Establishment and Production of Grasses under semiarid conditions in the intermountain west

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Idaho Agricultural Experiment Station

Bulletin 532
July 1972

UNIVERSITY OF IDAHO
College of Agriculture

Contents

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The authors acknowledge the contributions of Russell H. Stark and Donald S. Douglas, managers of the Aberdeen Plant Materials Center during the establishment and harvest phases of these studies; Waldo Frandsen, former regional range conservationist (west) for assistance throughout the study; and state conservationists in Idaho, Nevada and Utah for providing personnel to help during harvest years.

AGRICULTURAL EXPERIMENT STATION

University of Idaho **College of Agriculture**

Moscow, Idaho **NR 2.5M 7-72**

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Large areas of land in the semiarid part of the intermountain west are used for grazing. Forage production is low with from 4 to 20 acres required for an animal-unit-month of feed. Much of this land can be successfully reseeded to adapted perennial grasses and can produce enough feed for one animal-unit-month of grazing per acre.

Extensive studies maintain that average annual precipitation should exceed 10 inches for successful seedings on semi-arid range lands (11, 13, 14). Negative results were reported from seeding a large number of grasses, forbs and shrubs on soils in the Gray Desert Soil Group where precipitation was 6 to 7.95 inches annually (2).

Research was needed on methods of reseeding semiarid rangelands that receive less than 10 inches of annual precipitation. Accordingly, this study was initiated in 1947 near Aberdeen, Idaho, where the 38-year average precipitation is 8.79 inches. This is the most intensive study reported for this kind of soil and under these severely limiting climatic conditions. Douglas et al. (5) presented a brief summary earlier.

The primary objectives of this study were to evaluate several methods of land preparation and several methods of seeding in fall and spring over a period of years. Secondary objectives were to evaluate several grass species or varieties for reseeding semiarid ranges and to evaluate various overstory-understory grass combinations for ground cover and erosion control (8, 12).

Procedure

Initial plantings were made in the fall of 1947 and most were repeated in the fall and spring for 5 successive years. Data were collected as soon as the stand was 3 years old. In most instances, data were collected each year until the study was terminated in 1955.

Site Description

The study site was located near Aberdeen, Idaho, on an area that had been cultivated 25 years ago. Since then, it had been invaded by cheatgrass, big sagebrush and rabbitbrush, and had been used for grazing.

The soil was classified as Portneuf silt loam. This series is a member of the coarse-silty, mixed, mesic family of Xerollic Calciorthids. This family of soils is in the subgroup Xerollic Intergrades of most Aridisols. The soils of this subgroup are shallow, usually dry more than one-half of the time the soil temperature at 20 inches is above 41 degrees F., but moist more than one-fourth of the time that this temperature is above 41 degrees F.· The average precipitation is 6 to 11 inches per annum.

The elevation is 4400 feet. Daily weather records of precipitation were available from a weather station 3 miles from the site. The annual precipitation during this study was below the 38-year average of 8.79 inches. In 6 of the 8 years, only 70 percent of this amount was received (Appendix table 1).

However, the more important feature of precipitation at this location is its incidence. The critical periods are the fall and spring months. These are the times when precipitation has the most profound effect on establishment and production of plants. Precipitation in the winter is on frozen ground and in the

· From the Supplement to Soil Classification System (7th Approximation). Soil Survey Staff, SCS-USDA, March 1967. Washington, D.C.

summer it is characteristically low and ineffective. Precipitation in the fall months was average or above average in only 2 of the 5 years of planting and was less than average in the other years. In 3 of the 5 years, precipitation was far below average in the spring.

The results reported in this study apply to a large area in the Western States mapped as R-1 in Agricultural Handbook No. 339 (8).

Site Preparation

Five methods of land preparation, three methods of planting, two dates of seeding and two grass mixtures were used in this range reseeding study. In addition, several grasses were planted in pure stands to determine adaptation. Combinations of overstory and understory species were planted to evaluate their possible use for ground cover and erosion control.

All methods of land preparation and methods of planting were made with standard farm machinery in plots 30 x 200 feet. Plantings were made in the fall and spring of each of 5 years but were not replicated within years.

Fall plantings were made in mid-October to avoid soil freeze-up. Seeding at this time often delays germination until late winter or early spring. Spring plantings were made soon after the soil had thawed sufficiently to use farm equipment. The delay from spring thaws to seeding time allowed surface soil to dry and made establishment more dependent on subsequent spring rains.

Two mixtures of grasses were used in the study of land preparation and seeding methods. The crested wheatgrass mixture contained standard crested wheatgrass (6 lb/acre), 'Sodar' streambank wheatgrass (4 lb/acre) and Sandberg bluegrass (2 lb/acre). In the second mixture Whitmar beardless wheatgrass (8 lb/acre) replaced crested wheatgrass.

Data Collection

Data on yield and live basal density were taken each year after the stands were 3 years old. It was intended to collect these data for 5 years but, unfortunately, it was necessary to terminate the experiment before 5 years' data could be collected from the later plantings.

The entire area used in this study was fenced to exclude livestock and jack rabbits. Owl perches were erected to control small rodents. The area was inspected regularly to prevent trespass grazing.

Live basal density, expressed as percent ground cover by the basal portion of the plants, was taken by species before each harvest from 10 quadrats of 10 square feet each within each plot (17). Each quadrat was marked and harvested by hand to a 2-inch stubble height. The components of each harvest were separated into planted grass and invading species, dried and weighed.

Statistical analysis involved the calculation of mean squares for all main effects and interactions. Higher order interactions were used to provide a pooled error term. Treatment comparisons were made using Duncan's Multiple Range Test at the .05 level.

Fig. 1 Crested wheatgrass mixture drilled in the fall on late burn. Heavy invasion of big sagebrush seedlings. This reached grazing readiness in 5 years.

Fig. 2 Crested wheatgrass mixture drilled in the fall on early burn. This seeding had a light invasion of sagebrush and reached grazing readiness in 4 years.

Methods of Land Preparation

Extensive or intensive cultural methods can be used to prepare land for range seedings. Little preparation is used for the extensive method and the initial cost is low. The cost increases as more intensive culture is employed. However, the increased cost in preparing a better seedbed usually insures good establishment, earlier grazing readiness and higher yields per acre.

The methods of land preparation used in this study were no treatment, early burn, late burn, cultivation, and summerfallow. Seedings were made directly into the cheatgrass when no treatment was used. Early burning was done about mid-June before the cheatgrass had set seed. Late burning was in September after the cheatgrass seed had shattered. Some regrowth of rabbitbrush and perennial grasses occurred with early burning. Patches of sagebrush remained in some plots following both early and late burning (Figs. 1, 2).

A tandem disk was used to prepare land by cultivation just prior to fall seeding. The seedbed was sometimes rough and not entirely free from standing brush. No additional treatment was given the cultivated land before planting the following spring. Land prepared by fallowing was plowed in the spring before the cheatgrass headed. This was early enough to conserve some soil moisture. The plots were rodweeded once or twice in late spring or early summer as needed, to control volunteer growth.

