Competition in a Blue Grama-Broom Snakeweed-Actinea Community and Responses to Selective Herbicides

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Highlight

In a blue grama-broom snakeweed-Cooper actinea community, the presence of half-shrubs suppressed the growth of blue grama. Blue grama and forbs were increased when the half-shrubs were reduced by selective phenoxy sprays.

The portions of the juniper-pinyon woodland in Arizona and western New Mexico with highest rainfall and greatest potential for forage production are also particularly susceptible to weed infestations, and undesirable half-shrubs and forbs often outproduce desirable grasses. Typically, these areas fall along the Mogollon escarpment, and on other areas of rough topography. The study reported here shows the interrelations among some of the important species of these areas. These interrelations were studied by modifying the amounts of the different species with selective herbicides.

Methods

The study area was located at an elevation of 6,400 ft on the Beaver Creek Watershed, Coconino National Forest, 40 miles south of Flagstaff, Arizona. Precipitation, about equally divided between a winter and summer season, totals about 20 inches annually. The study was located in a natural opening among the alligator juniper trees *(Juniperus deppeana.)*[2] In addition, trees near the plot were removed to eliminate their competition with the herbaceous plants. Soils in the area, silty clays and clay loams, have developed from basalt.

At the time the study began, the area had been closed to grazing for 3 years. Blue grama *(Bouteloua gracilis)*, bottlebrush squirreltail *(Sitanion hystrix)*, broom snakeweed *(Gutierrezia sarothrae)*, Cooper actinea *(Hymenoxis cooperi)*, and a number of forbs comprised the vegetation. In aspect, half-shrubs were most conspicuous.

A series of 96 plots was laid out in the study enclosure. These plots were 9 x 9 ft, separated by 2-ft-wide walkways. All measurements were made on the 5- x 5-ft center of each study plot except production of squirreltail, which was determined on 8- x 8-ft areas. Weed competition was varied by spraying some of the plots with selective phenoxy compounds[3] (2,4-D and 2,4,5-T). Spray treatments were (1) None (Check), (2) sprayed in 1958, (3) sprayed in 1960, and (4) sprayed in both 1958 and 1960. In 1958, plots were sprayed in the spring with a mixture of 2,4-D and 2,4,5-T, and in the fall with 2,4-D. In 1960, 2,4-D was used alone

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[1] *In cooperation with Northern Arizona University; central headquarters maintained at Fort Collins in cooperation with Colorado State University.*

[2] *Latin nomenclature follows Kearney and Peebles, 1960.*

[3] *Thomas N. Johnsen, Jr., of the Agricultural Research Service, U. S. Department of Agriculture, provided and applied the chemical sprays.*

in the spring. Herbicide applications were similar to the higher rates tested by Johnsen (1962) on Colorado rubberweed *(Hymenoxis richardsoni)*. Treatments were applied to 24 replications.

Grasses were sampled each year from 1958 through 1961 by weight estimates. Estimated values of fresh weight were converted to ovendry weight values by a regression equation of dry weight on estimated fresh weight developed from clipped plots outside the enclosure. Grass seedlings were counted each year. In 1961 half-shrubs and forbs were clipped and their dry weight determined.

Responses to Herbicides

The first year of the study, grass seedlings were most commonly found in the shade of half-shrubs and taller forbs; this resulted in more seedlings on unsprayed plots than on sprayed plots (Table 1). In 1960, however, plots sprayed in 1958 had far more seedlings than plots left unsprayed in 1958. In 1959 there were very few seedlings found in the study plots, and none were found in 1961. Very few of the seedlings survived during any year of the study. In general, the number of seedlings had little relationship to later production of grasses.

Spraying generally resulted in an increase in grass production (Table 2). The plots sprayed in 1958 had increased grass weights in 1959; plots sprayed in 1960 had increased production in 1961. In 1961 there were statistically significant differences among the treatment means for both squirreltail and blue grama. The differences for squirreltail, however, were erratic and not clearly related to the various treatments except that all sprayed plots produced more than unsprayed plots. There were also some production changes on the check plots not related to treatments. Blue grama decreased slightly on unsprayed plots the second and third year of the study. During the course of the study, squirreltail increased on check plots from 9 to 35 lb/acre.

Table 1. Grass seedlings per 1,000 ft² on untreated plots and on plots sprayed with phenoxy compounds in 1958 and 1960.

Year of count	Not sprayed	Year of spray 1960	1958	1958 and 1960
1958	927	877	270	333
1959	68	80	28	68
1960	593	412	1,750	1,818
1961	0	0	0	0

Table 2. Major grasses produced (lb/acre) on untreated plots and on plots sprayed with phenoxy compounds in 1958 and 1960.

Year of herbage sample	Not sprayed	Year of spray 1960	1958	1958 and 1960
Blue grama				
1958	323	259	309	337
1959	247	214	369	400
1960	206	194	256	270
1961	272	309	335	376
Bottlebrush squirreltail				
1958	9	8	8	9
1959	15	18	24	26
1960	20	30	31	34
1961	35	106	70	91

After grass weights were determined in 1961, half-shrubs and forbs were clipped, dried, and weighed from the 5- x 5-ft center of each plot. The half-shrubs, broom snakeweed and Cooper actinea, produced less on sprayed plots (Table 3). The differences in the amounts of half-shrubs on plots sprayed at different times were minor and not statistically significant.

Some herbaceous forbs were most important on plots sprayed in 1960. These included common purslane *(Portulaca oleracea)* and sawatch knotweed *(Polygonum sawatchense)*. Western ragweed *(Ambrosia psilostachya)*, on the other hand, produced most on plots sprayed in 1958. Annual goldeneye *(Vigueria annua)* produced about the same on plots sprayed once in 1960 and plots sprayed once in 1958, but produced less on plots sprayed twice. All forbs produced as much or more on sprayed plots as on unsprayed plots.

