# Effect of 2,4-D on Composition and Production of an Alpine Plant Community in Wyoming

JOHN F. THILENIUS, DIXIE R. SMITH, AND GARY R. BROWN

**Highlight:** *Use of 2,4-D in an alpine plant community in the Medicine Bow Mountains of Wyoming almost completely eliminated* Geum rossii. *The graminoid:forb ratio of the vegetation was altered from approximately 3:7 to 8:2 without appreciably changing total standing crop or its digestible dry matter content. Resurgence of forbs could not be detected up to 4 years after treatment.*

Although the literature on herbicides is voluminous, reports of herbicide application in the alpine zone are rare. Smith and Alley (1966) reported that 2,4-D and 2,4,5-T were equally effective in reducing the density of *Geum rossii* by 98% in the alpine zone of the Medicine Bow Mountains of Wyoming. This paper reports subsequent research on herbicidal control of *Geum rossii* particularly on the effects of 2,4-D on species composition, aboveground standing crop, and digestible dry matter production of associated vegetation.

## Study Location and Methods

The area studied is in a livestock-proof exclosure on Libby Flats in the Medicine Bow National Forest of southeastern Wyoming, about 64 km west of Laramie. Elevation at the site is 3,240 m (10,600 ft). The site, located on a gentle north slope, has a soil developed from glacial till. Vegetation has been classified as a *Deschampsia* meadow community by Smith (1969) (Fig. 1).

The experimental design was a randomized complete-block system with unrestricted random sampling of the experimental units. Six blocks were used. Each experimental unit was 2.4 × 4.9 m (8 × 16 ft). The sample consisted of 10 randomly selected 0.3 × 0.3 m (1 × 1 ft) quadrats in each experimental unit.

Only two treatments were used—a control (unsprayed) and spray treatment. The spray treatment was a single application of 2,4-D in the form of propylene glycol ether ester at a rate of 2.2 kg/ha (2 lb/acre). The 2,4-D plus a wetting agent was sprayed in a water solution at a total volume of 227 l/ha (20 gal/acre). Herbicide was applied in July, 1966, at the time *Geum rossii* was in early bloom.

Standing crop was determined by clipping the aboveground herbage to ground level, segregating by species, and weighing the clippings after they had been oven-dried at 105°C for 24 hours. Samples were obtained at the time of maximum standing crop (late July-early August) in 1967, 1968, and 1970 (1, 2, and 4 years after treatment).

The digestible dry matter (DDM) content of the most productive species was determined by the in vitro technique (Tilley and Terry, 1963) using rumen fluid obtained from fistulated cattle on a grain and alfalfa diet.

Analysis of variance was used to determine whether the differences between treated and untreated vegetation were statistically significant. Significance was determined at the 95% level.

## Results

### Composition and Standing Crop on Unsprayed Plots

Samples of aboveground standing crop were obtained from 33 species of vascular plants. Most of the standing crop was produced by a small proportion of the species present (Table 1). Average total standing crop on the unsprayed units was 135 g/m$^2$ (1204 lb/acre) with a range of 155 to 119 g/m$^2$ (1383 to 1062 lb/acre).

On unsprayed units, forbs were the predominant life-form, producing two-thirds of the total standing crop. Although 19 species of forbs were present,