Fall and spring seedings were made on all land treatments with both mixtures for 5 successive years. Data on live basal density and yield were collected after the seedings were 3 years old to determine the effect of climate on establishment, ground cover and yield.

Results and Discussion

Yield

Average yield from fall seedings (table 1) was significantly higher than from spring seedings, 86 percent more with the crested wheatgrass mixture and 127 percent more with the Whitmar beardless wheatgrass mixture. In addition, the crested mixture outyielded the Whitmar mixture by 135 percent when fall seeded and by 186 percent when spring seeded.

Yields of the crested mixture on fallowed land were significantly higher than from other methods of land preparation for both fall and spring seeding. There were no differences in yield among the methods of land preparation for the Whitmar mixture in the fall. However, the yields from no preparation were lower than from the other methods. The yields for the spring-seeded Whitmar mixture were not different for fallow or cultivated land preparation but yields from both of these were higher than from the other methods.

Basal Density

The basal density of planted grass followed the trend in yield (table 1). The relationship was greater with the higher yielding crested mixture than with

Table 1. Effect of method of land preparation and time of planting on average yield and basal densities of the crested and Whitmar grass mixtures and invading perennials.

Method of land preparation	Crested wheatgrass mixture				Whitmar beardless wheatgrass mixture			
	Yield/acre		Basal density		Yield/acre		Basal density	
	Planted grass	Invading perennials	Planted grass	Invading perennials	Planted grass	Invading perennials	Planted grass	Invading perennials
	(lb.)	(lb.)	(%)	(%)	(lb.)	(lb.)	(%)	(%)
Fall-planted								
None	317d*	121	1.04c	.04	135b	133	.69b	.54
Early burn	473c	113	1.34b	.59	245a	143	1.11a	.48
Late burn	402cd	110	1.48b	.49	212a	125	1.13a	.48
Cultivated	530b	17	1.47b	.08	223a	61	.80b	.28
Fallow	780a	11	2.17a	.10	252a	34	1.14a	.13
Average	501	74	1.50	.34	213	99	.97	.38
Spring-planted								
None	136c	119	.40c	.52	29b	136	.27b	.43
Early burn	189c	99	.62b	.48	31b	192	.59a	.61
Late burn	160c	121	.65b	.64	76b	155	.64a	.61
Cultivated	319b	54	.76b	.25	185a	60	.62a	.29
Fallow	540a	13	1.36a	.02	149a	19	.55a	.06
Average	269	81	.76	.38	94	112	.53	.43

*Values followed by the same letter are not significantly different at the .05 level according to Duncan's Multiple Range Test.

Table 2. **Effect of year of planting and time of planting on average yield and basal density of the crested and Whitmar grass mixtures and invading perennials. All methods of land preparation and years of harvest were averaged.**

Year Planted	Crested wheatgrass mixture: Yield/acre: Planted grass	Crested wheatgrass mixture: Yield/acre: Invading perennials	Crested wheatgrass mixture: Basal density: Planted grass	Crested wheatgrass mixture: Basal density: Invading perennials	Whitmar beardless wheatgrass mixture: Yield/acre: Planted grass	Whitmar beardless wheatgrass mixture: Yield/acre: Invading perennials	Whitmar beardless wheatgrass mixture: Basal density: Planted grass	Whitmar beardless wheatgrass mixture: Basal density: Invading perennials
	(lb.)	(lb.)	(%)	(%)	(lb.)	(lb.)	(%)	(%)
				Fall-planted				
1947-48	933a	25	2.40a	.14	602a	82	1.77a	.34
1948-49	334c	270	1.27bc	1.25	159b	330	.74c	1.33
1949-50	303c	43	1.07c	.15	61c	36	.85bc	.11
1950-51	548b	16	1.30b	.08	63c	21	.44d	.07
1951-52	384c	17	1.46b	.07	163b	26	1.04b	.07
Average	501	74	1.50	.34	213	99	.97	.38
				Spring-planted				
1947-48	630a	58	1.49a	.21	273a	134	.98a	.52
1948-49	272b	302	.87b	1.52	116b	321	.89a	1.37
1949-50	145c	24	.46c	.08	7c	41	.26b	.11
1950-51	198bc	7	.63c	.04	45c	37	.21b	.09
1951-52	104c	17	.47c	.07	29c	29	.33b	.07
Average	269	81	.76	.38	94	112	.53	.43

* Values followed by the same letter are not significantly different at the .05 level.

Table 3. **Effect of age of stand, time of planting and method of land preparation on the date of grazing readiness and yield of the crested and Whitmar mixtures.**

Mixture	Age of stand	Fall-planted: None	Fall-planted: Early burn	Fall-planted: Late burn	Fall-planted: Culti-vated	Fall-planted: Fallow	Spring-planted: None	Spring-planted: Early burn	Spring-planted: Late burn	Spring-planted: Culti-vated	Spring-planted: Fallow
		(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
	3	81	244	141	244	443	9	32	18	118	288
	4	235	381	275	418	891	54	88	96	202	502
Crested	5	325	501	428	579	937	153	198	115	317	567
wheat-	6	443	691	673	658	873	313	419	412	617	944
grass	7	708	897	928	1190	1575	331	373	450	942	1033
	8	699	562	853	1070	472	562	875	531	700	567
Average		317	473	402	530	780	136	189	160	319	540
	3	35	97	88	28	76	0	8	11	43	34
	4	78	107	99	87	176	16	17	25	80	99
Whitmar	5	113	194	214	221	339	13	39	79	141	205
beardness	6	168	487	318	361	466	30	35	160	428	284
wheat-	7	434	583	633	851	630	77	98	238	617	377
grass	8	522	612	440	939	295	236	150	381	662	286
Average		135	245	212	223	252	29	31	76	185	149

the Whitmar mixture. The yield and basal density of invading perennials decreased as the yield and basal density of the planted grass increased and as the intensity of land preparation increased. From this and other data, it is apparent that the basal density of planted grass on this and similar soils under limiting climatic conditions must exceed 2 percent before satisfactory yields can be expected from any species or method of land preparation.

Average yields and basal densities (table 2) of both mixtures were highest in plantings made in the 1947-1948 season, both in the fall and in the spring. Precipitation was above average preceding or following seeding (Appendix table 1). The same result should have been obtained in 1948-1949, but yields and basal densities were significantly lower. Plantings that year were made in an area infested with perennial squirreltail. The yield and basal density of invading perennials was much higher from the 1948-1949 seeding year than from any other seeding year. Only on land that had been cultivated or fallowed was the competition from the squirreltail reduced.

Detailed data on yield and basal density of the crested and Whitmar mixtures, as influenced by planting years and method of land preparation, are included in Appendix Tables 2 and 3.

These data indicate that seasonal precipitation for relatively short periods before or after seeding has a major effect on stand establishment under these soil and moisture conditions.

The data in table 3 clearly show the advantage of fall seeding for the crested mixture. Fall plantings reached grazing readiness — a minimum yield of 300 pounds per acre — sooner than spring plantings: 1 year sooner on fallow, cultivated, and no land preparation, and 2 years sooner on the burned land.

