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FORAGE SPECIES FOR THE NORTHERN INTERMOUNTAIN REGION - A SUMMARY OF
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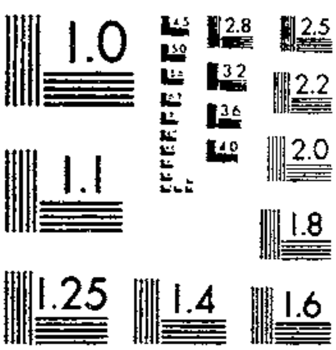
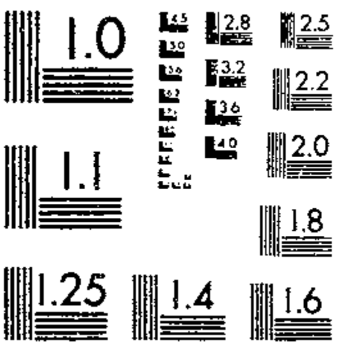


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
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PREFACE

Range and dry-pasture lands in Montana are highly diversified. Within the boundaries of the State, environmental conditions exist that are representative of large parts of surrounding States and Canada. Consequently, the results of studies performed in Montana are applicable to the Northern Intermountain Region, a large part of western North America, and other parts of the world.

Over several decades numerous plantings have been made by various State and Federal agencies to determine the productivity and adaptability of forage plants to specified environmental and site conditions. In 1953, Agricultural Research Service (ARS), U.S. Department of Agriculture, was given the responsibility for all Federal seeding research for rangelands used by domestic livestock. The close association ARS had with Montana Agricultural Experiment Station then made the consolidation of this information from all sources within the State possible.

Since 1963 little new research has been done on rangeland seeding. An era of extensive seeding studies initiated by Forest Service, Soil Conservation Service (predecessors of Agricultural Research Service), Bureau of Land Management, and Montana Agricultural Experiment Station has ended. Data assembled for this publication are unavailable in usable form. In the absence of publication, results from these tests will soon be lost, and, at some later date, the same or similar studies will be repeated. The task of summarizing and interpreting these results involved numerous drafts and revisions designed to reduce the size of the publication and to increase its use.

This report was written to preserve the results of these valuable studies, to consolidate them, and to publish them where they may be available to wide service areas, such as Extension personnel, technicians of Soil Conservation Service, Forest Service, and Bureau of Land Management. Agencies and individual researchers, technicians, and ranchers throughout the world who are concerned with the improvement of range and dryland pastures will find the results of this work informative and valuable in helping to guide their selection of forage species to specific site conditions.

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The following are gratefully acknowleged for their contribution to the subject matter research: The former Northern Rocky Mountain Forest and Range Experiment Station (now Intermountain), Forest Service, U.S. Department of Agriculture, for much of the work done on forested and adjacent rangelands; the Bureau of Land Management, U.S. Department of Interior; and the many private ranchers who provided land for many of the studies; the Montana Agricultural Extension Service through which much of the rancher cooperation was obtained; and R. E. Stitt (deceased) and personnel of the branch stations of the Montana Agricultural Experiment Station who established many of these studies.

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

PROTECT

Use Pesticides Safely

FOLLOW THE LABEL

CAUTION: Pesticides can be injurious to humans, domestic animals, beneficial insects, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

CONTENTS

FORAGE SPECIES for the NORTHERN INTERMOUNTAIN REGION

A Summary of Seeding Trials

By F. B. GOMM,[1] *range scientist, Western Region, Agricultural Research Service, United States Department of Agriculture*

The primary land use of the Northern Intermountain Region is for range livestock. As such much of the economy of the Region is derived from livestock and depends upon the productivity of its rangelands. Although much of the once depleted ranges have improved with management, the dryland areas of the Region are not producing up to their potential. Artificial seeding to increase forage and livestock production and to control erosion is an important tool in rangeland improvement.

Much of the abandoned cropland has been planted back to grass. Artificial seeding of high-producing forage plants on deteriorated rangelands has also been generally accepted by livestock operators and land management agencies. Too frequently, however, the adaptation, growth habits, or productivity of these plants has not been well known.

Because of the extreme diversity of site conditions, recommending satisfactory species for range improvement is difficult. To determine more accurately the adaptability and value of forage species and strains, several agencies cooperated in making many tests. This publication presents the results from many of these tests. Because of space involved, many studies and data from several years research were omitted from tables when they did not contribute significantly to the evaluation. A complete list of these data, however, has been compiled and filed with Arid Pasture and Range Investigations, Montana Agricultural Experiment Station, and Intermountain Forest and Range Experiment Station.[2]

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[1] Stationed at Burns, Oreg., formerly at Bozeman, Mont.

