Competition Between Big Sagebrush and Seeded Grasses on Foothill Ranges in Utah[1]

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On foothill rangelands of the Intermountain area it is a common practice to remove big sagebrush *(Artemisia tridentata)* prior to seeding grasses. This practice has proved to be successful in many respects, but sagebrush frequently reinvades and reduces the production potential of the seeded grass. Reinvasion occurs even in areas where good stands of grass have been obtained and grazing by livestock has been light.

Competition between big sagebrush and grass may be considerable since the growth of both is determined by the availability of soil moisture during late spring and summer.

The investigation reported herein was initiated in the spring of 1957 on seeded foothill range in central Utah where sagebrush had reinvaded following plowing and seeding operations. The extent of competition between sagebrush and grass was determined by studying differences in soil moisture, grass production, and grass vigor between areas treated with herbicide to control sagebrush and those left untreated. The extent of root development by sagebrush and grass on untreated areas was also studied.

Review of Literature

Reinvasion of sagebrush following its control is to be expected according to Hyder (1954). The period of most active reestablishment of sagebrush subsequent to its control has been reported to occur immediately after brush removal (Frischknecht and Bleak, 1957). Their study showed that approximately three-fifths of the sagebrush plants counted at the end of ten years following seeding had become established within two years after removal. Blaisdell (1949) found that as young sagebrush plants became larger they caused a reduction in grass density and yield, and eventually gained a prominent position in the stand.

Robertson (1947) noted that brush eradication increased forage production through increased vigor of the native grasses. Numerous studies have shown that eradication of sagebrush increased ground cover and production of native grasses (Alley and Bohmont, 1958; Alley, 1956; Hyder, 1954; Hull *et al.*, 1952; and Cornelius and Graham, 1951).

It was observed by Weaver and Clements (1938) that the taproot system of big sagebrush branched widely and penetrated to a depth of five to 11 feet. In addition, a highly developed system of laterals allowed absorption in the shallower soil depth. A tendency of sagebrush roots to concentrate above a depth of 15 inches was noted by Robertson (1943).

Experimental Area

The area studied is typical foothill range in central Utah. It is located on gentle, rolling ground adjacent to the steeper foothill slopes. The soil is a light brown silt loam, weakly calcareous, and somewhat structureless, breaking into single grains.

A clay hard pan exists at depths ranging from 14 to 22 inches. Coarse gravel imbedded in clay occurs from 14 to 30 inches below the soil surface.

The mean annual precipitation at Eureka, Utah, near the study area for the period of 1931-1955 was 14.5 inches, eight inches of which fell between December and May. Precipitation during the years 1957 to 1961, while the study was in progress, amounted to 13.7, 10.6, 12.6, 11.2, and 12.9 inches, respectively. The precipitation during 1962 prior to termination of the study was about average.

The experimental pastures were plowed in the summer of 1951 to eradicate big sagebrush, and various pastures were seeded the following fall to mixtures or pure stands of crested wheatgrass *(Agropyron cristatum)*[2], intermediate wheatgrass *(Agropyron intermedium)*, or tall wheatgrass *(Agropyron elongatum)*. A reasonably good stand of grass was established, yet sagebrush reinvasion was rapid and extensive. By 1957, the sagebrush had gained a uniform and dense distribution over the entire seeded areas. A good stand of seeded grass remained, but the competition with sagebrush had greatly reduced its productiveness.

Methods and Procedures

The pastures were about 70 acres in area and were grazed lightly by sheep during the spring of each year, starting in 1954, until the areas were treated with herbicide.

In 1957 and 1958 areas of seeded crested and intermediate wheatgrass were treated, in 1959 areas of crested and tall wheatgrass were treated, and in 1960 areas seeded to tall wheatgrass and mixtures of the three spe-

[1] *A cooperative study between the Utah Agr. Exp. Sta. and the Bureau of Land Management.*

[2] *The crested wheatgrass seeded was a commercial purchase and contained both Standard and Fairway varieties of crested wheatgrass.*

cies were treated. Herbicide (2,4-D, 50 percent isopropyl and 50 percent butyl ester) was applied in all instances at the rate of three pounds of active acid per acre during the last week in May to control sagebrush on the experimental plots. All treatments were applied in two replications in each pasture for each species in plots 80 feet wide and 1000 feet long. All treated areas were protected from grazing for three growing seasons following the application of herbicide.

