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COMPETITION BETWEEN SAGEBRUSH SEEDLINGS AND RESEEDED GRASSES [1]

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Knowledge of the effects of competition between sagebrush (*Artemisia tridentata* Nutt. and *A. tripartita* Rydb.) and reseeded grasses is a basic requirement for effective reseeding on extensive areas of depleted sagebrush-grass range in the Intermountain region. Studies have shown that water is the factor for which plant competition is usually greatest, especially in semiarid regions where the subsoil is perennially dry (Clements, Weaver, and Hanson, '29, and Piemeisel, '38). Sagebrush not only has a deep root system, but also a highly developed system of laterals which absorb from the shallower soils (Weaver and Clements, '29); consequently, it offers keen competition for the limited soil moisture typical of much of the sagebrush-grass type.

Sagebrush competition has received considerable attention in connection with range reseeding. Numerous investigators have reported that elimination of sagebrush is essential to success of reseeded species (Stoddart, '46, Stoddart and Smith, '43, Hull, '44, Hull and Pearse, '43, Pechanec *et al.*, '44). Robertson and Pearse ('45, '46) found that stands of grass in areas from which sagebrush had been removed prior to seeding were much more satisfactory than those planted in undisturbed sagebrush. They concluded that well-established, undisturbed stands of sagebrush are essentially closed to artificial reseeding. Robertson ('43) suggested that fall pruning of sagebrush roots could be expected to increase storage of soil moisture and promote establishment of grass seedlings. Robertson ('47) concluded that mature sagebrush plants dominated the area within a radius of roughly one meter and that as stands are reduced to wider spacings, release from competition will make conditions progressively better for growth of grasses.

Apparently, there is general agreement that sagebrush competition must be partially or entirely eliminated to insure success of reseeded species. The studies mentioned, however, all apply to well-established stands of sagebrush; the problem of competition between reseeded species and sagebrush seedlings has been given little attention. From preliminary studies, Hull ('41, '43) found that 3-year-old grass stands significantly decreased vegetative growth and reproductive vigor of 3-year-old sagebrush plants, but did not affect sagebrush plant numbers. This paper describes several studies which deal directly with the competition between sagebrush seedlings and reseeded grasses.

METHODS

The studies were conducted on abandoned farm land which had become occupied by sagebrush, at two locations in the sagebrush-grass type of Clark County, Idaho. One area, at the U. S. Sheep Experiment Station near Dubois, has an elevation of 5,500 feet and average annual precipitation of 10.8 inches. The other area, near Kilgore, has an elevation of 6,000 feet and average annual precipitation of approximately 17 inches. The sagebrush occurring on the area near

[1] This study was conducted by the Intermountain Forest and Range Experiment Station, U. S. Department of Agriculture, Forest Service, in cooperation with the Bureau of Animal Industry, at the U. S. Sheep Experiment Station, Dubois, Idaho.

[2] The author wishes to acknowledge the work of A. C. Hull, Jr., now with the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo., who established this study and collected the initial data.

Dubois is chiefly *Artemisia tripartita* whereas the sagebrush on the Kilgore area is chiefly *A. tridentata.*

At each location, an area 80 × 120 feet was selected and divided into two blocks, each containing 12 plots, 20 × 20 feet in size. Treatments were assigned at random to the plots within each block.

This study was designed to provide two 5-year replications within each block. In one replication, it was planned to drill a mixture of grasses on one plot each year from 1940 to 1944, and to sow sagebrush on all five plots in 1942. In the other replication, it was planned to drill the grass on one plot each year from 1941 to 1945, and to sow sagebrush on all five plots in 1943. In addition, two plots were to be sown to sagebrush alone, one in 1942 and another in 1943. It was necessary to sow the sagebrush because favorable years for natural sagebrush seedling establishment come at irregular intervals.