[2] Unpublished data *in Annual Progress Report 1963*, U.S. Department of Agriculture, Agricultural Research Service, Forage and Range Research Branch, Arid Pasture and Range Investigations.

The presence of a plant in a given locality is dependent on its introduction, establishment, and ability to survive and reproduce under a complex of environmental factors. The natural plant community in which this plant grows is also a product of all the environmental forces. Therefore, the establishment of an introduced plant into an area of a defined association probably would indicate the success or failure of seedings into other areas of the same association.

From results of studies conducted under similar environmental conditions, one might, with caution and judgment, interpolate that similar results could be obtained at other locations having similar site conditions.

Although some species and strains appear inferior under the conditions they were tested, under different conditions they might be useful forage species. Also, plant improvement through breeding and selection, as well as new methods of cultural management, might make possible strains of forage plants to be grown in areas where they do not now appear adapted.

ENVIRONMENTAL FACTORS

Because of the diversity among range sites, the magnitude of environmental factors varies from site to site. A discussion of some of these important environmental factors is presented to help divide the State of Montana into areas of similar topography, climate, soils, and vegetational zones as an aid for recommending forage species.

Topography

Montana varies in altitude from 1,800 to 12,850 feet above sea level (fig. 1). Approximately 35.2 percent of the area is below 4,000 feet, 34.8 percent between 4,000 and 6,000 feet, 23 percent between 6,000 and 8,000 feet, and about 7 percent above 8,000 feet. The lowest place is at the Idaho boundary on the Kootenai River, and the highest point is Granite Peak in southwestern Montana. The average elevation for the State is approximately 3,400 feet.

Seven mountain ranges in southwestern Montana rise to elevations over 10,000 feet. A few other 10,000-foot peaks exist elsewhere, but the area of these is small.

The Continental Divide crosses the western half of the State from north to south. To the west of the divide, the Kootenai,