A jeep-mounted power sprayer that had a 20-foot boom fitted with No. 1 nozzles under a pressure of about 70 pounds per square inch was used to apply the herbicide.

Data on the effectiveness of herbicide application in killing the sagebrush were collected the year following treatment by using a 100-foot belt transect one-foot wide. Seven of these transects were randomly located in each treated area. An estimate of foliage reduction as a result of the herbicide was recorded for each sagebrush plant encountered in the transects.

Soil moisture samples were collected during three successive summers following each spray treatment. Paired soil samples in sprayed and unsprayed areas were taken at three depths (one, two, and three feet). Twelve sample locations, equal distances apart, were established in both the treated and untreated areas.

Grass production was determined each fall for three years following treatment. Herbage production was measured by clipping circular plots 9.6 square feet in area. Grass plants in the paired plots of sprayed and unsprayed areas were clipped at one inch above the ground. For each treatment comparison, 25 paired plots were clipped. In each plot a random plant in the northwest quarter was measured for height and leaf length.

Root studies were made on untreated areas during the fall of 1959 by digging a trench five feet deep and five to 30 feet long with a back hoe digger mounted on a tractor. With the aid of an ice pick, the soil was removed from around the roots. Measurements were made of the distribution of roots of both grass and sagebrush plants growing adjacent to one another in a four-inch wide bisect dissecting the center of the individual plants.

The number of sagebrush plants for age groups was determined in each untreated area by counting the number of plants intercepted by a line transect 100 feet long. Ten transects were recorded in each replication. The age of sagebrush present in the control areas was determined by counting growth rings on a random sample consisting of 420 plants.

Results and Discussion

In the fall of 1959 most sagebrush plants in the study area were seven to eight years of age. Slightly more than 71 percent of the sagebrush plants had become established within two years after brush removal. This was concurrent with the establishment of the seeded grasses.

