Treating Forb-dominated Subalpine Range with 2,4-D: Effects on Herbage and Cattle Diets

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Highlight: *Treatment of forb-dominated summer cattle range in the Bighorn Mountains with 2,4-D changed the mean grass to forb ratio of the herbage from 27:73 to 81:19, but had no influence on total herbage production. The grass content of the diet of yearling steers was significantly greater only the first 2 years after herbicide treatment. Steers grazing sprayed units gained an average of 2.5 lb/day; those grazing unsprayed units 2.4 lb/day.*

Forbs comprise a large proportion of the total herbage on many high elevation cattle ranges in the Bighorn Mountains of Wyoming. Many range managers consider them to be undesirable forage for cattle, and herbicidal control of forbs is an accepted range management practice in this region. Control may be achieved through treatment of forb-dominated ranges, or when ranges are sprayed to control big sagebrush (*Artemisia tridentata*).

The response of the vegetation associated with big sagebrush in the Bighorn Mountains to 2,4-D has been reported by several workers (Alley and Bohmont, 1958; Alley, 1965; Smith, 1969; Thilenius and Brown, 1974). Hurd (1955) provided some information on the influence of 2,4-D on forbs growing on non-sagebrush range in this same area, but considered only two species, silky lupine (*Lupinus sericeus*) and avens (*Geum triflorum*) and covered only the year of treatment and the subsequent year.

Our study was designed to evaluate the effect of 2,4-D on forb-dominated mountain rangelands and to determine how alteration of the composition of the forage by herbicide influenced the diet and weight gains of yearling steers.

Study Area

The study was conducted on the Burgess Experimental Pasture, Bighorn National Forest (Fig. 1). This area is in north-central Wyoming at an elevation of 8,300 to 8,500 ft. Soils were derived from limestone and are relatively deep and well drained. Annual precipitation is about 24 inches, with over half coming as snow. Growing season precipitation is highly variable from year to year, and frost is possible during any month. Mean maximum air temperatures during the growing season rarely exceed 68°F.

The vegetation of the experimental units is representative of summer cattle range on which forbs are the predominant plant life-form. Major forbs are: Richardson geranium (*Geranium richardsoni*), northwest cinquefoil (*Potentilla gracilis*), fireweed willowherb (*Epilobium angustifolium*), fivenerve helianthella (*Helianthella quinquenervis*), western valerian (*Valeriana occidentalis*), and western yarrow (*Achillea lanulosa*). Silky lupine and avens are present on the units, but are not abundant. The important grasses are big bluegrass (*Poa ampla*), Kentucky bluegrass (*P. pratensis*), subalpine needlegrass (*Stipa columbiana*), pumpelly brome (*Bromus pumpellianus*), slender wheatgrass (*Agropyron trachycaulum*), and Idaho fescue (*Festuca idahoensis*). Idaho fescue is considered the key forage species for summer cattle range in the Bighorn National Forest. Several sedges (*Carex* spp.) are also present. These were considered as part of the grass portion of the herbage because they are not affected by 2,4-D.

Methods

Experimental Design and Treatments

The experimental design for all parts of the study was a randomized complete block with sampling of the experimental units. Each experimental unit was a completely fenced pasture about 11 acres in area. Three treatment replications were used.

There were two treatments—a sprayed application of herbicide and an unsprayed control. The herbicide treatment was a single application of the propylene glycol butyl ether ester of 2,4-D at a rate equivalent to 2 lb of acid per acre. Herbicide was applied with a truck-mounted sprayer using water as the carrier at a rate of 25 gal/acre. All units were sprayed on June 25, 1968, when principal taxa were in prebloom or vegetative stages of growth.

Herbage production

Herbage production was estimated in late June, mid July, and late August in 1969, 1970, and 1971. The initial date was dependent upon the stage of range readiness as determined by local Forest Service personnel.