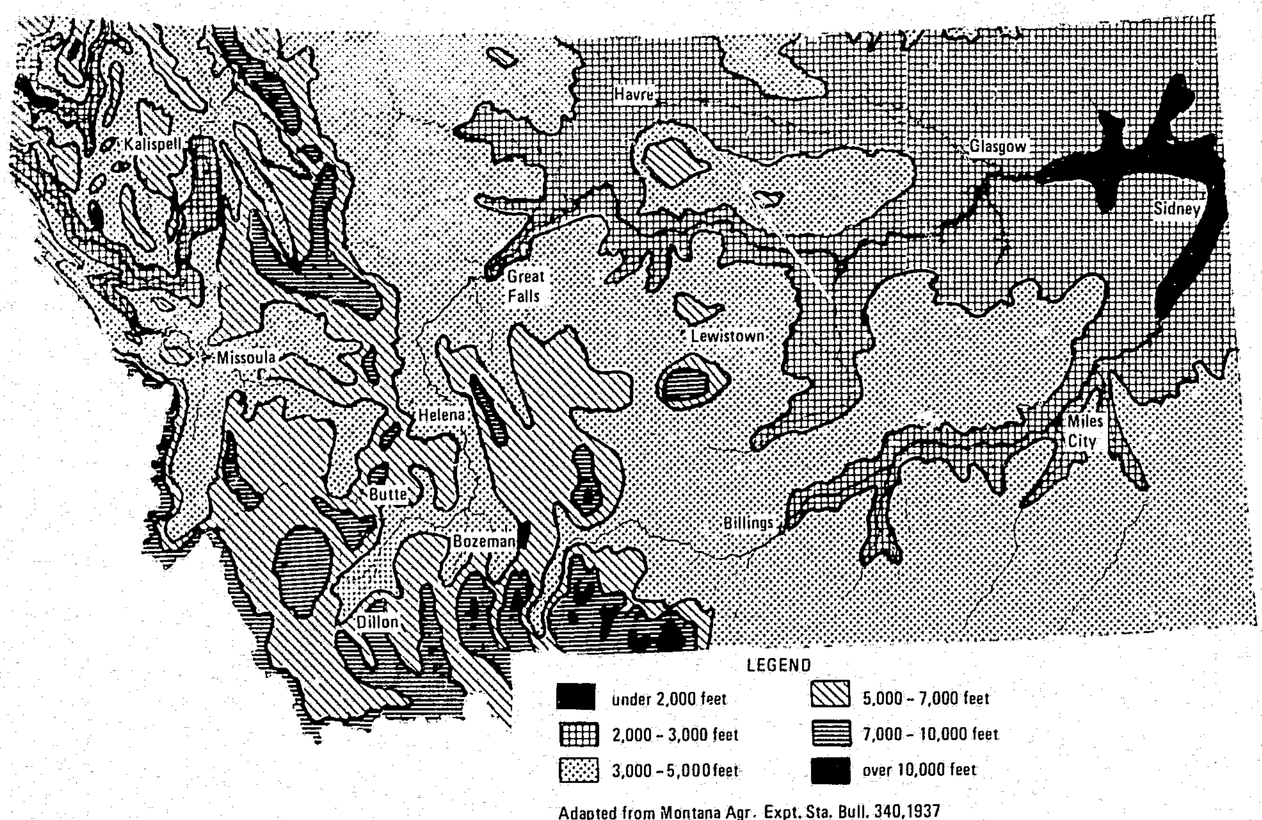

FIGURE 1. — Topography of Montana (Adapted From Mont. Agr. Expt. Sta. Bul. 340, 1937.)

Clark Fork, and Flathead Rivers drain to the Pacific Ocean. East of the divide, the St. Mary River drains a small triangular section of Glacier Park to the Hudson Bay, and the eastern two-thirds of the State is drained by the Missouri River to the Gulf of Mexico. Major drainages, which are tributaries to the Missouri River, are the Jefferson, Madison, Gallatin, Sun, Marias, Milk, Musselshell, and Yellowstone Rivers.

Except for the central-mountain region, the area east of the divide is relatively flat with a general slope toward the east. Relief is largely from river bottoms and small drainages. The central-mountain region is a mixture of mountain ranges and valleys. West of the divide, the elevation drops rapidly to the west. In the southern section it rises again into the Bitterroot Mountains. In the northern section the elevation of the intermixed mountains and valleys drops rapidly to the west where two major rivers leave the State.

About 15.5 percent of the State's land is cropland, 56.7 percent is nonforested pasture and range; and 10.7 percent is forest grazing land. The rest is inaccessible to livestock.

Environmental Divisions and Climate

Montana can be divided into three regions based on environmental factors and native vegetation (fig. 2). The western region includes the area west of the Continental Divide. The eastern region includes the area east of the divide below 4,000 feet elevation and is generally northeast of a line drawn diagonally from the Canadian border at Sweetgrass, Mont., to the southeastern corner of the State. Between these two regions is the central-mountain region, which is a transition zone of mountains, valleys, and high plains.

The climate is highly variable from site to site as might be expected from the differences in elevation and slope. Annual precipitation, length of growing season, and minimum and maximum temperatures for the State are shown in figures 3 to 7, and annual precipitation records from selected stations are given in table 1 (U.S. Department of Commerce 1955, 1965).[3]

Western region.—The climate west of the divide has been described as a modified North Pacific Coast type with mild winters, light winds, and precipitation more evenly distributed throughout the year. The humidity is higher and the growing

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[3]References to Literature Cited, p. 307, are indicated by the name of the author or authors and year of publication in parentheses.

season is shorter than in the eastern plains. Rainfall varies with a 24-year (1931-55) average of 10.28 inches at Deer Lodge to 48 inches in the Bitterroot Mountains. The average for the region is 19.04 inches of precipitation (U.S. Department of Commerce, 1960).

About 50 percent of the precipitation falls during the April to September period. The frost-free period varies from 120 to 140 days in the valleys to less than 30 days in the mountains. The average April to September temperature for the region is 55.7° F. In the valleys the mean maximum July temperatures are about the same as eastern Montana, but mean minimum January temperatures are not as low.

The western region is mostly forested, but large areas of grassland occur in the valleys.

Eastern region.—The average precipitation for most of the eastern region is 13 inches and varies from 10.45 inches at Simpson to 15.99 at Vida. About 75 percent of the total precipitation falls during the April to September period.

The frost-free period varies from 114 to 150 days, and the average temperature for the April to September period is about 58° F. The mean minimum January temperatures vary from -6° to 12°. Winter temperatures in the northeast corner of the State are usually the coldest. The eastern region is part of the Northern Great Plains and is covered with short-grass-type vegetation. The area generally north of the Missouri River consists of glaciated plains, while the area south is sedimentary plains.