Through the use of this system, four plots at each location would be planted to grass under each of the five following conditions: (1) 2 years before sagebrush, (2) 1 year before sagebrush, (3) simultaneously with sagebrush, (4) 1 year after sagebrush, and (5) 2 years after sagebrush. In addition, four plots would be sown to sagebrush alone at each location.

The study was carried out as planned except that grass plantings scheduled for 1944 and 1945 were delayed until 1945 and 1946, respectively. Due to this change, only two plots at each location were planted to grass 1 and 2 years after sagebrush, and four plots were planted 3 years after sagebrush.

Before planting grass or sagebrush, all vegetation was completely removed from the plots. *Artemisia tripartita* was sown on the plots near Dubois, and *A. tridentata,* on the plots near Kilgore. Responses of both sagebrush and grasses

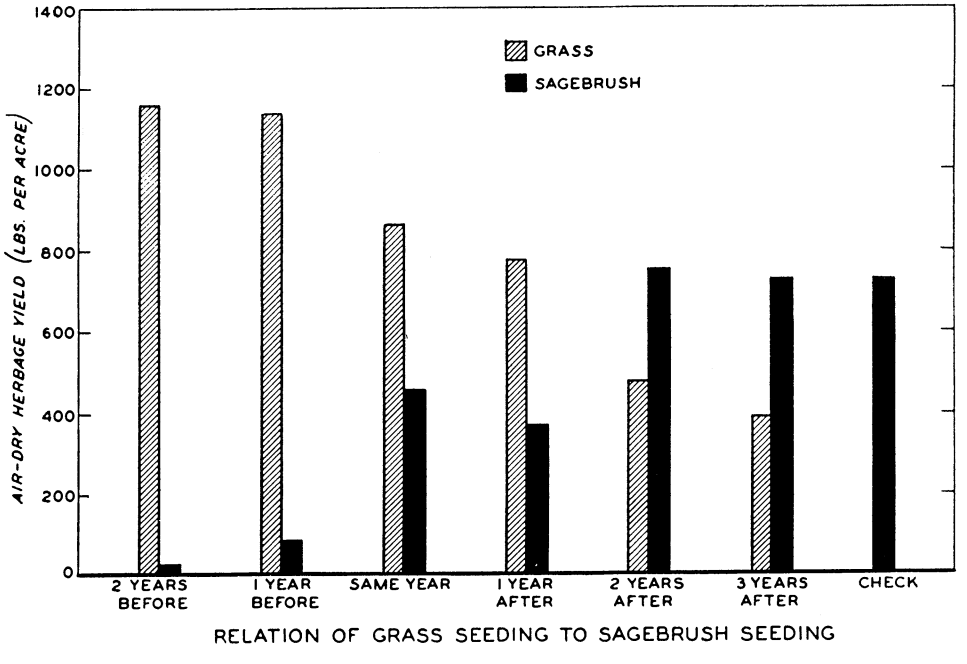

FIG. 1. Average yields of sagebrush and grass species as measured in 1948. The grasses were sown at various times, before, concurrently with, and after the sagebrush sowings which were made in 1942 and 1943.

were measured by weight estimates and plot ratings.[3]

Results and Discussion

Plot averages in 1948 show that the grass yields were much larger than sagebrush on plots seeded to grass prior to or at late as 1 year after sagebrush (fig. 1); however, sagebrush yields were much larger than grass on plots seeded to grass 2 or 3 years after sagebrush. The yield of grass varied inversely with the age of the sagebrush stand, but the yield of sagebrush was less directly affected by age of the grass. Yield of 2- and 3-year-old stands of sagebrush was not influenced by grass; these sagebrush stands produced as much herbage as the check plots in which no grass was planted. Apparently the young stands of pure sagebrush were unable to make full use of the available water and nutrients.