The Whitmar mixture reached grazing readiness 1 to 2 years later than the crested mixture from fall seedings (table 3). Spring plantings of the Whitmar mixture did not reach grazing readiness for 6 years on fallow and cultivated land and only after 8 years on late burn. They failed to reach grazing readiness on the no-treatment and early-burn methods of land preparation. Spring seedings for both mixtures required at least two additional years to reach grazing readiness than did fall seedings. Spring plantings cannot be recommended for use on soils in this subgroup, especially in years of below average precipitation.

The performance of Whitmar beardless wheatgrass reported by Stark **et al.** (16) was much better than was obtained here. In the earlier study, Whitmar equalled crested wheatgrass in yield by the fifth growing season. Both studies were on the same soil and in adjacent fields. The difference in performance is attributed to above average precipitation in the former study and about 25 percent below average precipitation in this study.

Conclusions

Intensive methods of land preparation produced satisfactory stands of grasses. Summerfallow was uniformly successful. Production from mixed seedings averaged more than one-half animal-unit-month of feed per acre. Heavy disking before seeding was the second best method, but depended more on the amount of precipitation before or at seeding time. Early and late burning were even more dependent on the incidence of rainfall. Seeding without land preparation gave poor results.

Fig. 3 Whitmar beardless wheatgrass drilled into an unprepared seedbed in a good year. The average of all plots so treated failed to reach grazing readiness in 6 years.

Fig. 4 One of the few successful stands of Whitmar beardless wheatgrass fall-seeded on fallow in 1947, the best moisture year.

Fallow or disking, the more intensive methods of land preparation, are superior in the subgroup of soils represented in this study and are outstanding in years of below average precipitation. The value of the more intensive methods of land preparation has been recognized by other workers (4, 7, 16).

The crested mixture was superior to the Whitmar mixture. In addition, fall seeding was superior to spring seeding in terms of yield, basal density, time required for grazing readiness and repression of invading annual and perennial grasses. Basal density of planted grass on this and similar soils under limiting climatic conditions must exceed 2 percent before satisfactory yields can be expected. There is an inverse relationship between the basal density of the planted grasses and invading annual and perennial grasses.

Seasonal precipitation in the fall and spring, for relatively short periods of time just before or after seeding, influences establishment more than annual precipitation under these climatic conditions.

Methods of Seeding

Methods of seeding greatly influence the probability of successfully establishing a stand of grasses. This is most evident on sites with a limiting or unfavorable environment such as is found on semiarid lands.

Seeding methods used in this study were broadcasting and drilling with a deep-farrow-press drill or a double-disk drill. In addition, the crested mixture only was fall-seeded in wheat stubble and in alternate rows with wheat. Except for the wheat stubble, all land had been fallowed the summer before seeding.

Results and Discussion

The fall-seeded crested mixture showed no significant difference in average yield (table 4) among 4 of the seeding methods. Only when seedings were drilled in wheat stubble were the yields significantly lower (Fig. 4). Seedings established by drilling produced consistently higher yields than seedings made by broadcasting. The good results with alternate-row seedings with winter wheat are important because this kind of land is subject to wind and water erosion which is greatly reduced by the quick cover provided by the winter wheat (Fig. 5).

Fall seedings that were drilled reached grazing readiness (a minimum yield of 300 pounds per acre) by the third growing season. Those that were broadcast or seeded in wheat stubble reached this stage by the fourth and sixth growing seasons, respectively. Spring seedings were equal in yield when drilled, but significantly lower when broadcast. They reached grazing readiness in the fourth year.

Average production of the fall-planted crested mixture increased rapidly after the third growing season, remained at a relatively high level from the fourth through the seventh season and then decreased. It is common on these and similar soils for range seedings to decline in production after they reach a mature age. The decline is often greater under limiting climatic conditions.

Sharp (13) reported that 70 to 80 percent of the variation in yield of mature stands of crested wheatgrass was due to variation in April and June rainfall. Precipitation during the last year of this study was 30 percent below the 38-year average of 8.79 inches. However, studies not reported here indicate that a partial restoration of production can be obtained by the addition of nitrogen fertilizer. This suggests that there was an imbalance in the C:N ratio in the soil when yields declined after a certain age. Other workers report similar results (9).

Again, the crested mixture significantly outyielded the Whitmar mixture, both from fall to spring seedings (table 4). This reflects the inherently slower rate of establishment of Whitmar beardless wheatgrass which was accentuated by the abnormally low precipitation. On the same soil when precipitation was above average, this grass developed more rapidly and eventually sustained higher production than crested wheatgrass (16).

Fall seedings of the Whitmar mixture reached grazing readiness by the fifth season when they were drilled but never when broadcast. There was no significant difference in yield between the two methods of drilling the Whitmar beardless wheatgrass mixture in the fall, but production was significantly lower when broadcast.

Spring seedings were not successful because they did not reach grazing readiness. However, there were significant differences in yield among all methods of planting in the spring. Best results were obtained when the mixture was planted with a deep-furrow press drill. Deep furrow drilling helps keep the seed in contact with moist soil in the bottom of the furrow (10).

Influences of year of seeding, year of harvest, and fall and spring planting on yield are summarized in table 5. None of the spring plantings of the Whitmar mixture could be regarded as successful; the yields were too low. Only the plantings made in the fall of 1947 and 1948 had possibilities of reaching satisfactory production (Fig. 6). Highest yields of the crested mixture, based on year of planting, were obtained in 1947-1948, 1948-1949, and 1950-1951.

Fig. 5 Crested wheatgrass drilled into wheat stubble in the fall of 1948, a good year. Grazing readiness was delayed until the 5th year.

Fig. 6 This 8-year-old crested wheatgrass stand, seeded in the fall in alternate rows with winter wheat on fallow, averaged 800 pounds per acre. Grazing readiness was reached in 3 years.

Table 4. Average production of the crested and Whitmar mixtures on fallow as affected by age of stand, method of seeding and time of seeding.

Seeding methods	Crested wheatgrass mixture: Age of stand in years from planting 3	4	5	6	7	8	Avg	Whitmar beardless wheatgrass mixture: Age of stand in years from planting 3	4	5	6	7	8	Avg
	(yield in lb.)							(yield in lb.)						
Fall-seeded														
Deep furrow press	572	891	938	873	788	472	798a*	76	176	339	466	630	295	298a
Double disk	524	730	813	835	765	408	707a	111	179	305	394	649	494	291a
Broadcast	285	563	745	767	758	476	591ab	85	154	170	267	275	172	174b
Alt. row with wheat	581	810	836	1081	849	445	798a							
Seeded in wheat stubble	17	168	299	464	647	576	281b							
Average, fall-seeded	396b	632ab	726a	800a	761a	475b	635	91e	170d	271c	376b	518a	320bc	251
Spring-seeded														
Deep furrow press	291	502	567	946	1033	567	599a	34	99	205	284	377	286	176b
Double disk	245	481	651	718	1071	517	579ab	60	102	125	166	297	213	135c
Broadcast	299	432	530	617	525	535	471b	34	91	77	51	127	73	73d
Average, spring-seeded	278c	472bc	583b	760a	876a	540bc	550	43ef	97de	136cd	167bc	267a	197b	128

*Values within groups followed by the same letter are not significantly different at .05 level.