Central mountain.—Both climate and vegetation are highly variable within the central-mountain region and within short distances. The precipitation is highly variable. It varies from less than 8 inches at the Wyoming border in Carbon County to 25.77 at Hebgen Dam. Areas adjacent to the mountains are generally the wettest, but there are exceptions where "rain-shadow effects" appear. The average annual precipitation for the region varies from 14 to 20 inches, 50 to 70 percent of which falls during the growing season. The frost-free period varies from less than 30 days in the high mountains to about 120 days in the warmer valleys, and the average April-September temperatures are 54° to 59° F. Mean minimum July temperatures vary from 72° to 90°, and mean January temperatures vary from -2° to 16°.

The vegetation includes both bunchgrass and mixed-grass types as in western Montana and short-grass types as in eastern Montana.

TABLE 1.—*Annual precipitation (inches) from selected Weather Bureau station records in Montana, 1936-63*

Station		'36	'37	'38	'39	'40	'41	'42	'43	'44	'45	'46	'47	'48	'49
Billings [1]		--	--	18.0	14.0	20.9	23.2	18.0	11.6	19.9	13.5	13.6	13.9	8.1	14.0
Bozeman [2]		12.8	18.0	20.4	14.1	18.9	22.9	17.2	17.2	20.9	19.5	18.6	23.6	19.5	17.1
Butte		--	--	--	--	--	--	--	--	--	--	14.2	14.1	12.5	10.8
Cut Bank [1]		12.0	11.2	13.6	8.2	12.6	11.0	12.9	9.5	7.5	12.0	14.2	13.0	15.7	9.9
Dillon [1]		--	--	--	--	10.7	10.6	6.3	7.9	12.0	8.2	10.4	9.6	12.3	9.4
Glasgow [1]		--	--	--	--	--	--	--	--	--	--	--	--	--	--
Great Falls [1]		9.2	--	--	--	--	--	--	--	--	--	--	--	--	--
Hebgen Dam		24.9	31.2	38.9	21.6	34.3	29.2	23.8	25.7	22.5	29.0	27.5	27.3	27.4	22.8
Helena [1]		--	9.3	10.6	8.4	9.6	13.7	8.8	8.3	13.4	10.4	13.6	12.6	14.9	8.2
Havre		--	--	--	--	--	--	--	--	--	--	--	--	--	--
Kalispell [1]		--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lewistown [1]		13.0	14.6	19.8	15.0	15.7	21.2	19.8	15.8	22.4	15.6	20.0	15.3	19.7	19.5
Malta		7.3	12.5	18.7	14.1	16.2	13.3	15.7	14.1	12.0	10.9	12.5	12.8	10.7	7.6
Miles City [1]		--	--	10.8	9.2	14.4	18.1	15.7	15.0	19.0	12.6	17.8	11.8	16.1	8.8
Missoula		11.0	8.7	12.9	10.5	12.0	16.8	15.6	14.4	12.9	11.0	13.0	16.2	15.9	10.0
Sidney		--	--	--	--	--	--	--	--	--	--	--	--	--	--
Billings [1]	12.9	12.0	10.8	11.7	11.8	19.9	10.6	21.2	16.7	11.6	9.4	13.5	14.2	14.9	14.6
Bozeman [2]	18.2	20.2	19.6	16.4	12.7	19.1	11.3	16.5	18.1	19.6	14.6	16.1	19.9	--	17.9
Butte	--	12.1	12.0	9.8	7.6	12.8	10.5	9.8	11.5	10.6	8.4	11.0	12.4	13.1	11.4
Cut Bank [1]	9.2	17.3	8.3	16.1	10.2	10.9	16.6	8.7	15.2	12.3	8.2	10.6	9.8	8.8	11.6

Dillon [1]	8.3	7.6	8.1	6.9	8.1	10.2	6.6	10.4	9.8	10.5	6.9	8.9	10.9	14.3	9.4
Glasgow [1]	--	--	--	--	--	--	9.2	10.4	7.1	9.7	7.3	6.9	17.8	14.7	10.4
Great Falls [1]	--	21.6	9.0	20.8	15.7	19.6	10.8	16.2	16.1	13.6	9.8	10.5	16.0	12.0	14.7
Hebgen Dam	20.8	29.9	23.1	25.0	21.2	25.9	24.4	25.4	25.1	29.8	25.7	33.0	28.5	33.2	27.0
Helena [1]	11.9	12.0	9.0	8.9	10.5	11.9	9.1	14.6	12.9	9.4	7.5	8.2	11.9	11.6	10.8
Havre	--	17.0	7.3	14.0	13.9	16.0	9.3	11.6	11.2	13.4	10.7	7.4	11.6	9.5	11.8
Kalispell [1]	--	21.9	11.2	14.6	15.3	16.9	17.1	12.4	18.0	21.0	14.2	16.4	11.5	15.2	15.8
Lewistown [1]	15.9	14.9	13.3	20.0	16.4	17.1	11.2	16.6	14.2	18.5	12.6	13.4	25.6	14.3	16.8
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Missoula	12.9	15.1	8.9	10.6	14.4	17.1	16.6	11.6	15.2	16.5	6.9	14.1	12.0	14.9	13.1
Sidney	--	9.2	8.5	20.6	13.7	13.1	11.0	13.6	10.9	11.4	11.2	9.8	18.8	14.2	12.8