The degree of brush invasion was somewhat different on the

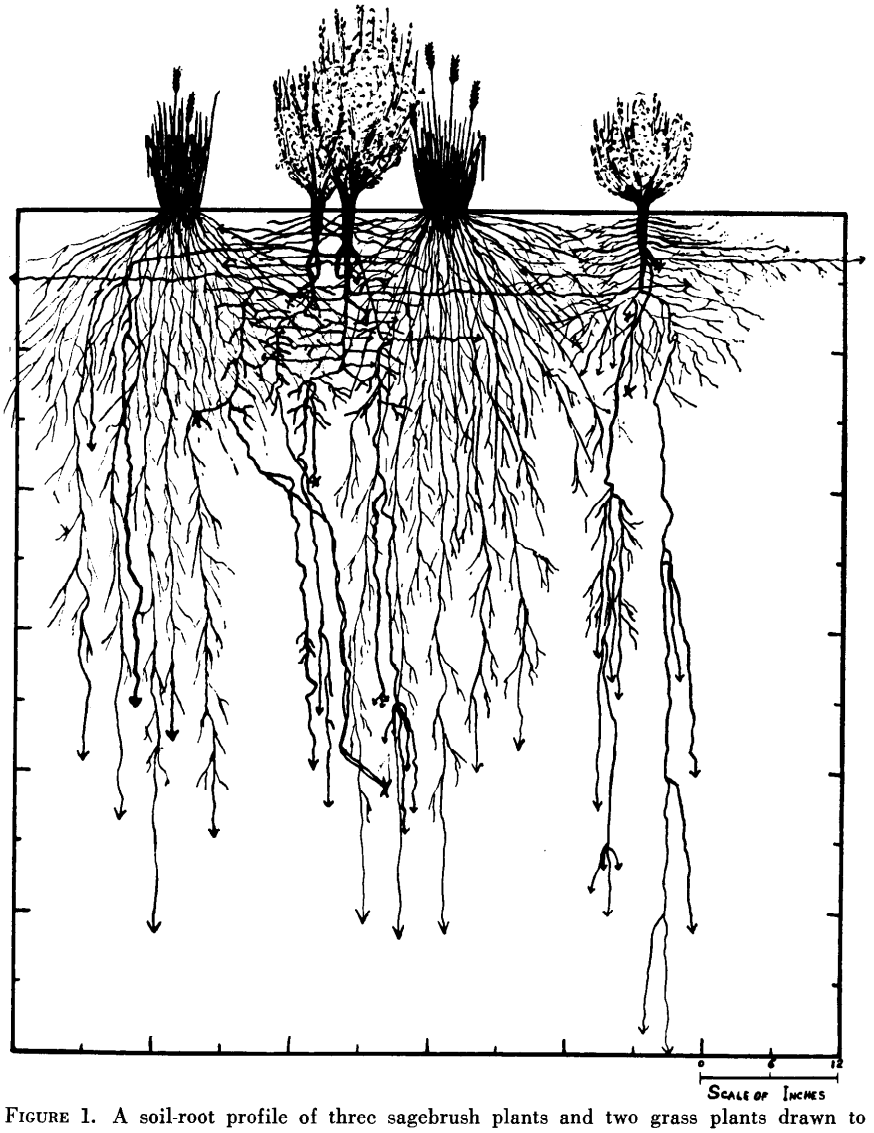

FIGURE 1. A soil-root profile of three sagebrush plants and two grass plants drawn to scale as they were actually found in the field. Scaled in six-inch intervals to a maximum depth of 72 inches.

Table 1. Average measurements of wheatgrass and big sagebrush plants on untreated areas.

Maximum depth	Concentration zone depth	Concentration zone width	Average lateral root spread[1]	Crown diameter	Plant height	Number roots from crown	Number roots at max. depth	Number plants studied
			(Inches)					
Sagebrush 7-8 years old								
60.0[2]	10.7	12.4	34.4	.84	13.0	1.0	2.9	43
Sagebrush 2-3 years old								
21.7	6.5	4.7	11.9	.20	4.2	1.0	2.0	19
Intermediate wheatgrass 8 years old								
54.9	11.2	13.1	22.3	—	16.8	68.4	6.4	15
Crested wheatgrass 8 years old								
58.1	10.2	12.6	23.9	3.0	14.3	59.9	3.5	18
Tall wheatgrass 8 years old								
50.8	10.5	14.4	24.2	4.1	19.5	66.9	3.5	13

[1] Represents diameter of lateral root spread beneath the plant.
[2] A few sagebrush roots penetrated beyond this depth, but no grass roots were observed to go deeper.

areas treated during the various years. The area treated in 1957 had an average of 32.1 plants per 100 square feet and a canopy cover of 12.6 percent; the area sprayed in 1959 had only 14.9 plants per 100 square feet and a 7.3 percent canopy cover. Areas sprayed in 1958 and 1960 had less sagebrush invasion than the areas sprayed in 1957 but more than the areas sprayed in 1959.

Kill of Sagebrush

The control of sagebrush varied with year of treatment. During 1960 the herbicide killed 96.8 percent of the plants and 99.5 percent of the foliage; in 1959 only 58.9 percent of the sagebrush plants were killed and only 76.3 percent of the foliage. The control of sagebrush in the other two years of the study were intermediate between 1960 and 1959.

Root Distribution of Sagebrush and Grass

The roots of big sagebrush and grass were found to be in the same general zones (Figure 1).

The zone of root concentration for the older sagebrush plants and the three species of grass was approximately 11 inches deep and 12 to 14 inches in diameter (Table 1). The area of root concentration of young sagebrush plants was approximately one-fifth that of the older sagebrush plants. Average lateral root spread was 34.4 inches, 22.3 inches, 23.9 inches, and 24.2 inches for sagebrush, intermediate, crested, and tall wheatgrass, respectively. The longer lateral roots of sagebrush frequently would extend completely through and beyond the zone of root concentration of adjacent grass plants. A few of the older sagebrush plants had maximum lateral diameters of more than 50 inches. The spread of roots for all three species of grass was somewhat less than the spread of roots of the older sagebrush plants (Table 1).