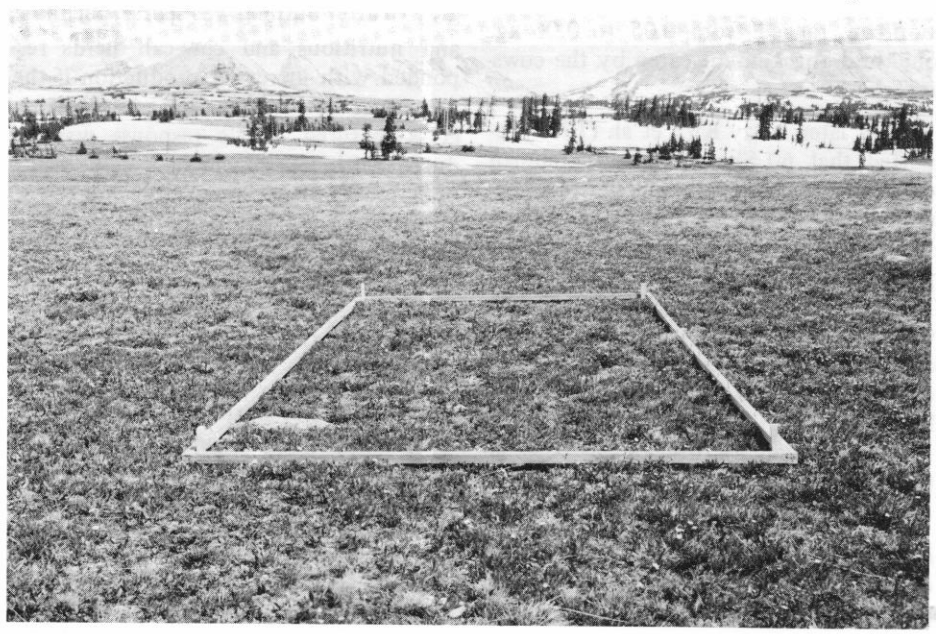

**Fig. 1.** *The* Deschampsia *meadow community on Libby Flats, Medicine Bow National Forest, Wyo.*

Thilenius and Smith are principal plant ecologists and Brown, range research technician at the Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, at Laramie, in cooperation with the University of Wyoming. Smith is now with the Division of Forest Environment Research, Range and Wildlife Habitat Ecology and Management Section, Forest Service, U.S. Dep. Agr., Washington, D.C. Station's central headquarters is maintained at Fort Collins, in cooperation with Colorado State University.

Manuscript received May 19, 1973.

Table 1. Standing crop ($g/m^2$)[1] of major species in an alpine plant community as influenced by application of 2,4-D at 2.2 kg/ha. Experimental units sprayed in July, 1966.

| Species | 1967 | | 1968 | | 1970 | |
|---|---|---|---|---|---|---|
| | Unsprayed | Sprayed | Unsprayed | Sprayed | Unsprayed | Sprayed |
| Forbs | | | | | | |
| *Trifolium parryi* | 37 | 2* | 31 | 7* | 26 | 4* |
| *Geum rossii* | 30 | t*[2] | 18 | 1* | 18 | 0 |
| *Artemisia scopulorum* | 5 | t* | 17 | 1* | 14 | t* |
| *Polygonum bistortoides* | 10 | 11 | 8 | 14* | 6 | 8 |
| *Arenaria obtusiloba* | 8 | 1* | 3 | 1* | 2 | 3 |
| *Potentilla diversifolia* | 4 | t* | 4 | t* | 3 | 0 |
| *Achillea lanulosa* | 3 | 1 | 3 | 3 | 5 | 4 |
| Other forb species[3] | 9 | 2 | 3 | t | 4 | 4 |
| Total forbs | 106 | 18 | 87 | 28 | 78 | 23 |
| Graminoids | | | | | | |
| *Deschampsia caespitosa* | 23 | 36 | 31 | 65 | 31 | 55 |
| *Poa rupicola* | 14 | 49* | 5 | 12* | 1 | 6* |
| *Poa alpina* | 9 | 19* | 2 | 3 | 3 | 8 |
| *Agrostis idahoensis* | 0 | 0 | 1 | 13* | 2 | 8* |
| *Festuca ovina* | 0 | 3 | 2 | 12* | 1 | 2 |
| *Trisetum spicatum* | 0 | 0 | 1 | 5* | 0 | 0 |
| Other graminoid species[4] | 3 | 3 | 3 | 4 | 3 | 6 |
| Total graminoids | 49 | 110 | 45 | 114 | 41 | 85 |
| Total standing crop | 155 | 128 | 132 | 142 | 119 | 108 |
| Graminoid:forb | 32:68 | 86:14 | 34:66 | 80:20 | 34:66 | 79:21 |