There were noticeable departures from the average pattern shown in figure 1 in only 3 of the 40 plots seeded to both grass and sagebrush (table I). Further examination of this table shows that there is a negative correlation between yields of grass and sagebrush on individual plots, producing a highly significant correlation coefficient ($r = -0.477$). In other words, high yields of grass were generally associated with low yields of sagebrush irrespective of relative ages. Plot ratings show that on the average there are sufficient plants to produce a "good" or "very good" stand of grass on all plots and that there are enough sagebrush plants to produce a "good" or "very good" stand on all plots except those on

[3] Plot ratings were made on the following basis: 1–2, very poor; 3–4, poor; 5–6, fair; 7–8, good; 9–10, very good. Weight estimates were made of the non-woody, aerial portions of the plants on circular subplots located within each plot.

Table I. *Air-dry herbage yields and average plot ratings of sagebrush and grass seeded on the same plots at various times*

Yield and seeding times of grass in relation to sagebrush												Sagebrush check plot
2 years before		1 year before		Same year		1 year after		2 years after		3 years after		
Grass	Sage	Grass	Sage	Grass	Sage	Grass	Sage	Grass	Sage	Grass	Sage	
Pounds per acre												
Dubois												
1,063	26	778	24	760	310	475	386	153	523	288	350	250
1,112	0	573	113	939	329	251	439	202	756	219	530	161
896	82	838	48	602	228	—	—	—	—	193	305	658
1,270	0	746	185	521	245	—	—	—	—	164	593	480
Kilgore												
1,428	38	1.452	175	766	919	1,207	264	873	1,205	360	1,042	1,200
1,354	19	1,826	38	973	576	1,181	386	714	518	504	1,334	1,090
1,218	58	1,431	77	1,135	331	—	—	—	—	763	818	979
973	12	1,486	22	1,166	746	—	—	—	—	645	816	970
Average yield												
1,164	29	1,141	85	858	460	778	369	486	750	392	724	724
Average plot rating												
10.0	2.4	9.5	6.8	9.2	8.6	9.5	7.0	7.8	9.5	7.8	8.8	8.9