The better yields resulted from more favorable precipitation for a protracted period following seeding (Appendix table 1). The average production of both mixtures from spring seedings made in 1950 and 1952 was significantly lower than in all other years. The reason was the low annual and, particularly, the low seasonal precipitation.

Weather conditions associated with the harvest seasons were more favorable in 1953 and 1954. Precipitation during the springs preceding harvest was 22 and 30 percent above normal in these 2 years (Appendix table 1). Yet precipitation for the entire crop year was 25 percent below average in 1954 and 5 percent below average in 1953. Further, in the 1952-1953 crop year, 35 percent of the annual precipitation was received in one 10-day period in December on frozen ground (Appendix table 1).

These results do not agree with Blaisdell (1) and Sneve and Hyder (15), who were able to predict forage production from long-range precipitation and climatic averages. These results along with those of Sharp (13) indicate that forage yield is determined largely by spring precipitation prior to harvest.

Average live basal densities for planted perennials, invading perennials (squirreltail), and invading annuals (cheatgrass) are shown in table 6. Fall and spring seedings are shown separately and all densities are shown by age of stand. Live basal densities of planted perennials increased with age of stand. The basal density of the invading squirreltail increased gradually until the stands were 7 years old and then declined. Cheatgrass declined rapidly after the stands of planted grass were 4 years old. The decline was most rapid when the plantings were drilled. Cheatgrass retarded, but did not prevent, successful establishment of seeded perennials as has been reported (14).

Conclusions

Yields and live basal density from plantings in fallow with the deep-furrow-press and double-disk drills were not significantly different for fall seeding with either mixture or in the spring with the crested wheatgrass mixture. The deep-furrow-press drill was significantly better for spring seedings with the Whitmar beardless wheatgrass mixture. Broadcasting gave the lowest yields in both spring and fall with both mixtures. The crested wheatgrass mixture resulted in a higher yield and basal density than the Whitmar beardless wheatgrass mixture. Fall seeding was superior to spring seeding for both mixtures.

Table 5. Effect of year of planting and year of harvest on fall and spring seedings of the crested and Whitmar mixtures on fallow.

Year planted	Crested mixture: Fall	Spring	Avg	Whitmar mixture: Fall	Spring	Avg
	(forage yield in lb.)					
1947-48	736a*	755a	743a	355a	148a	251b
1948-49	595a	566a	584a	388a	201a	295a
1949-50	561a	233b	438b	126bc	24b	76d
1950-51	668a	711a	684a	87c	178a	132c
1951-52	524a	256b	424b	147b	24b	87d
Year harvested						
1951	410c	290b	365b	126b	39b	82c
1952	506bc	325b	438b	246a	76b	148b
1953	725ab	720a	723a	266a	136a	210a
1954	792a	691a	755a	277a	175a	226a
1955	551abc	457ab	516b	257a	140a	198ab

*Averages followed by the same letter are not significantly different at .05 level.

Two additional seeding methods were tested with the crested wheatgrass mixture in the fall. When this mixture was planted in alternate rows with winter wheat, the results were the same as when it was drilled alone. But when it was drilled into wheat stubble, production was lower and grazing readiness was delayed until the stands were 6 years old. Drilling in alternate rows with winter wheat has the advantage of providing a quick cover that prevents wind and water erosion until the grass is established.

Live basal density of planted perennial grasses increased with age of stand, whereas basal density of invading annual and perennial grasses decreased. The high basal density of crested wheatgrass resulted in a low basal density of other components of the mixture and of invading grasses. Whitmar beardless wheatgrass had a lower basal density than crested wheatgrass and was less competitive, so basal densities of other planted and invading grasses were higher.

Weather conditions, particularly precipitation, for relatively short periods preceding or following planting had greater influence on the establishment of both grass mixtures than did total annual precipitation. Despite the abnormally low precipitation during this study period, there were no failures to obtain stands with either mixture when they were drilled in the fall on fallow. Forage yields were influenced more by the incidence of precipitation in mid-and late spring of the harvest year than by total annual precipitation.

Table 6. Basal densities of crested and Whitmar grass mixtures and invading squirrel tail and cheatgrass as influenced by age of stand, method of seeding and time of seeding. Plantings were made for 5 successive years on fallow.

Planting method	Grass/ invader	Crested wheatgrass mixture — Age of stand in years from planting 3	4	5	6	7	8	Whitmar beardless wheatgrass mixture — Age of stand in years from planting 3	4	5	6	7	8
		(% basal density)						(% basal density)					
					Fall-planted								
Drilled	Planted perennials	1.37	1.98	2.41	2.94	2.65	3.11	.58	.95	1.35	1.96	1.89	2.12
	Squirrel tail	.14	.09	.22	.24	.53	.18	.08	.10	.27	.26	.45	.48
	Cheatgrass	.30	.21	.03	.01	.01	.00	.42	.67	.12	.07	.03	.01
Broadcast	Planted perennials	.83	1.39	1.72	1.52	2.28	3.10	.54	.67	1.05	1.01	1.81	1.08
	Squirrel tail	.13	.17	.31	.31	.50	.32	.14	.17	.26	.28	.72	.67
	Cheatgrass	.48	.79	.11	.11	.07	.02	.27	.95	.22	.18	.19	.11
					Spring-planted								
Drilled	Planted perennials	.67	.99	1.84	1.91	2.65	2.87	.18	.37	.79	.93	1.26	1.17
	Squirrel tail	.05	.04	.06	.09	.12	.07	.04	.03	.15	.12	.36	.10
	Cheatgrass	.23	.46	.10	.06	.02	.00	.43	.64	.16	.18	.17	.03
Broadcast	Planted perennials	.76	1.19	1.72	1.50	2.61	2.68	.19	.38	1.09	.74	1.33	.81
	Squirrel tail	.08	.09	.12	.12	.37	.20	.02	.07	.19	.23	.47	.19
	Cheatgrass	.38	.95	.11	.12	.13	.05	.38	.90	.16	.15	.10	.05

Table 7. Average yield per acre for P-27 Siberian wheatgrass, standard crested wheatgrass and Fairway crested wheatgrass by planting and harvest years.

Year planted	P-27 Siberian wheatgrass 1953	1954	1955	Avg	Standard crested wheatgrass 1953	1954	1955	Avg	Fairway crested wheatgrass 1953	1954	1955	Avg	Avg of year planted
	(lb. harvested per acre)				(lb.harvested per acre)				(lb. harvested per acre)				
1947	712	1457	699	956	1148	1003	503	885	826	681	585	697	846b**
1948	1030	1135	771	979	1207	1585	934	1242	1034	1511	848	1131	1117a
1949	939	1231	880	1017	585	885	694	721	603	681	644	643	794b
1950	694	1226	445	788	115	962	485	521	581	739	476	599	636b
1951	--*	921	871	896	--*	711	789	750	--*	730	671	700	782b
Average yield, year harvested	844	1194	733	929a**	764	1029	681	829a	761	868	645	758a	839

*1951 planting not harvested in 1953.