[1] All weights rounded to nearest gram; $g/m^2 \times 8.92$ = lb/acre.
[2] t = less than 1 $g/m^2$, value of 0.5 $g/m^2$ used for calculations.
* statistically significant difference at $\alpha = 0.05$.
[3] Other forb species: *Cerastium arvense, Antennaria rosea, Solidago ciliosa, Saxifraga rhombidea, Arenaria congesta, A. rubella, Sagina saginoides, Trifolium dasyphyllum, Lewisia pygmaea, Stellaria longipes, Sedum stenopetalum, Erigeron simplex.*
[4] Other graminoid species: *Koeleria cristata, Danthonia intermedia, Agropyron scribneri, Carex ebenea, C. rossii, C. elynoides, C. obtusata, Luzula spicata.*

three species, *Trifolium parryi, Geum rossii,* and *Artemisia scopulorum*, together produced half of the total standing crop and almost 75% of the standing crop of forbs.

The most productive forb—surprisingly—and also the most productive species on the unsprayed units was *Trifolium parryi*. Although *Geum rossii* was the most visually prominent species, the standing crop of *Trifolium parryi* was 20 to 40% greater than that of *Geum rossii* during the 3 years of sampling (Table 1).

Other forbs on the unsprayed plots which produced an average of 3 $g/m^2$ (27 lb/acre) or more during the 3 years of the study were, in order of importance, *Polygonum bistortoides, Potentilla diversifolia, Arenaria obtusiloba,* and *Achillea lanulosa*. Together these four species accounted for about 18% of the total standing crop and 21% of the total standing crop of forbs.

Graminoids (nine grasses, four sedges, and a woodrush) as a group were much less productive than the forbs on the unsprayed plots. One grass, *Deschampsia caespitosa*, was the second most productive of all species, providing over 20% of the average standing crop and 63% of the total graminoid standing crop. Two species of *Poa* were also moderately productive on the unsprayed plots. *Agrostis idahoensis* and *Festuca ovina* were not encountered in the samples on the unsprayed plots the first year but contributed a small part of the total standing crop in subsequent years.

*Carices* were a minor component of the vegetation.

### Composition and Standing Crop on Sprayed Plots

Application of 2,4-D significantly reduced the standing crop of most of the major forbs but had no significant effect on total standing crop. Average total standing crop on the sprayed plots was 127 $g/m^2$ (1133 lb/acre) with a range of 142 to 108 $g/m^2$ (1267 to 972 lb/acre), compared to the average of 135 $g/m^2$ (1204 lb/acre) produced on the unsprayed plots.

*Geum rossii* was almost completely eliminated. The average standing crop of this species was less than 1 $g/m^2$ (9 lb/acre) on the sprayed plots, compared to 22 $g/m^2$ (196 lb/acre) on the unsprayed plots—a difference of 98%. The fourth year after spraying, *Geum rossii* was not present on any of the 60 plots sampled.

The average standing crop of *Trifolium parryi* was also significantly reduced by 2,4-D, although this species appears to be less susceptible to the herbicide than *Geum rossii*. Average production of *Trifolium parryi* after spraying was 4 $g/m^2$ (36 lb/acre) or about 87% less than that on unsprayed plots.

Other important forbs significantly suppressed by 2,4-D were *Artemisia scopulorum* and *Potentilla diversifolia*, both of which were about 96% less productive on the sprayed areas. *Arenaria obtusiloba* was less severely affected by 2,4-D, showing only a 63% difference. *Achillea lanulosa* did not show a significant response to 2,4-D.

Three species of forbs, *Saxifraga rhombidea, Arenaria congesta,* and *Lewisia pygmaea,* all somewhat abundant the first year after spraying, were not encountered during subsequent sampling periods. *Luzula spicata* was common during the first two sampling periods but absent from the samples taken 4 years after spraying.