Production of all plants on sprayed plots averaged 560 lb/acre compared to 735 lbs on unsprayed plots. Herbaceous plants increased an average of 158 lb/acre as a result of treatment while half-shrubs decreased 333 lb. This indicates that each pound of half-shrubs killed by the sprays was replaced by less than 0.5 lb of herbaceous plants.

The gain in herbaceous plant production as a result of spray

Table 3. Plants produced (lb/acre) in 1961 on untreated plots and on plots sprayed with phenoxy compounds in 1958 and 1960.

Species	Not sprayed	Year of spray 1960	1958	1958 and 1960
Grasses				
Blue grama	272	309	335	376
Bottlebrush squirreltail	35	106	70	91
Other grasses	2	0	5	0
Total grasses	309	415	410	467
Half-shrubs				
Broom snakeweed	285	32	44	8
Cooper actinea	125	62	54	30
Total half-shrubs	410	94	98	38
Forbs				
Western ragweed	9	12	53	7
Knotweed	1	10	1	4
Purslane	4	20	10	10
Annual goldeneye	0	7	6	2
Other forbs	2	8	5	3
Total forbs	16	57	75	26

treatments would apply to areas with a similar composition of plants prior to treatment. It is reasonable to assume that if more half-shrubs had been present, responses of herbaceous plants due to treatment would have been greater. Covariance analysis was used to show how much of the treatment response of blue grama was related to changes in half-shrubs. Blue grama was taken as the dependent variable, and the two species of half-shrubs as the independent variables. This is probably valid since other work has shown that the half-shrubs do not respond to changes in the amount of blue grama present (Arnold et al., 1964).

The covariance analysis showed that the difference between treatment means of blue grama was not significant when the effect of the half-shrubs was accounted for. Thus it can be concluded that increases in blue grama on the treated plots were a result of reductions in half-shrubs.

Interspecific Relations

In this study, partial correlation coefficients were used to express the relationship of each species to the others. Full descriptions of the meaning of these coefficients and methods of analyses can be found in most statistics texts.

Species may competitively exclude each other, compete to a lesser degree than total exclusion, passively coexist, or cooperate (Patten, 1961). In terms of correlation analysis, correlation coefficients would be expected to range from −1 for competitive exclusion to some value between 0 and +1 with interspecific cooperation.

Previous studies have indicated that broom snakeweed competes little with blue grama (Stewart and Keller, 1936) and black grama (Campbell and Bomberger, 1934). In these reports, other species present were not mentioned in the interpretation of results. Dwyer (1958) found that 12.5 g/plot of broom snakeweed reduced big bluestem *(Andropogon gerardi)* 2.1 g. The presence of 16.2 g of western ragweed, on the other hand, reduced big bluestem 14.2 g. Dwyer's results were taken from plots with only two species per plot.

In this study, the five species that made up most of the herbage weight were considered separately in the analysis (Table 4). The remaining species were included as a group so that all herbage would be considered. The partial correlation coefficients indicate that the most interesting and important relationships were between the grasses and other categories of plants. Interspecific relationships among the forbs and half-shrubs were much less important. Blue grama was significantly and negatively related to both the half-shrubs and to forbs other than western ragweed. Squirreltail, on the other hand, was not related to half-shrubs. This indicates that half-shrubs and squirreltail are not competitive, and that reducing the amount of half-shrubs on an area would not be expected to increase the amount of squirreltail.

The relationships between squirreltail and blue grama, and between squirreltail and forbs were positive and highly significant. Since squirreltail makes most of its growth in spring while blue grama and the forbs make most of their growth in summer, a negative correlation between squirreltail and the other herbaceous plants would not be expected. The highly significant positive coefficients indicate more than a lack of competition, however. Two hypotheses are apparent: (1) squirreltail is adapted to the same microsites as blue grama and the forbs, and since squirreltail grows at a different season both classes of plants can increase simultaneously on the better microsites, or (2) squirreltail either benefits or is benefited by the presence of blue grama or forbs.

Observations on the study plot indicate that there are probably some microsite effects involved in the squirreltail-blue grama-forb relationship. A plot-by-plot and species-by-species study of the data showed that the positive relationship between squirreltail and the forbs was perhaps strongest in the case of purslane. Purslane was largely confined to microsites with slightly less soil structure and a slightly darker soil color than the average for the study area, and on these plots production of squirreltail was higher than average. Other species of forbs, however, which did not appear to be more abundant on one microsite than on another, also contributed to the positive relationship with squirreltail. In addition, blue grama and the forbs may have provided some protection to new seedlings

Table 4. Matrix of partial correlation coefficients of weights of major species in the study plots.

Species	Bottlebrush squirreltail	Broom snakeweed	Cooper actinea	Western ragweed	Other forbs
Blue grama	+.401**	−.445**	−.434**	−.152	−.502**
Bottlebrush squirreltail		−.032	−.032	+.038	+.406**
Broom snakeweed			−.137	−.205*	−.115
Cooper actinea				−.099	−.214*
Western ragweed					+.121

* Indicates significance at the 5 per cent level.
** Indicates significance at the 1 per cent level.

of squirreltail, which could possibly result in a positive relationship.

Summary

Selective phenoxy sprays applied to broom snakeweed and Cooper actinea reduced the weight of these half-shrubs on study plots about 90 and 60%, respectively. As a result of reductions in half-shrubs, blue grama on the treated plots increased 14 to 38% over the untreated check plots. Bottlebrush squirreltail and forbs also increased on the sprayed plots. Squirreltail production was positively related to production of blue grama and forbs, but not directly related to the amount of half-shrubs. Blue grama production was inversely related to the amount of half-shrubs and forbs.

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