control pasture for the period 1969 through 1973.

Herbaceous Vegetation-Species Composition

The herbaceous vegetation in this community consisted of relatively stable perennial grasses, with downy brome (*Bromus tectorum*) or ephemeral annual forbs that fluctuated widely in abundance from year to year (Table 2). The ephemeral annual forbs—skunk mimulus (*Mimulus nanus*) and dwarf monkey flower (*M. guttatus*)—became the dominant annual flora on dry years such as 1968 (Table 2). During years of average or above precipitation, downy brome dominated the herbaceous vegetation, almost to the exclusion of native annual forbs (Young and Evans, 1974b).

In the 2,4-D-treated pasture, the effect of partial brush control was expressed largely by an increase in annuals (Table 2). Needleandthread (*Stipa comata*) tended to increase in frequency, but the other perennial grasses remained stable. In the exclosure treated with picloram + 2,4-D the increase of needleandthread was more dramatic in the years after the herbicides were sprayed (Table 2). This increase was greater because of the higher initial frequency of perennial grasses and better control of big sagebrush and rabbitbrush. The frequency of annuals in the treated areas with picloram + 2,4-D remained relatively stable from 1969 through 1972; even in 1973, a very favorable season for downy brome, this species did not increase as much as it did in the control pasture.

Table 3. Herbage yields (kg/ha) from control, 2,4-D, and 2,4-D + picloram treatments on pastures from 1968 through 1973.^a

Year	Herbage yield		
	Control	2,4-D	2,4-D + picloram
1968	170 k	210 jk	570 fg
1969	210 jk	310 hi	660 f
1970	190 k	520 g	930 d
1971	240 i-k	610 fg	1,120 c
1972	180 k	380 h	1,310 b
1973	290 h-j	760 e	1,550 a

^aMeans followed by the same letter are not significantly different at the 0.01 probability level, as determined by Duncan's Multiple-Range Test.

Herbage Yield

Herbage yield was initially higher in the exclosure treated with picloram and 2,4-D, because we had selected an area that had enough perennial grasses to take advantage of the release in environmental potential expected after brush control (Table 3). The steady increase in herbage production in this exclosure has been more dramatic than changes in herbaceous species composition. Herbage production has increased also in the area treated with 2,4-D, but most of this increase was downy brome. In 1972, when drought limited the establishment and growth of downy brome, total production of this area decreased sharply (Table 3).

Perennial-Grass Caryopsis Production

The key to management of this community, after reduction of brush competition, is increasing the density of perennial grasses. In 1973, an excellent year for grass caryopsis production, slightly more than 8 kg/ha of perennial-grass caryopses were produced (Table 4). The maximum number and the heaviest caryopses were produced by needleandthread. In the terminology of range condition and trend, needleandthread is a "decreaser," which falls in density as range condition declines in this environment (Tueller and Blackburn, 1974).

The lack of seedling establishment of perennials, other than needleandthread, in spite of abundant caryopsis production, indicates that seedbed conditions in this community are limiting. The ground cover is very low, with bare granitic soil between the clumps of perennial grasses. Most species cannot germinate on bare soil (Evans and Young, 1974b). Some species overcome the harsh environment of bare seedbeds by

Table 4. Density (number/m²) and weight (kg/ha) of perennial-grass caryopses produced in 1968 and 1973, on area treated with picloram + 2,4-D.

Species	Caryopsis production		Density ^a	
	Density	Weight	1968	1973
Needleandthread	62	3.50	0.6	1.1
Desert needlegrass	55	1.50	0.7	0.7
Squirreltail	28	0.50	0.7	0.7
Indian ricegrass	46	2.60	0.4	0.4
Sandberg bluegrass	16	0.03	T	T

^aT = Trace.

such adaptations as: a) extremely rapid germination, such as is shown by Russian thistle (*Salsola iberica*) (Evans and Young, 1972a); b) seed mucilage, such as that of tumble mustard (*Sisymbrium altissimum*) (Young et al., 1970); c) fortuitous burial by ants or rodents, such as occurs to downy brome (LaTourrette et al., 1971); and d) self-burial. Needleandthread is highly adapted by virtue of a needle-like tip of callus and a spiral awn for self-burial.

Significance to Management

Aerial application of mixtures of 2,4-D + picloram is as effective for control of green rabbitbrush and big sagebrush as previously tested ground applications. The addition of picloram reduces the chance of failure caused by improper timing of application.

By application of herbicides, big sagebrush/green rabbitbrush/desert needlegrass community, growing under very droughty conditions, can be so managed that brush competition is reduced and yield and density of needleandthread is increased. It became clear that, in order to increase the density of other perennial grasses, management must devise a way to modify the potential receptivity of the seedbed. If the stand of perennial grasses is low in density before the brush is controlled, downy brome will preempt the released environmental potential.

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