The standing crop of *Polygonum bistortoides* generally increased following spraying, but the increase was statistically significant only in the 2nd year after the herbicide was applied. *Polygonum bistortoides* was the fifth most productive species on the unsprayed plots and the third most productive on the sprayed plots. Increased production after spraying may be due to a reduction in competition from other forbs, but the apparent lack of effect of 2,4-D on the species cannot be explained from the results of this study. Hurd (1955) also found *Polygonum bistortoides* growing on subalpine ranges in the Bighorn Mountains was little affected by 2,4-D, and Ward (personal communication) noted a similar reaction on subalpine ranges in Colorado.

With the reduction in the forb component, grasses became the dominant life-form on the sprayed plots. *Deschampsia caespitosa*, the most productive grass on the unsprayed plots, became the most productive of all species on the sprayed plots. On the average, it produced 41% of the total standing crop after spraying.

Several other grasses showed significant increases in standing crop on the sprayed plots. Most important of these were *Poa rupicola, P. alpina, Agrostis idahoensis,* and *Festuca ovina*. The standing crop of *P. rupicola* was larger than that of *Deschampsia caespitosa* the 1st year after spraying but in subsequent years was less. *P. alpina* also produced its greatest standing crop the 1st year after spraying and declined in subsequent years. *A. idahoensis* and *F. ovina* were most productive 2 years after spraying.

Table 2. Mean standing crop (SC in g/m²)[1], digestion coefficients (DC in %), and mean digestible dry matter (DDM in g/m²) for forbs (F) and graminoids (G) on unsprayed and sprayed plots.

| Plots and species | SC | DC | DDM |
|---|---|---|---|
| Unsprayed plots | | | |
| Ten major species | | | |
| *Trifolium parryi* (F) | 31 | 59 | 18 |
| *Deschampsia caespitosa* (G) | 28 | 58 | 16 |
| *Geum rossii* (F) | 22 | 42 | 9 |
| *Artemisia scopulorum* (F) | 12 | 58 | 7 |
| *Polygonum bistortoides* (F) | 8 | 63 | 5 |
| *Poa rupicola* (G) | 7 | 61 | 4 |
| *Poa alpina* (G) | 5 | 61 | 3 |
| *Arenaria obtusiloba* (F) | 4 | 45 | 2 |
| *Potentilla diversifolia* (F) | 4 | 60 | 2 |
| *Achillea lanulosa* (F) | 3 | 70 | 2 |
| Subtotal (10 species) | 124 | | 68 |
| Other graminoids (10 species) | 5 | 62[2] | 4 |
| Other forbs (11 species) | 6 | 60[2] | 3 |
| Total (31 species) | 135 | | 75 |
| Sprayed plots | | | |
| Ten major species | | | |
| *Deschampsia caespitosa* (G) | 52 | 58 | 30 |
| *Poa rupicola* (G) | 22 | 61 | 13 |
| *Polygonum bistortoides* (F) | 11 | 63 | 7 |
| *Poa alpina* (G) | 10 | 61 | 6 |
| *Agrostis idahoensis* (G) | 7 | 62 | 4 |
| *Festuca ovina* (G) | 6 | 47 | 3 |
| *Trifolium parryi* (F) | 4 | 59 | 2 |
| *Achillea lanulosa* (F) | 3 | 70 | 2 |
| *Trisetum spicatum* (G) | 2 | 70 | 1 |
| *Arenaria obtusiloba* (F) | 2 | 45 | 1 |
| Subtotal (10 species) | 119 | | 69 |
| Other graminoids (8 species) | 5 | 62[2] | 3 |
| Other forbs (13 species) | 3 | 60[2] | 2 |
| Total (31 species) | 127 | | 74 |

[1] All weights rounded to nearest gram; g/m² × 8.92 = lb/acre.
[2] Mean value for all species.

*Trisetum spicatum* occurred in the sample only in the second sampling period, but at this time it was abundant enough to be included among the most productive species on the sprayed plots.