Fig. 1. *Burgess Experimental Pasture, Bighorn National Forest, Wyoming, in mid July, 1969, the year after treatment. Sprayed area is on the right. Herbage production averaged almost 2150 lb/acre in both treatments.*

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An unrestricted random sample of fifteen, 1 X 2-ft, permanently located quadrats was distributed in each experimental unit (90 total quadrats) to measure herbage production and utilization. A double sampling technique combining ocular-estimate-by-plot (Pechanec and Pickford, 1937) and clipped-plot methods was used to determine herbage production. Herbage was classified only as grass or forb. The estimates for these two classes were summed to provide a measure of total herbage. An ocular estimate of forage utilization expressed as a percentage of herbage weight removed was made concurrently on the plots used for estimating herbage production.

Animal Production

Each experimental unit was stocked with six good quality yearling Hereford steers (36 total steers) provided by the Bighorn Permittee Association. Steers remained in the experimental units from late June to late August for an average grazing season of 62 days. They were weighed to the nearest 5 lb prior to turn-on; at mid season; and when removed from the experimental units in late August.

Composition and Nutritive Status of the Steer's Diet

The ratio of grasses to forbs in the steer's diet was determined by microscopic examination of the rumen content following the technique of Sparks and Malechek (1968). Samples of the rumen content were obtained at the middle and at the end of the grazing season by inserting a plastic pipe, about 1 inch in diameter, down the esophagus and into the rumen (Fig. 2). A sample of rumen content (5 g minimum) was removed by suction. Rumen content samples were obtained in early morning shortly after the steers had finished feeding. Samples were taken from all 36 steers each time, but it was not always possible to obtain the minimum of 5 g of rumen content from each steer.

The nutritional quality of the steer's diet was determined by analysis of the volatile fatty acid (VFA) concentration of the rumen fluid. Analyses were made for total VFA (mM/liter) and for the percentage contribution of acetate, propionate, butyrate, isovalerate, and valerate fatty acids. These digestion end products represent the primary energy sources for ruminants (Shaw, 1959). All analyses were done by the Animal Science Department, University of Wyoming.

Statistical Analyses

The statistical significance of the experimental results was determined through analyses of variance. A mixed, split-split plot in time model (Steel and Torrie, 1960) was followed. The treatments were considered fixed effects and all time variables were designated as random effects. Significance was $\alpha = .05$.

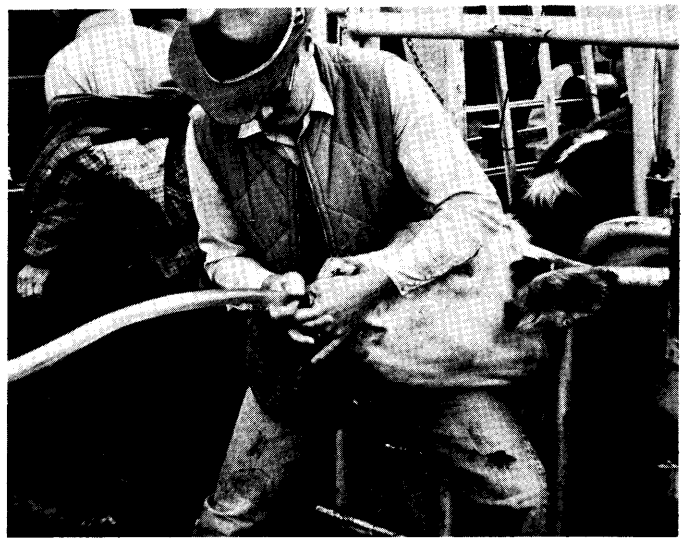

Fig. 2. *Extracting the sample of rumen content with suction apparatus.*

Results and Discussion

Herbage Production and Productivity

Not unexpectedly, the effects of herbicide were partly obscured by year-to-year variations in the amount of herbage produced and by the time at which production was estimated. Total herbage production differed markedly over the 3-year period (Table 1). In 1969, the second growing season after spraying, production in late August under both treatments exceeded 2,200 lb/acre. On sprayed units, 90% of the herbage was grasses. On unsprayed units, grasses comprised only 21% of the herbage. Although the difference in total herbage production between treatments was not statistically significant, the increase in grass production on the sprayed units was significant, as was the decrease in forb production.