[1] Airport.
[2] Montana State University.

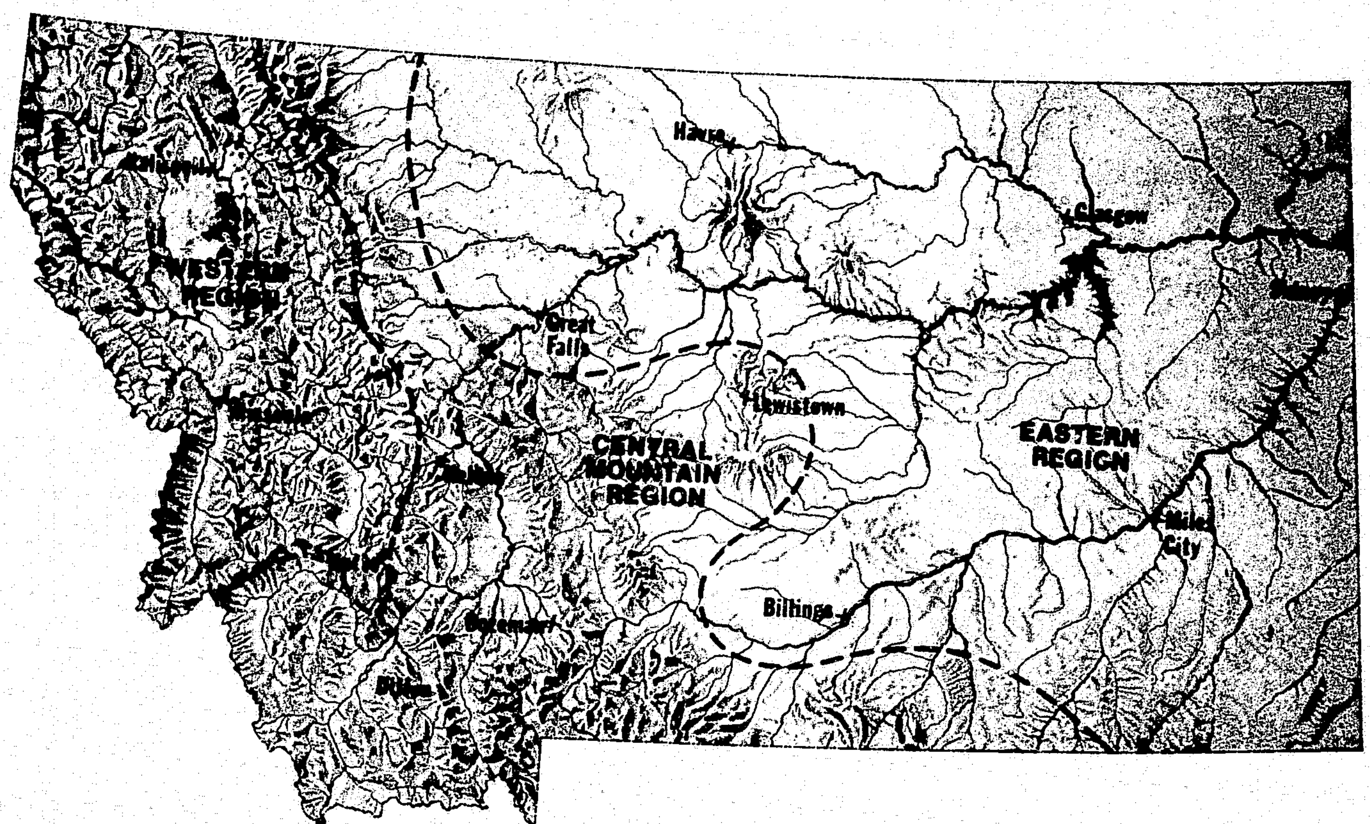

FIGURE 2.—Climatic and environmental divisions of Montana. (Base map drawn by E. S. Smyrl, Dept. Earth Sci., Mont. State Col., Bozeman, Mont.)