**Averages followed by the same letter are not significantly different at the .05 level.

Species and Varieties

Little was known about the adaptation of species to the soils and climatic conditions represented by the site where this work was done. Improved plants included in the study were selected for their potential to increase forage production and to lengthen the grazing season.

Twelve grasses representing several species and varieties were planted on fallow with a double disk drill in the falls of 1947 to 1951. The entries were Siberian wheatgrass, P-27[a]; standard crested wheatgrass; 'Fairway' crested wheatgrass; Russian wildrye, P-9012; Whitmar beardless wheatgrass; bluebunch wheatgrass, P-739 and P-6409; 'Sherman' big bluegrass; 'Greenar' intermediate wheatgrass; 'Topar' pubescent wheatgrass; 'Alkar' tall wheatgrass; and 'Durar' hard fescue.

Results and Discussion

Consistent stands and yields were produced only by Siberian wheatgrass and standard and Fairway crested wheatgrass. Whitmar beardless wheatgrass and Russian wildrye produced erratic stands and yields among years and the remaining grasses failed to become successfully established. The climatic conditions during this study were too limiting for these species.

Yield data on Siberian wheatgrass, P-27, and on standard and Fairway crested wheatgrass were collected in 1953 to 1955 (table 7). Siberian wheatgrass was the highest yielding entry (927 lb/acre) but it was not significantly higher in yield than standard crested wheatgrass (839 lb/acre) or Fairway crested wheatgrass (758 lb/acre). The average production of these three species was highest from the 1954 harvest when there was favorable precipitation in late spring. Siberian wheatgrass, P-27, consistently outyielded the other two species. This agrees with results obtained with field plantings in the area typified by the site on which these plantings were made.

Other data show that Siberian wheatgrass, P-27, is lower in lignin content and higher in feed value and intake rate by livestock than is crested wheatgrass (8). These characteristics plus its ability to remain green longer into the season under arid conditions indicate that Siberian wheatgrass, P-27, is also superior to crested wheatgrass in drought tolerance.

Other researchers have compared various grasses in semiarid areas (3). In eastern Nevada, standard and Fairway crested wheatgrass were compared on three sites. Standard crested wheatgrass was better at the lower elevation on soils with the higher organic matter content and Fairway did better at higher elevation on soils with low organic matter (6).

Data on live basal density of Siberian wheatgrass, P-27, standard and Fairway crested wheatgrasses were collected in 1953 to 1955 (table 8). Live basal density of Siberian wheatgrass (3.21 percent) was significantly higher than for standard crested wheatgrass (2.64 percent) and Fairway crested wheatgrass (2.39 percent). The live basal density of these 3 species was highest from plantings made in 1948. In addition, highest live basal density occurred in 1955 when the stands were the oldest.

The 1948 planting year resulted in the highest yield and the highest basal density of the 5 planting years. Favorable precipitation occurred before planting in the fall of 1948 (Appendix table 1) and this favored uniform stand establishment. The live basal densities were uniformly high for these 3 species over the entire time of the study, indicating that they are well adapted to the site.

Among the grasses that either established slower, were slow in development, or low in production, were Whitmar and bluebunch wheatgrasses and Sherman big bluegrass. In an earlier study on the same soil, these grasses established slower but eventually produced as much as or more than standard crested wheatgrass (16). The difference was that in the former study precipitation was more favorable in amount and distribution.

Three introduced grasses, Greenar intermediate, Topar pubescent, and Alkar tall wheatgrass, were clearly unadapted. Good stands with satisfactory basal density were obtained with Russian wildrye, but the yields were low. Poor stands, low basal density, and low production characterized Durar hard fescue. All of these grasses require more moisture.

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[a] P-numbers are accession numbers of the Plant Materials Centers of the Soil Conservation Service.

Table 8. Average live basal density for P-27 Siberian wheatgrass, standard crested wheatgrass and Fairway crested wheatgrass by planting and harvest years.

Year planted	P-27 Siberian wheatgrass 1953	1954	1955	Avg	Standard crested wheatgrass 1953	1954	1955	Avg	Fairway crested wheatgrass 1953	1954	1955	Avg	Avg of year planted
	(% basal density)				(%basal density)				(% basal density)				
1947	2.60	2.46	4.26	3.11	3.56	2.85	3.70	3.33	1.35	1.28	4.35	2.33	2.93b
1948	5.75	4.47	4.21	4.81	4.67	2.76	3.51	3.65	2.68	1.75	2.43	2.29	3.58a
1949	2.41	2.75	3.41	2.86	1.71	1.97	2.59	2.09	2.30	1.82	2.62	2.25	2.40c
1950	1.27	1.89	2.49	1.88	.86	1.65	2.30	1.60	1.29	2.01	2.87	2.06	1.85d
1951	--*	2.76	4.10	3.43	--*	2.17	2.92	2.55	--*	2.72	4.02	3.37	3.12a
Average	3.01	2.87	3.69	3.21a**	2.70	2.24	3.00	2.64b	1.91	1.92	3.26	2.39b	2.75

*1951 planting not harvested in 1953

**Averages followed by the same letter are not significantly different at the .05 level (compare species and planting years separately).

Table 9. Yields and basal densities of planted overstory-understory combinations and invaders.

Planted grass: Overstory	Understory	Yield	Yield-invaders: Perennial	Annual	Basal Density, Planted grass: Overstory	Understory	Basal Density, Invaders: Perennial	Annual
		(lb.)	(lb.)		(%)		(%)	
Crested wheatgrass (standard)	Streambank wheatgrass	706	6	18	2.51	.24	.13	.07
	Thickspike wheatgrass	707	32	11	2.51	.06	.27	.05
	Sandberg bluegrass	649	5	5	2.95	.33	.04	.08
	Alfalfa	674	1	5	2.59	.09	.11	.03
Averages		684a*	11	10	2.64a	.18c	.14	.06
Beardless wheatgrass (Whitmar)	Streambank wheatgrass	389	89	111	.83	.66	.21	.24
	Thickspike wheatgrass	306	204	127	1.00	.11	.76	.22
	Sandberg bluegrass	315	48	139	.77	.53	.22	.32
	Alfalfa	510	40	218	1.06	.41	.14	.31
Averages		380b	95	149	.92b	.43b	.33	.27
Tall wheatgrass (Alkar)	Streambank wheatgrass	285	154	97	.21	1.19	.50	.25
	Thickspike wheatgrass	110	292	182	.23	.27	.53	.31
	Sandberg bluegrass	64	78	294	.14	.72	.30	.34
	Alfalfa	75	134	314	.18	.23	.38	.42
Averages		134c	164	222	.19c	.60b	.43	.33
Big bluegrass (Sherman)	Streambank wheatgrass	214	50	160	.40	1.01	.24	.31
	Thickspike wheatgrass	224	136	216	.58	.26	.52	.32
	Sandberg bluegrass	135	35	309	.40	.40	.11	.35
	Alfalfa	144	60	386	.25	.22	.17	.40
Averages		180c	70	268	.41c	.47b	.26	.35
None	Streambank wheatgrass	254	66	122		1.78	.37	.31
	Thickspike wheatgrass	188	84	327		.92	.41	.36
	Sandberg bluegrass	36	86	311		1.25	.28	.36
	Alfalfa	34	111	287		.24	.46	.41
Averages		128c	87	262		1.05a	.38	.36
Averages for understory species								
	Streambank wheatgrass	370a				.98a		
	Thickspike wheatgrass	307ab				.32c		
	Sandberg bluegrass	287b				.65b		
	Alfalfa	240b				.24c		

*Values in vertical columns followed by the same letter are not significantly different at the .05 level.