Total herbage production on both treatments was lower in 1970 than in 1969 (Table 1). The average grass:forb ratio

Table 1. Production of herbage (lb/acre, oven dry) and percentage grass:forb ratios (G:F) on sprayed (1968) and unsprayed units of the Burgess Experimental Pasture, 1969-1971.

		Late June		Mid July		Late August	
Year	Herbage	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed
1969	Grasses	768	275	1946	344	2024	479
	Forbs	157	1343	201	1803	231	1800
	Total herbage	925	1618	2147	2147	2255	2279
	G:F	83:17	17:83	91:9	16:84	90:10	21:79
1970	Grasses	446	179	997	324	1276	674
	Forbs	222	1176	596	1637	358	1251
	Total herbage	668	1355	1593	1961	1634	1925
	G:F	67:33	13:87	63:37	17:83	78:22	36:65
1971	Grasses	628	188	514	196	1150	355
	Forbs	213	997	296	1130	441	1074
	Total herbage	841	1185	810	1326	1591	1429
	G:F	75:25	16:84	63:37	15:85	78:22	25:75
Average	Grasses	614	214	1152	288	1483	503
	Forbs	197	1172	364	1523	344	1374
	Total herbage	811	1386	1516	1811	1827	1877
	G:F	76:24	15:84	76:24	16:84	81:19	27:73

Table 2. Grass:forb ratios of the steers' diet and of the herbage.

Measurement and season	1968		1969		1970		1971		Average[1]	
	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed
Diet										
Mid July	67:33*	59:41	67:33*	61:39	60:40	60:40	68:32	63:37	65:35	60:40
Late August	79:21*	66:34	74:26*	62:38	62:38	58:42	63:37	63:37	66:34	61:39
Herbage										
Mid July	NA	NA	89:11	16:84	63:37	17:83	63:37	15:85	72:28	16:84
Late August	NA	NA	90:10	21:79	78:22	35:65	72:28	25:75	80:20	27:73

[1] 3-year (1969-1971) average.
*Statistically significant difference at $\alpha = .05$.

(G:F) of the sprayed units was 78:22 in 1970 as compared to 90:10 in 1969, indicating some resurgence of forbs. The increase in the forb component was due to renewed growth of forbs not completely killed by the 2,4-D rather than a reinvasion of new plants. The major species contributing to total forb production were Richardson geranium and northwest cinquefoil. As in 1969, total production was not influenced by the herbicide treatment.

Total herbage production on the sprayed units in 1971 was not significantly different from that in 1970. The G:F ratio in 1971 was 72:28 on the sprayed units, a reduction of 6% in the contribution of grasses to the herbage in comparison to 1970, and 18% less than in 1969, indicating further slow increase in the forb component. While the G:F ratio on the sprayed units showed a general decline in the grass component during the three years, the G:F ratio of the unsprayed units was erratic (Table 1).

The decline in herbage production during the period of study may be attributed, at least in part, to a concomitant decline in growing season (June through August) precipitation from 1969 to 1971. Precipitation recorded during the growing season was: 1969, 4.39 inches; 1970, 1.68 inches; and 1971, 0.73 inch. The simple correlation coefficients between maximum total herbage production and growing season precipitation are approximately $r = .99$ for sprayed units, and $r = .93$ for the unsprayed units. The former is significant at $\alpha = .10$; the latter at only $\alpha = .25$ because of the small number of years in the sample. The year of highest growing-season precipitation was also the second year after spraying, which is normally when post-spraying grass production reaches a maximum. It is possible that maximum production in 1969 would have been much reduced if the 1969 and 1971 precipitation regimes had been reversed.

As would be expected, the time during the growing season when herbage production was sampled had a strong influence on the amount of herbage recorded. Differences in herbage production between sampling dates were statistically significant in all years, with the late-June to Mid-July production contributing most of the variation.