Climate and vegetation in isolated mountains that lie in eastern Montana, such as the Bear Paws and Rosebud Mountains, are similar to those in the central-mountain area.

Soils

Environmental factors linked with elevation and topography influence the growth of plants. In certain locations soil also has a pronounced influence on the type of vegetation.

The soils of Montana are largely of the Brown and Chestnut soil groups (Aridisol and Mollisol) developed from four major ages of rock formation. Generally, the area west of the Continental Divide consists of parent material from the late Precambrian period, the central half of the State from the Mesozoic, and the eastern fourth from the Cenozoic periods. The southwestern and central-mountain areas are mottled by the Cenozoic, Mesozoic, and Precambrian intermixed with Paleozoic and crystalline rock.

Many soil series associations have developed in the State. In this study the soils have been combined into 11 major soil classifications (fig. 8). Generally, the area east of the mountains and north of the Missouri River is of moderate dark-colored loams. Three major types of vegetation, the northern, the northeastern, and the Judith Basin grasslands, are associated with these soils. In the southeastern fourth of the State thin loams over bedrock are the dominant soils. Types of vegetation associated with these thin loams are eastern ponderosa pine, ponderosa savannah, prairie grassland, and southeastern grassland. The coniferous forest types occur on light-colored timbered soils, and the alpine grasslands are found on the thin soil and rocky lands of the high mountains. The valleys are somewhat mottled with alluvial soils, black loamy soils, and moderate dark loamy soils. The vegetation supported on these soils is also somewhat zoned depending on site, moisture conditions, and salt concentrations. Severely eroded, steep and broken lands along the Missouri and Yellowstone drainages support the badland grasslands and the scrub-pine type of the Missouri breaks.

At several locations throughout the State thin clay soils over shale exist. These soils vary in alkalinity and generally support saltbush and other alkali-tolerant plants. Salt-tolerant plants are also found on alkaline, strongly developed clay-pan soils in Phillips, Hill, and Lake Counties and on the periphery of mountain valleys where salts have accumulated in the soil.

A small area of light-colored soil is located on the Wyoming border in Carbon County where precipitation is the lowest in