Overstory - Understory Mixtures

nterest in ground cover prompted a study of under- y and overstory grasses. Results of an earlier study ested the species that were used (16). Plantings drilled in the fall on fallow for 5 years. Forage uction and live basal densities were taken only e last year of the study.

he study included 4 understory species each seeded and in alternate rows with each of 4 overstory ies. The overstory species were standard crested, mar beardless and Alkar tall wheatgrasses, and man big bluegrass. The understory species were r streambank and thickspike wheatgrasses, 'Sand- ' bluegrass, and alfalfa.

ults and Discussion

andard crested wheatgrass provided the highest and basal density as the overstory (table 9). vigor and density of the crested wheatgrass stand ted in the lowest basal density of the understory es and of the invading annuals and perennials. mar beardless wheatgrass, as the overstory grass, significantly lower in yield and basal density standard crested wheatgrass, but significantly r than Alkar tall wheatgrass or Sherman big blue- . The reduced basal density of the overstory grass ted in an increase in basal density of the under- species and invading annual and perennial es.

e average basal density of the understory species the highest when they were seeded alone and t when seeded with a well-adapted, vigorous like crested wheatgrass. Sodar wheatgrass was nderstory grass with the highest basal density, ved by Sandberg bluegrass. Sodar wheatgrass ely used for soil stabilization on highway rights- y, airports, waterways, and irrigation ditches. tablishes slowly under stringent climatic con- s, but persists and increases once established.

If a fast ground cover is needed, a moderately vigorous overstory grass should be used. Thickspike wheatgrass and alfalfa provided the lowest basal density of the understory species, primarily because they were not adapted to the site and the limiting climatic conditions.

The data on yield and basal density of invading annuals and perennials were not analyzed. However, data in table 9 indicate that yield and basal density of invading annuals and perennials were inversely related to the yield and basal density of the planted species. The yield and basal density of the invading annuals and perennials were lowest with Sodar wheatgrass and highest with thickspike wheatgrass.

The influence of planting year on yield and basal density of the planted grasses is shown in table 10. Highest yield and live basal density occurred from the 1948 seedings and second highest from the 1947 seedings. Soil moisture from effective precipitation before fall planting in 1947 and 1948 accounts for the better establishment from these two years (Appendix table 1).

The results of this study support the choice of understory grasses used in the mixtures for evaluation of land preparation methods, seeding methods, and dates of seeding. Sodar streambank wheatgrass and Sandberg bluegrass have promise for use as understory species even under the rigorous conditions encountered in this study. The planting of a perennial legume as an understory species was not justified.

The results also indicate that understory species that are adapted to the soil and climatic conditions in the area of Xerollic Intergrades of most Aridisols compete with the adapted forage species and tend to reduce the yield of feed per acre. Forage yield was 829 lb/acre when crested wheatgrass was planted alone and 689 lb/acre with the mixture. This evidence of competition between perennial species has been verified by others (9).

10. Average production and basal densities of overstory and understory mixtures as affected by year of planting.

	Overstory grasses with all understory grasses						
	Standard crested wheatgrass	Beardless wheatgrass	Tall wheatgrass	Big bluegrass	Understory grasses alone	Avg yield planted grasses	Avg basal densities
	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(%)
	609	140	70	228	94	228c*	.60ab
	651	117	34	191	15	198c	.20c
	744	238	83	59	84	244c	.46b
	856	867	307	325	270	525a	.82a
	559	538	174	95	177	304b	.65ab
erage	684a	380b	134c	180c	128c		

Values followed by the same letter are not significantly different at the .05 level.

Summary

An 8-year range reseeding study was conducted on Portneuf silt loam near Aberdeen, Idaho. The 38-year average annual precipitation is 8.79 inches. In 6 of the 8 years only 70 percent of this amount was received.

Five methods of land preparation and three methods of seeding two mixtures in fall and spring were evaluated for forage yield and live basal density of planted grasses and invading annual and perennial grasses. Results indicated:

1. Fall seeding was superior to spring seeding.
2. A standard crested wheatgrass mixture consistently out-performed a Whitmar beardless wheatgrass mixture.
3. Seedings on fallow land became established quicker than seedings on land that received a single cultivation. Both methods of land preparation were superior to early burn, late burn, and no cultivation.
4. Seedings established with a deep-furrow-press drill were equal or superior to those established with a double-disk drill and both were markedly superior to broadcast seedings.
5. Seedings made in the fall in alternate rows with winter wheat also resulted in rapid stand establishment and good yields. These have the advantage of providing a rapid ground cover for erosion control.
6. Seasonal precipitation just before or after seeding had a greater effect on the degree and rate of establishment than annual precipitation.
7. Precipitation in the spring before harvest influenced yields more than annual precipitation.
8. The grasses that produced the highest yield and live basal density had the least invasion by annual and perennial species.
9. Live basal density of planted species increased with age of stand.
10. Seedings attaining a live basal density of 2 percent or more were successful.
11. Drilled seedings of well-adapted spe grazing readiness in 3 years when s fall on fallow. This was 1 to 3 years any other type of seedbed and date of s

Twelve grass species were evaluated fo to this site.

1. P-27 Siberian wheatgrass was con highest yielding variety but it did r nificantly more than standard crested wheatgrass.
2. P-27 Siberian wheatgrass had a higher basal density than standard crested wheatgrass, established maintained a more consistent level of
3. P-27 Siberian wheatgrass and stand way crested wheatgrass produced animal-unit-month of feed per acre.
4. None of the other grasses were ac site.

Several overstory-understory combin evaluated for ground cover and erosion cont

1. Standard crested wheatgrass a beardless wheatgrass were the over with the highest yield and basal densit
2. Streambank wheatgrass was the grass with the highest basal density.
3. The use of understory species in r reduces soil erosion, but also re yields, and is known to create problems.

Results of this study should be applic areas of the Intermountain West that hav subgroup of Xerollic Intergrades of most that dominate the soils mapped as R-1 i Handbook 339 (8).

Bibliography

1. Blaisdell, James P. 1949. Seasonal development and yield of native plants on the upper Snake River plains and their relation to certain climatic factors. U.S. Dep. Agr. Bull. 1190. 68 p.

2. Bleak, A. T., N. C. Frischknecht, A. Perry Plummer, and R. E. Eckert, Jr. 1965. Problems in artificial and natural revegetation of the arid shad-scale vegetative zone of Utah and Nevada. J. Range Manage. 18:59-65.