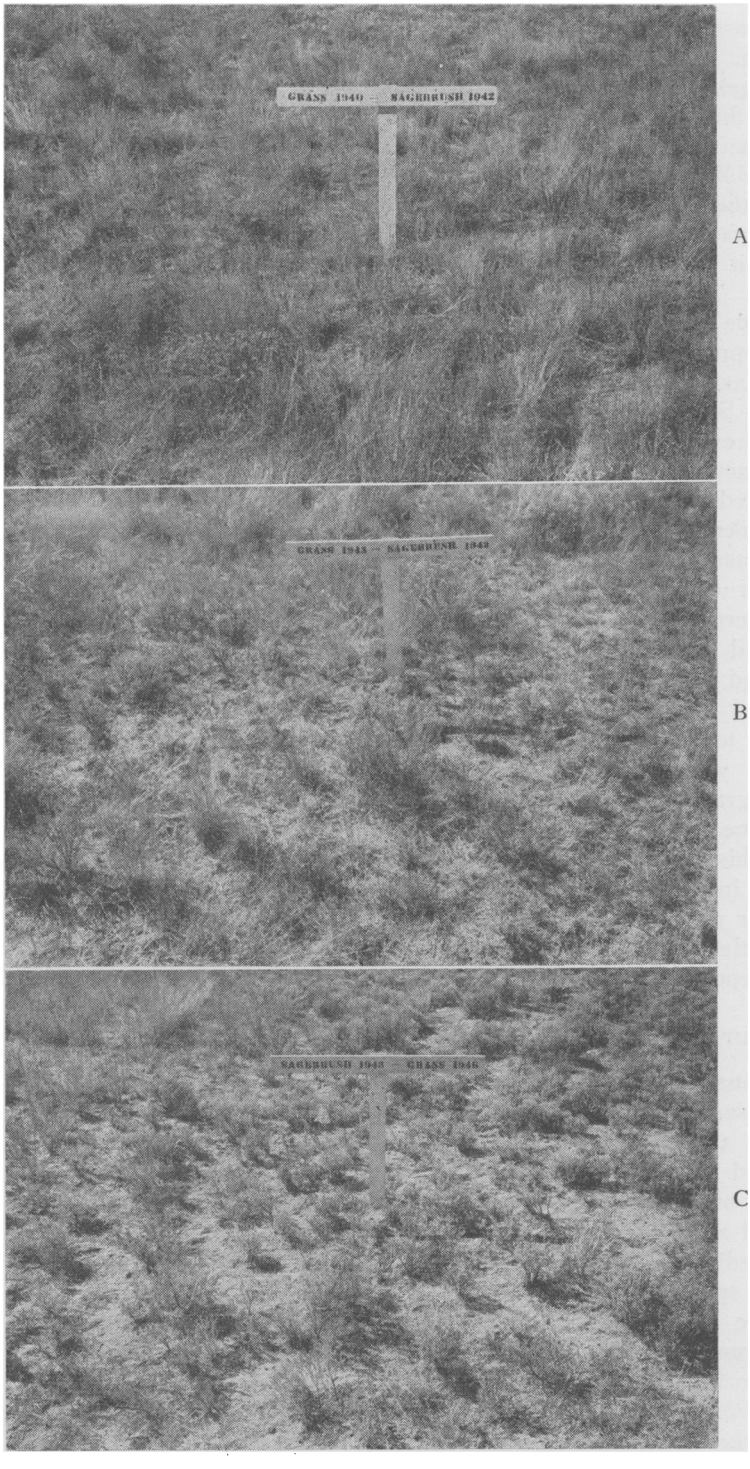

FIG. 2. Appearance of reseeded plots on the Dubois area in 1948. A. Plot seeded to grass in 1940 and to sagebrush in 1942. B. Plot seeded to grass and sagebrush in 1943. C. Plot seeded to sagebrush in 1943 and to grass in 1946.

which grass was seeded 2 years before sagebrush. Apparently competition between sagebrush and grass was the chief factor influencing their relative yields rather than inability of the plants to become established. Figure 2 shows typical plots on the Dubois area.

Good stands of grass often prevented subsequent establishment of sagebrush seedlings. Where sagebrush seedlings did invade the stand, they were very much suppressed. Prior establishment of grass by as little as 1 year was very important. Stands of sagebrush seedlings did not prevent subsequent establishment of satisfactory grass stands, but did greatly reduce grass yields. Evidently establishment of a satisfactory grass stand does not assure a satisfactory yield where sagebrush competition is present. On plots where sagebrush and grass were established concurrently, the grass has maintained the advantage. The relative amount of sagebrush on all the plots is expected to increase somewhat in the next few years; it is slower maturing than the grasses and has not yet had sufficient time to offset their initial advantage. This is supported by the large increases in sagebrush yield and the decreases or only slight increases in grass yields in the second of the supplementary studies reported below.

Supplementary Studies

Additional information on competition between sagebrush and grass was provided by two other studies previously established at the Kilgore area. This area was burned during the summer of 1937, and a good stand of natural sagebrush seedlings became established the following spring.

In one study, crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.) was planted on 24 plots each fall for a 4-year period, 1939 to 1942; consequently, the crested wheatgrass was planted into 2-, 3-, 4-, and 5-year-old stands of sagebrush. Success of crested wheatgrass was measured by plot ratings, and survival of sagebrush, by plant counts.

Plot ratings in 1945 showed that the stands of crested wheatgrass were reduced as seedings were made into older and older sagebrush stands. The average ratings for plots planted in the various years were: 1939 = 8.8, 1940 = 7.0, 1941 = 6.1, and 1942 = 4.2. This suggests that the 2-year-old stands of sagebrush into which crested wheatgrass was planted in 1939 offered less competition for moisture than did the 3-, 4-, and 5-year-old stands into which subsequent grass seedings were made. Plant counts, on the other hand, indicate that success of the crested wheatgrass had little effect on sagebrush already established. Sagebrush numbers averaged essentially the same on plots planted to crested wheatgrass in 1939 as on plots planted in 1942, even though the 1939 grass stand had a rating over twice as great.