The average maximum depths of the roots were 21.7, 54.9, 58.1, and 50.8 inches for younger sagebrush, intermediate, crested and tall wheatgrass plants, respectively. Approximately three branches of the main taproot of the older sagebrush plants penetrated beyond the bottoms of the trenches which were dug to a depth of 60 inches. The grass roots at maximum depth were small and not widely branched.

This study verified that sagebrush has a branching taproot with a highly developed system of lateral roots that tend to con-

FIGURE 2. Experimental area on seeded foothill range showing response of intermediate wheatgrass (at left) to control of sagebrush with herbicides. Picture was taken 3 years after spraying and 9 years after seeding.

centrate in the zone above 15 inches as reported by Robertson (1943) and Weaver and Clements (1938). All three species of wheatgrass appear to have a zone of root concentration almost identical with that of sagebrush. In addition, sagebrush roots were found at maximum depths of all grass roots. Thus, direct competition for available soil moisture exists between sagebrush and grass because they have similar root distributions and the plants are actively growing during the same season. During extreme drought older sagebrush plants would have the advantage over grasses because of deeper root penetration.

Soil Moisture

Differences in soil moisture among the areas occupied by the various grass species cannot be compared because years were confounded with species treated. Differences between sprayed and unsprayed areas, however, can be compared statistically.

In most cases the percent soil moisture was significantly greater on sprayed plots at the two- and three-foot depths during the first two growing seasons, but in only one case was the difference significantly greater in the surface foot (Table 2). No significant differences in soil moisture were found between sprayed and unsprayed area during the third year following treatment. Differences in soil moisture on sprayed plots compared to unsprayed plots increased soil depth (Table 2).

Grass Response

Production: Three years after the original seedings were made, production averaged 699 pounds per acre for crested, 719 for intermediate, and 783 for tall wheatgrass (Table 3). After four to seven years of light use and reinvasion by sagebrush, these same pastures were producing from 30 to 70 percent less forage. This reduction was believed to be primarily a result of sagebrush invasion since ungrazed exclosures in each of the experimental pastures showed comparable reductions in forage yield over the same period.

Comparisons of production among the seeded species following the application of herbicide are not possible since the species were not all treated or harvested the same years. Production differences between sprayed and unsprayed areas can be compared. Grass production was significantly increased in all cases by spraying (Figure 2). The average increase was 688 pounds per acre for crested wheatgrass, 322 pounds for intermediate wheatgrass, and 855 pounds for tall wheatgrass (Table 3).

Production on sprayed areas was greatest after the second or third growing season following treatment. Differences in production between the sprayed and unsprayed areas also were greatest after the second or third year except for intermediate wheatgrass. The difference in yield of intermediate wheatgrass

Table 2. Average soil moisture on sprayed and unsprayed areas for three seeded wheatgrass species during July and August for three years following the application of herbicides.[1]

Year following treatment[2]	Depth	Crested Wheatgrass			Intermediate Wheatgrass			Tall Wheatgrass		
		Sprayed	Unsprayed	Diff.	Sprayed	Unsprayed	Diff.	Sprayed	Unsprayed	Diff.
	Feet	(Percent)								
1	1	8.9	8.2	0.7	9.1	6.9	2.2*	10.1	9.2	0.9
	2	10.6	9.6	1.0*	9.8	8.2	1.6*	10.7	9.6	1.1*
	3	11.8	9.7	2.1*	10.7	8.2	2.5*	10.8	9.7	1.1*
	avg.	10.4	9.2	1.2**	9.9	7.8	2.1**	10.5	9.5	1.0*
2	1	8.8	8.0	0.8	6.4	5.9	0.5	8.7	8.1	0.6
	2	9.1	8.4	0.7	7.4	6.3	1.1*	10.1	9.4	0.7
	3	10.2	8.5	1.7*	8.1	6.7	1.4*	10.7	9.2	1.5**
	avg.	9.4	8.3	1.1**	7.3	6.3	1.0**	9.8	8.9	0.9*
3	1	8.2	8.1	0.1	8.0	7.9	0.1	6.6	7.2	—0.6
	2	9.3	9.0	0.3	8.7	8.7	0.0	9.8	10.0	—0.2
	3	9.5	9.4	0.1	9.0	8.9	0.1	10.1	10.1	0.0
	avg.	9.0	8.8	0.2	8.6	8.5	0.1	8.8	9.1	—0.3

[1] Average percent moisture at wilting point (wilting coefficient at 15 atmospheres pressure) is 10.0, 8.9, and 9.0 at the one-, two- and three-foot levels, respectively.