3. Cooper, C. S. and D. N. Hyder. 1958. Adaptability and yield of eleven grasses grown on the Oregon high desert. J. Range Manage. 11:235-237.

4. Cornelius, D. R. and M. W. Talbot. 1955. Rangeland improvement through seeding and weed control on the east slope of the Sierra Nevada and southern Cascade mountains. U.S. Dep. Agr. Hdbk. 88.51 p.

5. Douglas, Donald S., A. L. Hafenrichter and K. H. Klages. 1960. Cultural methods and their relation to establishment of native and exotic grasses in range seedings. J. Range Manage. 13:53-57.

6. Eckert, Richard E., A.T. Bleak, Joseph H. Robertson, and E. A. Naphan. 1961. Responses of **Agropyron cristatum**, **A. desertorum** and other range grasses to three different sites in eastern Nevada. Ecology 42:775-783.

7. Frischknecht, Neil C. and A. T. Bleak. 1957. Encroachment of big sagebrush on seeded ranges in northeastern Nevada. J. Range Manage. 10:165-170.

8. Hafenrichter, A. L., John L. Schwendiman, Harold L. Harris, Robert S. MacLauchlan and Harold W. Miller. 1968. Grasses and legumes for soil conservation in the Pacific Northwest and Great Basin states. U.S. Dep. Agr. Hdbk. 339. 69 p.

9. Hedrick, D. W., D. D. Hyder and F. A. Sneva. 1964. Overstory-understory grass seedings on sagebrush-bunchgrass range. Oregon Agr. Exp. Sta. Tech. Bull. 80. 31 p.

10. McGinnies, William J. 1959. The relationship of furrow depth to moisture content of soil and to seedling establishment on a range soil. Agron. J. 51:13-14.

11. Plummer, A. Perry, A. C. Hull, Jr., George Stewart and Joseph Robertson. 1955. Seeding rangelands in Utah, Nevada, southern Idaho and western Wyoming. U. S. Dep. Agr. Hdbk. 71. 73 p.

12. Schwendiman, John L. 1956. Improvement of native range through new grass introductions. J. Range Manage. 9:91-95.

13. Sharp, L. A. 1970. Suggested management programs for grazing crested wheatgrass. Idaho Forest, Wildlife and Range Exp. Sta. Bull. 4.

14. Shown, L. M., R. F. Miller and F. A. Branson. 1969. Sagebrush conversion to grassland as affected by precipitation, soil and cultural practices. J. Range Manage. 22:303-311.

15. Sneva, Forrest A. and D. N. Hyder. 1962. Estimating herbage production on semiarid ranges in the intermountain region. J. Range Manage. 15:88-93.

16. Stark, R. H., J. L. Toevs and A. L. Hafenrichter. 1946. Grasses and cultural methods for reseeding abandoned farm lands in southern Idaho. Idaho Agr. Exp. Sta. Bull. 267. 36 p.

17. Stewart, George and S. S. Hutchings. 1936. The point-observation plot (square-foot-density) method of vegetative survey. J. Amer. Soc. Agron. 28:714-722.

Appendix Table 1 : Precipitation by months and 10-day intervals for crop years 1947-1948 through 1954-1955, Aberdeen, Idaho.

Crop Year	SEP.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	TOTAL
1947-48													
1-10	.00	.25	.63	.99	.50	.37	.10	.69	.44	.00	.13	.32	4.42
11-20	.64	-.16	.24	.11	.01	.00	.24	.19	.16	.27	.00	.00	2.02
21--	.03	.27	.08	.12	.01	.40	-.25	.21	.00	1.43	.00	.00	2.80
Totals	.67	.68	.95	1.22	.52	.77	.59	1.09	.60	1.70	.13	.32	9.24
1948-49													
1-10	.00	.13	.75	.43	.18	.31	.02	.10	.00	.28	.30	.07	2.57
11-20	.90	-.00	.30	.23	.28	.44	.00	.07	1.82	.05	.00	.00	4.09
21--	.16	.00	.08	.12	.30	.00	-.49	.03	.00	.00	.00	.37	1.55
Totals	1.06	.13	1.13	.78	.76	.75	.51	.20	1.82	.33	.30	.44	8.21
1949-50													
1-10	.00	.31	.48	.15	.10	.35	.26	-.13	.58	.11	.14	.26	2.87
11-20	.07	-.52	.00	.14	.89	.00	.78	.00	.06	.08	.03	.14	2.71
21--	.33	.05	.14	.00	.70	.00	.42	.14	.00	.31	.05	.00	2.14
Totals	.40	.88	.62	.29	1.69	.35	1.46	.27	.64	.50	.22	.40	7.72
1950-51													
1-10	.32	.00	.11	.69	.20	.99	.27	.00	.17	.03	.00	.54	3.32
11-20	.00	-.08	.54	.02	.19	.01	.02	.00	.00	.05	.00	.03	.94
21--	.03	.38	.15	.04	.23	.14	.10	-.62	.15	.09	.53	.53	2.99
Totals	.35	.46	.80	.75	.62	1.14	.39	.62	.32	.17	.53	1.10	7.25
1951-52													
1-10	.00	.14	.00	.31	.01	.48	.26	.06	.00	.00	.00	1.23	2.49
11-20	.00	.28	.32	.38	.10	.24	.37	-.24	.07	.00	.08	.00	2.08
21--	.00	-.20	.03	.86	.46	.07	.01	.00	.05	.74	.00	.00	2.42
Totals	.00	.62	.35	1.55	.57	.79	.64	.30	.12	.74	.08	1.23	6.99
1952-53													
1-10	.00	.00	.00	.24	.12	.27	.37	.45	.19	.85	.00	.00	2.49
11-20	.09	.00	.45	2.63	.47	.08	.08	.05	.26	.01	.00	.21	4.33
21--	.00	.00	.01	.03	.03	.00	.01	.06	1.30	.00	.05	.00	1.49
Totals	.09	.00	.46	2.90	.62	.35	.46	.56	1.75	.86	.05	.21	8.31
1953-54													
1-10	.18	.00	.11	.08	.02	.00	.43	.00	.00	.87	.00	.02	1.71
11-20	.00	.27	.00	.02	.08	.38	.03	.06	.00	.15	.01	.10	1.10
21--	.05	.70	.18	.00	.29	.00	.56	.88	.31	.57	.00	.19	3.73
Totals	.23	.97	.29	.10	.39	.38	1.02	.94	.31	1.59	.01	.31	6.54
1954-55													
1-10	.00	.00	.00	.33	.14	.04	.00	.23	.22	.21	.00	.04	1.21
11-20	.00	.42	.45	.07	.25	.08	.29	.28	.05	.64	.00	.08	2.61
21--	.05	.38	.00	.06	.03	.18	.05	.50	.35	.44	.33	.00	2.37
Totals	.05	.80	.45	.46	.42	.30	.34	1.01	.62	1.29	.33	.12	6.19
Averages													
1-10	.06	.10	.26	.40	.16	.35	.21	.21	.20	.29	.07	.31	2.62
11-20	.21	.22	.29	.45	.28	.15	.23	.11	.30	.16	.02	.07	2.49
21--	.08	.25	.08	.15	.26	.10	.24	.30	.27	.45	.12	.14	2.44
Totals	.35	.57	.63	1.00	.70	.60	.68	.62	.77	.90	.21	.52	7.55

NOTE: Dash marks (-) shown in October, March and April columns denote seeding dates.