Peak production of grasses usually was reached in late August, while forb production reached a maximum by mid July and had decreased by late August. This decline in forbs was due to the normal maturation processes with consequent loss of weight caused by drying of foliage, dissemination of propagules, and death. The major forb species, Richardson geranium and northwest cinquefoil, displayed autumn coloration by late August; other forbs such as western yarrow were just reaching full bloom, so there was some compensation. In the very dry year of 1971, mid-July herbage production by grasses on the sprayed units was 114 lb/acre less than that recorded in late June. No reduction was evident on unsprayed units.

Herbicide treatment also influenced productivity (rate of change in weight per unit area per unit of time, lb/acre/day). On the average, the sprayed units produced more total herbage and grasses than the unsprayed units, but less of the forb component. The greater productivity of total herbage is the result of the increased grass growth after herbicide treatment. Average grass productivity was over seven times greater on the sprayed units during the late-June to mid-July period. It diminished during the second part of the season, but was still about 1.5 times greater on the sprayed units.

The average rate of weight loss (negative productivity) by the forb component during the latter part of the season was less on the sprayed units, where it was -0.9 lb/acre/day as compared to -3.8 lb/acre/day on untreated units.

The generally lower productivity on the unsprayed units may be partially an artifact of the time at which the sampling was done and the growth habits of forbs. If forbs begin growth earlier than grasses, their period of greatest productivity may have been finished before they were first sampled.

Steer Diet

The greatest difference in the grass content of the steer's diet was in 1968, the year the units were sprayed. That year, the grass content of the diet of steers grazing sprayed units exceeded that of the steers grazing unsprayed units by 8% in mid July and by 13% in late August (Table 2). These differences were statistically significant, as were those between sprayed and unsprayed units in 1969. Dietary differences in 1970 and 1971 were not significant, nor were the 4-year averages.

Changing the G:F ratio of the herbage with 2,4-D had no overall effect on steer diet (Table 2). In mid July when the herbage G:F of sprayed units averaged 72:28, the diet G:F of the steers grazing these units was 65:35. The mid-July diet G:F of the steers on the unsprayed units was 60:40, although the herbage G:F was 16:84. In late August, when the average grass portion of the herbage was about three times greater on the sprayed units than on the unsprayed (G:F 80:20, sprayed vs G:F 27:73 unsprayed), the diet G:F ratios of the steers on both treatments were very similar to those in mid July and to each other (Table 3).

The G:F ratios of the steers' diet determined in this study represent forage selection under light grazing intensity. With this level of grazing, the steers selected a diet where about 40% of the intake was forbs. Thus, since it appears they actively sought out forbs when they were rare, this class of plants is an important and perhaps necessary part of the forage resource on summer cattle ranges, particularly in the early part of the grazing season. Conversely, the steers had to actively seek out

Table 3. Average grass:forb (G:F) ratios of the steers' diet as determined by rumen analysis and ocular estimate of forage utilization.

Method	Sprayed		Unsprayed	
	Mid July	Late August	Mid July	Late August
Rumen analysis	66:34	70:30	61:39	62:38
Ocular estimate	84:16	86:14	51:49	63:37

grasses on the unsprayed ranges to keep the G:F of their diet at 60:40.

The stocking rate used in this study was considered adequate to measure animal variation and approximated the Forest Service standards for the unsprayed units. The usual management practice on Forest Service ranges has been not to increase stocking rate after herbicide treatment (Kearl, 1965). Consequently, the same number of steers were used in both treatments. As the trials were carried out at a light rate of stocking, different ruminal G:F ratios might have been obtained at heavier stocking rates where the steers would have had less complete freedom in forage selection.

The possible performance of the cattle if all forbs had been killed by the herbicide cannot be determined from this study and the question of the necessity for forbs in the steers' diet has not been answered. Complete control of forbs is probably quite rare, however, and G:F ratios we measured are probably what can be expected under normal rangeland conditions after a single herbicidal treatment.

The G:F ratios of the herbage on the sprayed units more closely matches the G:F ratios of the steers' diet. It is therefore possible that the increased availability of grasses on the sprayed units would have allowed these units to be more heavily stocked than unsprayed units, with a greater animal gain per unit as the result.