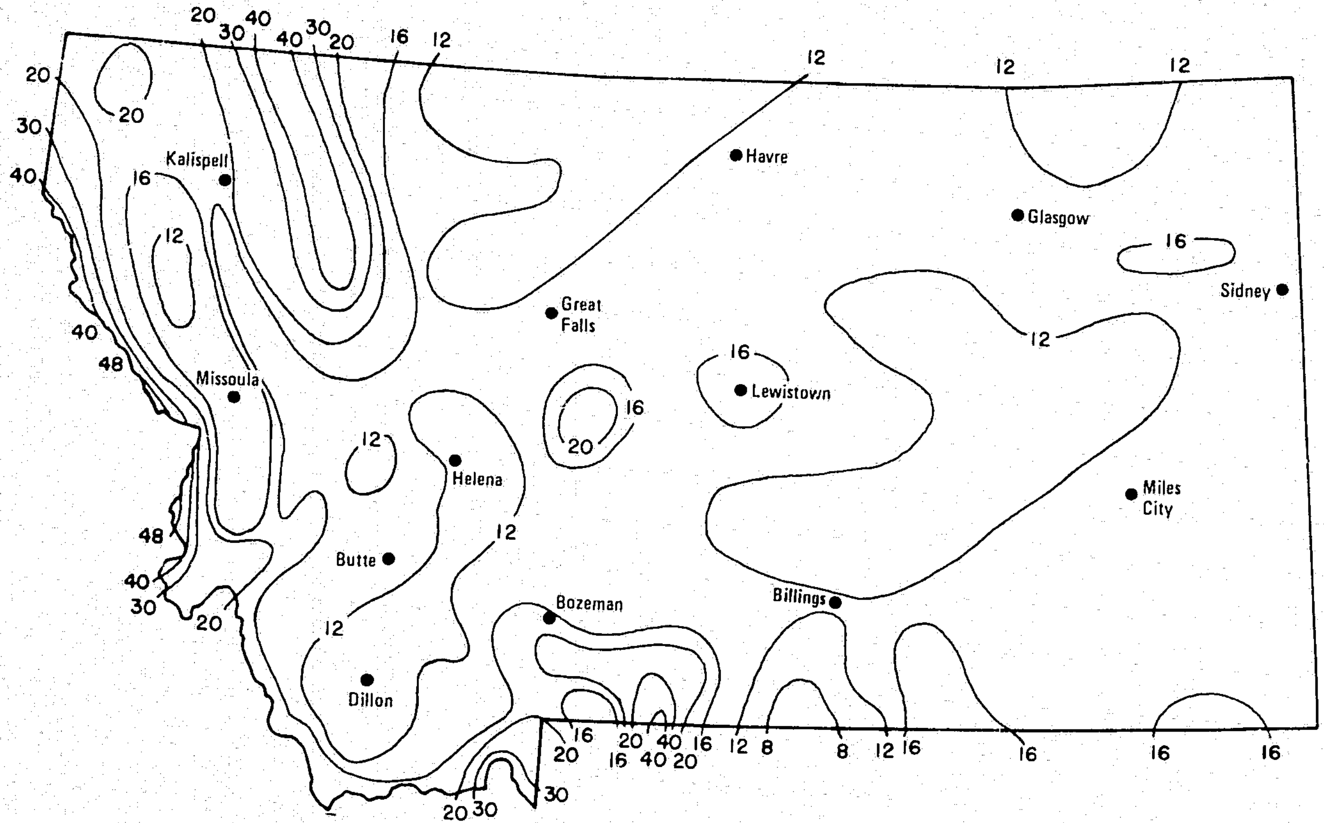

FIGURE 3.—Average annual precipitation (inches), 1931-35. (Adapted from Climates of the States, Montana. U.S. Dept. Com. No. 60-64, 1960.)

the State. The vegetation is closely associated with that of the saltbush-sagebrush and the beartooth juniper types.

Vegetation Distribution

In Montana, four natural range regions are recognized: Northern coniferous forest; bunchgrass; shortgrass; and northern desert shrub. These four regions have been divided further into 22 types of vegetation (fig. 9).

PROCEDURE

Studies were located throughout the State on many sites characteristic of areas that could benefit from the introduction or reestablishment of forage plants (fig. 10). These studies have been grouped according to the natural associations of vegetations, which are believed to have originally dominated the different sites.

Various data were recorded depending on the primary purpose of the study. Adaptation of species was determined by plant counts, by percentage of row occupied with seeded species, or in some instances, by adjective or numerical ratings.

The different ratings systems may be compared as follows:

Comparable stand evaluations

Percent of rows occupied	Average number of seedlings per foot of row [1]	Rating	
		Adjective [2]	Numberical
100	6	E	10
90	4.3	E	9
80	3.4	G	8
70	2.7	G	7
60	2.3	G	6
50	1.7	F	5
40	1.4	F	4
30	1.0	F	3
20	.7	P	2
10	.3	P	1
[3]	---	P	

[1] Rating where plants are uniformly distributed.

[2] E = excellent; G = good; F = fair; P = poor.

[3] Less than 5 percent stand.

Herbage yields were taken by clipping samples near ground level.