Appendix Table 2. Yield and basal density of the crested wheatgrass mixture and invading perennials as influenced by planting years and method of land preparation. Seedings made in late fall and early spring.

		Fall seeded				Spring seeded			
		Yield per acre		Basal density		Yield per acre		Basal density	
Year planted	Method of land preparation	Planted grass	Invading perennials	Planted grass	Invading perennials	Planted grass	Invading perennials	Planted grass	Invading perennials
		lbs.	lbs.	%	%	lbs.	lbs.	%	%
1947-48	No treatment	761	12	1.90	.02	430	46	1.10	.09
	Early burn	898	47	2.66	.27	522	100	1.45	.32
	Late burn	1011	34	2.62	.20	455	97	1.35	.50
	Cultivated	1077	12	2.40	.04	807	38	1.67	.12
	Fallow	918	24	2.40	.17	938	17	1.89	.02
	$\bar{x}$	933	26	2.40	.14	630	60	1.49	.21
1948-49	No treatment	137	541	.51	1.84	23	514	.23	2.39
	Early burn	163	357	.54	2.04	41	330	.45	1.76
	Late burn	216	368	1.02	1.82	164	419	.76	2.37
	Cultivated	472	60	1.85	.28	401	204	.87	1.01
	Fallow	685	26	2.45	.28	733	42	2.06	.06
	$\bar{x}$	335	270	1.27	1.25	272	302	.87	1.52
1949-50	No treatment	55	25	.40	.06	165	20	.37	.01
	Early burn	368	95	1.00	.40	297	32	.92	.15
	Late burn	158	90	.74	.22	47	39	.26	.11
	Cultivated	141	0	.54	.01	47	22	.28	.07
	Fallow	794	5	2.68	.04	166	6	.45	.04
	$\bar{x}$	303	43	1.07	.15	144	24	.46	.08
1950-51	No treatment	267	18	.69	.18	29	18	.22	.05
	Early burn	660	34	1.30	.12	57	3	.13	.06
	Late burn	358	15	1.06	.03	81	6	.39	.04
	Cultivated	495	15	1.28	.05	273	5	.75	.03
	Fallow	959	0	2.17	.00	549	2	1.66	.01
	$\bar{x}$	547	16	1.30	.08	198	7	.63	.04
1951-52	No treatment	366	7	1.72	.03	35	0	.10	.05
	Early burn	277	32	1.20	.12	30	29	.14	.10
	Late burn	268	45	1.96	.20	73	54	1.10	.18
	Cultivated	467	0	1.29	.01	70	0	.26	.02
	Fallow	544	0	1.14	.01	313	0	.74	.00
	$\bar{x}$	384	17	1.46	.07	104	17	.47	.07

Appendix Table 3. Yield and basal density of the Whitmar beardless wheatgrass mixture as influenced by planting years and method of land preparation. Seedings made in late fall and early spring.

		Fall seeded				Spring seeded			
		Yield per acre		Basal density		Yield per acre		Basal density	
Year planted	Method of land preparation	Planted grass	Invading perennials	Planted grass	Invading perennials	Planted grass	Invading perennials	Planted grass	Invading perennials
		lbs.	lbs.	%	%	lbs.	lbs.	%	%
1947-58	No treatment	460	66	1.52	.24	91	144	.49	.33
	Early burn	767	140	2.03	.48	118	259	1.45	.77
	Late burn	637	72	2.24	.52	300	177	.72	1.24
	Cultivated	676	70	1.62	.21	594	53	1.43	.22
	Fallowed	471	64	1.46	.23	262	38	.81	.02
	$\bar{x}$	602	82	1.77	.34	273	134	.98	.52
1948-49	No treatment	22	461	.22	2.20	10	377	.22	2.28
	Early burn	59	464	.79	1.47	7	510	.69	1.75
	Late burn	96	415	.40	1.46	44	436	1.43	1.38
	Cultivated	266	209	1.06	1.11	214	223	.79	1.17
	Fallowed	351	101	1.25	.41	303	57	1.31	.26
	$\bar{x}$	159	330	.74	1.33	116	321	.89	1.37
1949-50	No treatment	14	46	.30	.12	6	21	.25	.09
	Early burn	66	60	.94	.24	6	116	.25	.33
	Late burn	8	68	.78	.16	5	68	.41	.11
	Cultivated	21	2	.43	.02	7	0	.22	.01
	Fallowed	195	3	1.82	.02	12	0	.17	.00
	$\bar{x}$	61	36	.85	.11	7	41	.26	.11
1950-51	No treatment	44	20	.47	.04	9	68	.05	.04
	Early burn	69	29	.52	.12	21	36	.33	.13
	Late burn	27	38	.27	.11	21	59	.14	.23
	Cultivated	55	20	.29	.07	31	20	.16	.06
	Fallowed	118	0	.64	.00	141	2	.35	.01
	$\bar{x}$	63	21	.44	.07	45	37	.21	.09
1951-52	No treatment	136	70	.93	.10	27	68	.33	.15
	Early burn	166	20	1.20	.09	5	39	.21	.07
	Late burn	290	34	1.98	.13	9	34	.48	.11
	Cultivated	96	4	.59	.01	79	2	.52	.01
	Fallowed	125	3	.51	.01	25	0	.13	.00
	$\bar{x}$	163	26	1.04	.07	29	29	.33	.07

Common and Botanical Names Of Species Mentioned

Grasses

Bluegrass, Sherman big	*Poa ampla*
Bluegrass, Sandberg	*Poa secunda*
Cheatgrass (Downy brome)	*Bromus tectorum*
Fescue, Durar hard	*Festuca duriuscula*
Squirreltail	*Sitanion hystrix*
Wheatgrass, Whitmar beardless	*Agropyron inerme*
Wheatgrass, P-739, P-6409 bluebunch	*Agropyron spicatum*
Wheatgrass, standard crested	*Agropyron desertorum*
Wheatgrass, Fairway crested	*Agropyron cristatum*
Wheatgrass, Greenar intermediate	*Agropyron intermedium*
Wheatgrass, Topar pubescent	*Agropyron trichophorum*
Wheatgrass, P-27 Siberian	*Agropyron sibiricum*
Wheatgrass, Sodar streambank	*Agropyron riparium*
Wheatgrass, Alkar tall	*Agropyron elongatum*
Wheatgrass, P-1822 thickspike	*Agropyron dasystachyum*
Wildrye, Russian	*Elymus junceus*

Legumes

Alfalfa	*Medicago sativa*

Shrubs

Rabbitbrush, rubber	*Chrysothamnus nauseosus*
Sagebrush, big	*Artemesia tridentata*