Forage Utilization

The light stocking rate and high production of both sprayed and unsprayed units were reflected in the very low field estimates of forage utilization. Mean estimated utilization of grasses for the 4-year period was 10.7% on sprayed units and 10.9% of unsprayed units. Forb utilization averaged 1.9 and 7.9% respectively.

For comparative purposes, the field estimates of utilization have been converted to G-F ratios (Table 3). On the sprayed units, the G:F ratio based on field estimates indicated a greater use of grasses than was indicated by rumen analyses at both mid and end season. On unsprayed units in mid July, grass use as determined by field estimate was less than that determined by rumen analyses, but the two methods were in close agreement in late August. It appears field estimates of forage use may give biased impressions of the importance of the two forage classes, especially on sprayed ranges where forbs are less abundant.

Table 4. Average ruminal concentrations of individual volatile fatty acids (VFA) (molar %) and total VFA (mM/liter), 1968 to 1971.

Treatment	C_2	C_3	C_4	C_5	C_{5i}	Total VFA
Unsprayed	70.1	16.5	10.6	1.5	1.5	68.7
Sprayed	70.8	16.1	10.5	1.4	1.5	68.1

C_2 = acetate
C_3 = propionate
C_4 = butyrate
C_5 = valerate
C_{5i} = isovalerate

Table 5. Mean steer weight gains (pounds).

Measurement	Sampling period		
	Mid	End	Total
Total gain			
Sprayed	73	79	152
Unsprayed	69	73	142
Difference[1]	+4	+6	+10
Daily gain			
Sprayed	3.3	2.1	2.5
Unsprayed	3.1	1.9	2.4
Difference[1]	+0.2	+0.2	+0.2

[1] Sprayed - unsprayed.

Ruminal VFA Content

Ruminal concentrations of both individual VFA and total VFA (Table 4) were not significantly affected ($\alpha = .05$) by treatment of the herbage with 2,4-D in any of the 4 years. The absence of differences between levels of acetate and propionate indicates that the nature of the fermentation of the diets selected by the steers was not altered by the treatment.

Steer Weight Gains

Because of the G:F ratios and VFA contents of the steers' diets were so similar, it is not surprising the weight gains of the steers were also similar (Table 5). The mean total gain over the four years of record was 152 lb/steer for animals grazing the sprayed units and 142 lb/steer for those grazing the unsprayed units. The 10 lb/steer difference was not statistically significant.

Mean total weight gains of the steers varied between years, and between measurement periods within years, but in no instance were differences between the two treatments statistically significant.

The average daily weight gain was 2.5 lb/day for steers grazing sprayed units and 2.4 lb/day for those on the unsprayed units, rates the livestock owner considered very adequate for yearling steers on native range.

Summary and Conclusions

The objective of our study was to assess the effects of herbicidal treatment of forb dominated high-elevation summer cattle range on the diet and weight gains of cattle grazing them. The results of the study may be summarized in three statements:

1) Treatment of forb-dominated summer range with 2,4-D profoundly increased the ratio of grasses to forbs. It did not appreciably alter total herbage production. The grasses gradually decreased as forb production increased during the 3 years following treatment.

2) Increasing the grass to forb ratio of the herbage significantly increased the grass component of the steers' diet only during the first two growing seasons after herbicide treatment, but did not alter the VFA content of the diet at any time.

3) Steer weight gains were not influenced by herbicide treatment of the herbage.

The lack of a significant increase in herbage production, the seemingly temporary nature of the grass increase, the lack of important alterations in the composition and quality of the cattle diet, and the absence of a significant increase in steer weight gains indicate forb control is not necessarily a desirable practice, especially under light rates of stocking.

According to this study, forbs are more important as forage for cattle on summer range than previously thought. For example, Pond and Smith (1971) indicated grasses comprised 90% of all cattle forage in the Bighorn Mountains. Part of the problem in evaluating forbs as forage is that it is difficult to visually detect utilization on forbs because of their diverse growth forms; part may be an unconscious "grass-bias" of range managers. Whatever the reason, the role of forbs in the summer diet of cattle grazing high-elevation, forb-dominated native range certainly deserves greater attention than it has received in the past.

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