[2] Averages for crested wheatgrass include three separate sprayings during three separate years, 1957-58-59. Intermediate wheatgrass and tall wheatgrass include two separate sprayings during two separate years, 1957-58 and 1959-60, respectively.

*Statistically significant at the .05 probability.

**Statistically significant at the .01 probability.

Table 3. Average air dry production, plant height, and leaf length for the wheatgrasses where sagebrush competition was controlled by the application of herbicide compared to untreated areas.

Species[1]	Treatment	1954 Production[2]	Production following spraying			Plant height			Leaf length		
			1st year	2nd year	3rd year	1st year	2nd year	3rd year	1st year	2nd year	3rd year
			(lbs/acre)			(cm)					
Crested wheatgrass	Sprayed		974	869	1012	63	40	41	10.9	9.4	10.4
	Unsprayed	699	360	273	314	59	42	40	10.2	9.3	10.3
	Difference		614**	596**	688**	4*	—2	1	0.7	0.1	0.1
Intermediate wheatgrass	Sprayed		882	782	934	78	65	60	24.0	19.0	18.2
	Unsprayed	719	560	630	624	57	53	54	19.5	17.3	17.0
	Difference		322*	152*	310**	21**	12*	6	4.5**	1.7	1.2
Tall wheatgrass	Sprayed		505	1188	1065	53	93	82	23.6	29.6	27.7
	Unsprayed	783	260	333	325	45	83	78	20.2	25.5	26.2
	Difference		245*	855**	740**	8*	10*	4	3.4*	4.1*	1.5

[1]Averages for crested wheatgrass include three separate sprayings during three separate years, 1957-58-59. Intermediate wheatgrass and tall wheatgrass include two separate sprayings during two separate years, 1957-58 and 1959-60, respectively.

[2]Areas seeded in 1951. Production taken at end of third growing season.

*Statistically significant at the .05 probability.

**Statistically significant at the .01 probability.

on sprayed and unsprayed areas was slightly higher the first year following treatment compared to the second or third year.

Vigor: Plant vigor was evaluated on the basis of plant height and leaf length. Height of grasses was always greatest on sprayed areas (Table 3). Differences were more pronounced during the first and second year following treatment. Three years after treatment differences were only slight.

Leaves of all three species of grasses were somewhat longer in the sprayed areas. Such differences were generally greater during the first and second year following treatment compared to the third year (Table 3). These differences were statistically significant only for intermediate wheatgrass during the first year following treatment, and for tall wheatgrass during the first and second year following treatment.

Summary

From 1957 to 1962 a study was conducted on foothill range in central Utah to determine the competitive effect of sagebrush on seeded grasses.

About 71 percent of the reinvading sagebrush present in the seeded areas was established two years after brush removal. The intensity of brush invasion ranged from 32.1 to 14.9 plants per 100 square-foot plot.

Death of brush from 2,4-D esters varied from 96.8 to 58.9 percent.

The zones of root concentration for sagebrush and the three seeded wheatgrasses were approximately the same. The average maximum depth of roots for the wheatgrasses was 51 to 58 inches while roots of the older sagebrush plants penetrated beyond 60 inches. Thus, direct competition for soil moisture is indicated between sagebrush and grass.

Soil moisture was significantly higher in sprayed than in unsprayed areas during the midsummer for two years following treatment. This difference increased with increased soil depth. No significant differences in soil moisture between sprayed and unsprayed plots were found during the third summer following treatment.

Yields increased after spraying by as much as 688 pounds per acre for crested wheatgrass, 322 pounds for intermediate wheatgrass, and 855 pounds for tall wheatgrass.

Grass plants on sprayed areas were taller and had longer leaves than plants on unsprayed areas during the first two years following treatment. Differences were only slight during the third year.

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