This study shows that as stands of sagebrush become older, the establishment of satisfactory grass stands becomes more and more difficult. Seeding into 2- and 3-year-old stands of sagebrush produced stands of crested wheatgrass which rated "good" to "very good," whereas comparable seedings into 4- and 5-year-old stands of sagebrush produced only "poor" to "fair" grass stands. However, sagebrush numbers in this study were not affected by crested wheatgrass, nor was yield of 2- and 3-year-old sagebrush stands affected by the grass mixture in the main study in which sagebrush was sown. After reaching the age of 2, sagebrush plants are apparently well enough established so that grass offers them little or no competition. However, a good stand of grass will probably prevent an increase in sagebrush numbers.

The second supplementary study was one testing adaptation of several grasses to this area. In the fall of 1937, plots of crested wheatgrass, slender wheatgrass (*Agropyron trachycaulum* (Link) Malte), smooth brome (*Bromus inermis* Leyss.), bluebunch wheatgrass (*Agropyron spi-*

TABLE II. *Row spacing, plot ratings, and herbage yields of seven grasses seeded on a burned area near Kilgore, Idaho in 1937*

Species	Row spacing	Average rating				Average herbage yielded	
		1938	1940	1941	1948	1940	1945
	Inches					*Pounds per acre*	
Crested wheatgrass	6	10	10	10	7	3,892	2,355
	12	10	10	10	8	3,598	2,398
	18	5	8	10	8	3,240	2,211
	24	8	9	10	9	3,546	2,141
Slender wheatgrass	12	9	9	10	4	2,478	487
Bluebunch wheatgrass	12	4	8	9	9	1,044	1,557
Tall oatgrass	12	2	4	8	9	507	—
Mountain brome	12	7	7	8	3	642	—
Smooth brome	12	5	8	10	10	1,454	1,833
Sheep fescue	12	2	7	9	10	500	—

catum (Pursh) Scribn. & Smith), mountain brome (*Bromus carinatus* Hook & Arn.), tall oatgrass (*Arrhenatherum elatius* (L.) Mert. & Koch), and sheep fescue (*Festuca ovina* L.) were drilled in rows spaced 12 inches apart. In addition, plots of crested wheatgrass were drilled at 6-, 18-, and 24-inch row spacings. Development of sagebrush seedlings was measured by plant counts and weight estimates, and success of the grasses, by plot ratings and weight estimates.

The development of stands of grass established concurrently with sagebrush seedlings in this study was not impaired by the sagebrush competition. Stands of grass that were initially very good maintained themselves, and poorer stands improved until in 1941 all rated "good" or better (table II). Since that time, however, yields of many species have decreased and stands have thinned out, mountain brome and slender wheatgrass most noticeably.

In 1940, 3 years after the study was begun, there were no significant differences between sagebrush numbers on the various plots (table III). The plants on the unseeded plots were much larger, however, as shown by the significantly larger yield of sagebrush herbage on these plots. Counts made in 1948 showed that sagebrush numbers had changed little

TABLE III. *Average air-dry sagebrush yields and numbers on plots seeded to grass on a burned area near Kilgore in 1937*

Grass species on plot	Row spacing	Sagebrush herbage yield		Sagebrush numbers per acre	
		1940	1948	1940	1948
	Inches	*Pounds per acre*			
Crested wheatgrass	6	18	250	4,410	4,356
	12	20	270	4,452	4,704
	18	59	336	4,628	3,398
	24	46	269	4,396	3,659
Slender wheatgrass	12	56	440	4,043	6,708
Bluebunch wheatgrass	12	121	288	4,342	3,833
Tall oatgrass	12	171	273	5,146	4,008
Mountain brome	12	98	512	5,009	6,795
Smooth brome	12	57	148	3,553	3,659
Sheep fescue	12	190	283	6,180	4,617
Unseeded plot	—	383	1,012	6,480	16,291