Generally, the effect of 2,4-D on composition was relatively consistent and long-lived. Graminoid:forb ratios (G-F) based on the percentage contribution of these life-form groups to total standing crop changed little on sprayed plots. Spraying with 2,4-D altered the mean G:F to 81:19 with a range of 79:21 to 86:14. Concomitant variation in total standing crop on the sprayed plots was 142 g/m² to 108 g/m² (1267 to 963 lb/acre). The mean G:F for unsprayed plots was 33:67 with a range of only 32:68 to 34:66 for the 3 years of collection. During this period total standing crop varied from 155 g/m² to 119 g/m² (1383 to 1062 lb/acre).

### Production of Digestible Dry Matter

Digestible dry matter (DDM) was determined for the 10 most productive species in each treatment (Table 2). On the unsprayed plots, three grasses and seven forbs produced an average of 90% of the total standing crop, or 124 g/m² (1106 lb/acre). Of this amount, 68 g/m² (607 lb/acre) was calculated to be DDM for an average DDM content of 56%. On the sprayed plots the 10 most productive species included six grasses and four forbs. They produced 94% of the total herbage or 119 g/m² (1062 lb/acre). The average DDM content of this herbage was 69 g/m² (616 lb/acre) or 59%. Differences in DDM and total standing crop were statistically and practically nonsignificant.

## Discussion

The use of 2,4-D altered the composition of the community from a forb-dominated vegetation to one dominated by grasses. The G:F ratio succinctly summarizes the effects. Spraying of this herbicide changes the G:F from approximately 3:7 to 8:2 without appreciably altering the total standing crop or DDM produced by the community.

However, just because the conversion is feasible does not necessarily mean it is desirable. From the standpoint of forage production for large herbivores, either wild or domestic, there appears to be little justification for conversion. Lack of increase in standing crop or DDM is sufficient in itself to question the usage of the herbicide since the grazing capacity of the community is not increased.

The change in the relative proportions of graminoids and forbs also offers little advantage. While the diet of large herbivores on alpine range has had little quantitative study, available evidence indicates forbs are an important component.

Strasia et al. (1970) found *Trifolium* spp. and *Geum rossii* accounted for 32% of the diet of free-ranging sheep grazing alpine ranges in northwestern Wyoming. Forbs as a group comprised 66% of the diet in early summer (July) and 31% in late summer (August). *Trifolium* spp. and *Geum rossii* are markedly reduced by 2,4-D.

The decrease of *Trifolium parryi* is particularly important. Hamilton (1961) showed this species to be high in crude protein, carotene, and calcium and low in crude fiber; it was an excellent source of carotene for a considerable period after maturity. The mean digestibility coefficient of 59% established in this study shows it to have a relatively high content of DDM in mid-summer. Therefore, the loss of approximately 85% of the *Trifolium parryi* could considerably diminish the overall nutritive quality of the forage resource.

In some instances, increased grass production may be desirable on alpine ranges. In the latter part of the growing season, after many forbs have dried, grasses generally predominate the diet of grazing animals. Converting certain areas to grass dominance and reserving them for late-season use should increase the available usable forage at that time.

## Literature Cited


**Hamilton, J. W. 1961.** Native clovers and their chemical composition. J. Range Manage. 14:327-331.

**Hurd, R. M. 1955.** Effect of 2,4-D on some herbaceous range plants. J. Range Manage. 8:126-128.

**Smith, Dixie R. 1969.** Vegetation, soils and their interrelationships at timberline in the Medicine Bow Mountains, Wyoming. Wyo. Agr. Exp. Sta. Sci. Monogr. 17. 14 p.

**Smith, D. R., and H. P. Alley. 1966.** Chemical control of alpine avens. J. Range Manage. 19:376-378.

**Strasia, C. A., M. Thorn, R. W. Rice, and D. R. Smith. 1970.** Grazing habits, diet and performance of sheep on alpine ranges. J. Range Manage. 23:201-208.

**Tilley, J. M., and R. A. Terry. 1963.** A two-stage technique for the in vitro digestion of forage crops. J. Brit. Grassl. Soc. 18:104-111.