during the 8-year interval except on the unseeded plots; on these there was a substantial increase. Apparently competition from the reseeded grasses prevented comparable increases in sagebrush numbers on the reseeded plots. Yield data, however, show that the sagebrush plants were able to increase in size. These larger plants probably competed more severely with the reseeded grasses and apparently were largely responsible for the reduction in yield and density of many grasses. Examination of tables 2 and 3 shows that most pronounced decreases in grass occurred on plots on which there were greatest net increases in sagebrush yield, whereas increases in grass generally occurred on plots having the least net increase in sagebrush yield.

Concurrent establishment of grasses and sagebrush gave an initial advantage to the grasses and resulted in a reduction in rate of sagebrush growth. Existing sagebrush numbers were not reduced, but grass competition apparently prevented any sizable increase, whereas sagebrush numbers continued to increase on the unseeded areas. For the first few years, the sagebrush seedlings were too small to have much effect on the grass, but as they became larger, they apparently competed with the grass and on many plots caused a reduction in grass density and yield. Different row spacings of crested wheatgrass had little effect on the resulting stand of grass or on sagebrush size or numbers.

Summary and Conclusions

Competition between sagebrush seedlings and reseeded grasses was studied at two locations in Clark County, Idaho.

A grass mixture was planted 1 and 2 years before sagebrush, simultaneously with sagebrush, and 1, 2, and 3 years after sagebrush. In addition, crested wheatgrass was drilled into 2-, 3-, 4-, and 5-year-old stands of sagebrush, and several other grasses were drilled concurrently with natural sagebrush seedling establishment. Relative success of the sagebrush and grass seedlings was measured by plot ratings, plant counts, and weight estimates.

Plot averages showed that grass yields were much larger than sagebrush on plots seeded to grass prior to or as late as 1 year after sagebrush, but sagebrush yields were larger than grass on plots seeded to grass 2 or 3 years after sagebrush. High yields of grass were generally associated with low yields of sagebrush. Suppression of established plants was chiefly responsible for yield differences rather than failure of plants to become established.

In a supplementary study seeding into 2- and 3-year-old stands of sagebrush produced stands of crested wheatgrass which rated "good" or "very good," whereas comparable seedings into 4- and 5-year-old stands of sagebrush produced only "poor" or "fair" stands of wheatgrass. Sagebrush numbers were not affected by success of crested wheatgrass.

Concurrent establishment of grasses and sagebrush in a second supplementary study gave an initial advantage to the grasses. As the sagebrush plants became larger, however, they apparently competed with the grasses and caused a reduction in grass density and yield on many plots.

From the results of these studies, the following conclusions are drawn with respect to sagebrush-grass range:

1. The effect of sagebrush competition on reseeded grasses depends chiefly upon their relative ages. The older the stand of sagebrush, the less chance there is for successful grass establishment and production.

2. Young sagebrush seedling stands may allow establishment of satisfactory grass stands, but they suppress the grass and cause a great reduction in yield. Older sagebrush stands may prevent grass establishment.

3. Sagebrush plants over 2 years of age are not greatly affected by grass subsequently established.

4. Good stands of reseeded grasses established prior to sagebrush suppress the sagebrush seedlings or entirely prevent sagebrush establishment for an indefinite period.

5. Due to their earlier maturity, reseeded grasses established concurrently with sagebrush have an initial advantage and suppress the sagebrush seedlings. The sagebrush, however, eventually gains a prominent position in the stand.

6. Sagebrush-grass mixtures produce a much higher total herbage yield than sagebrush grown alone.

7. Reseeding depleted ranges during the same year as sagebrush destruction by fire or mechanical means will give the reseeded species maximum opportunity to gain an advantage over sagebrush seedlings. Reseeding areas on which stands of sagebrush seedlings are already established is not recommended.

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