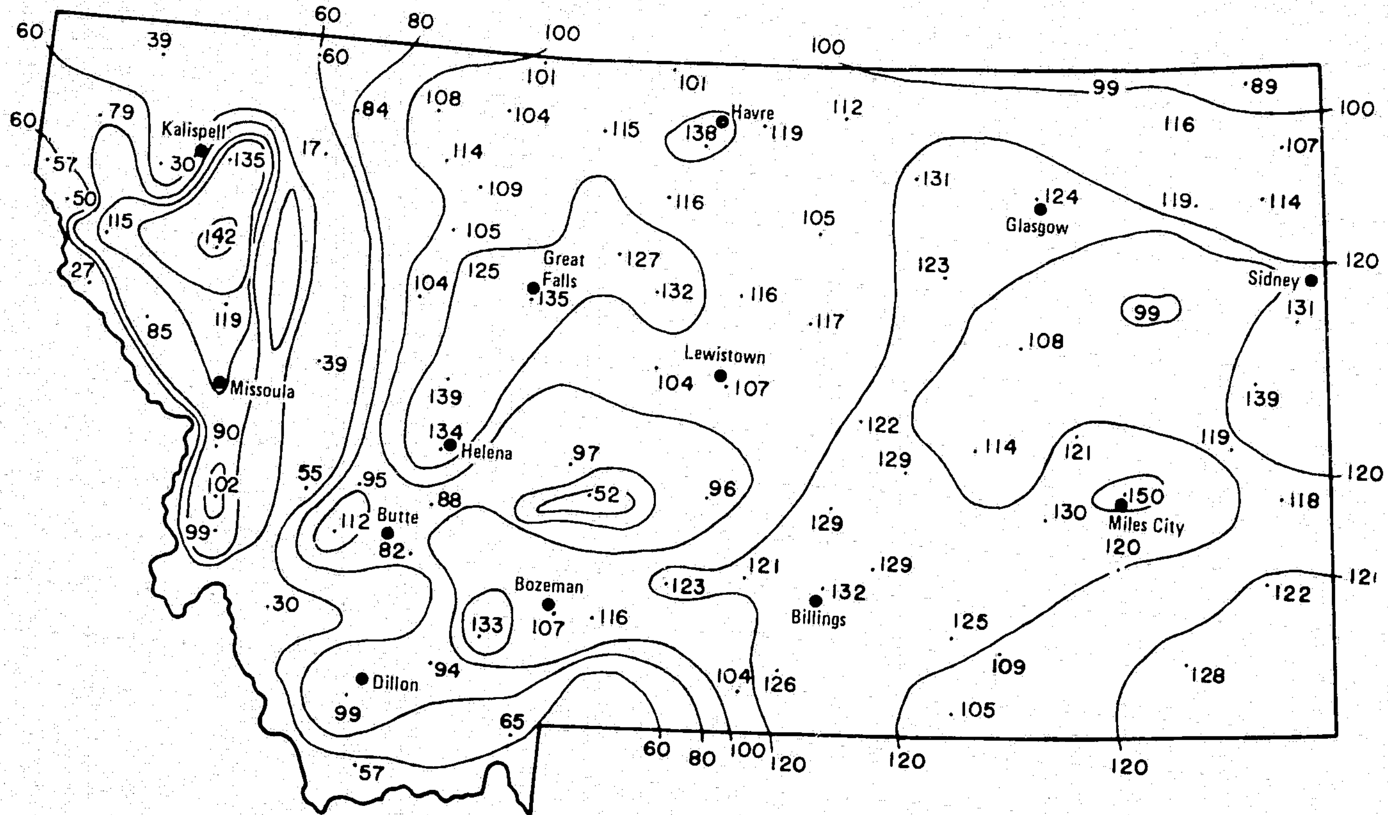

FIGURE 4.—Average length of growing season based on 32° F freeze data, 1921-50. (Adapted from Climatic Summary of the United States, Montana, U.S. Dept. Com. No. 60-24, 1960.)

Other pertinent data obtained from the various studies, such as palatability ratings, chemical composition, phenological development, and grazing values, are given as observed.

RESULTS

Alpine Grassland

This type of vegetation occurs above timberline. Primarily, it is located north of Yellowstone National Park, but it is also found in small areas on isolated mountain peaks throughout the western part of the State. It comprises approximately 576,800 acres at elevations varying from 6,000 feet in the north to 10,000 feet in the south. Growing conditions are severe. The soils are residual, undeveloped, thin, and rocky. The precipitation falls mostly as snow and varies from 20 to 50 inches. The winter winds blow the snow from high ridges and pack it in low areas and ravines where it may remain as snow banks and drifts late into the summer. The growing season is short, ranging from 16 to 60 days.

The dominant vegetation is mostly alpine species of *Poa*,[4] *Phleum*, *Agrostis*, and *Carex* mixed with a multitude of forbs.

Seeding studies have not been made on this type. Nor is it presently feasible to attempt seeding, since it is relatively inaccessible. Even where accessible, the soil is too rocky to cultivate, and it is doubtful if species other than those native to the site would be adapted.

Subalpine Forest and Grassland

The subalpine is characterized by *Pinus albicaulis* near timberline and by *Picea engelmanni*, *Abies lasiocarpa*, and *Pinus flexilis* at lower elevations. *Carex geyeri* and *Calamagrostis rubescens* comprise much of the forest understory. Throughout the type, grassy parks of various sizes create complex mosiacs of forest and grassland. *Festuca idahoensis*, *Bromus carinatus*, *Phleum alpinum*, *Melica spectabilis*, and *Trisetum spicatum* are the dominant grasses. Many forbs are also found, including *Geum triflorum*, *Claytonia lanceolata*, *Lomatium dissectum* and species of *Dodecatheon*, *Mertensia*, *Potentilla*, and *Delphinium*.

This type of vegetation is located on the high mountain ranges

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[4] Common names together with botanical names and authority are given at the end of this bulletin.

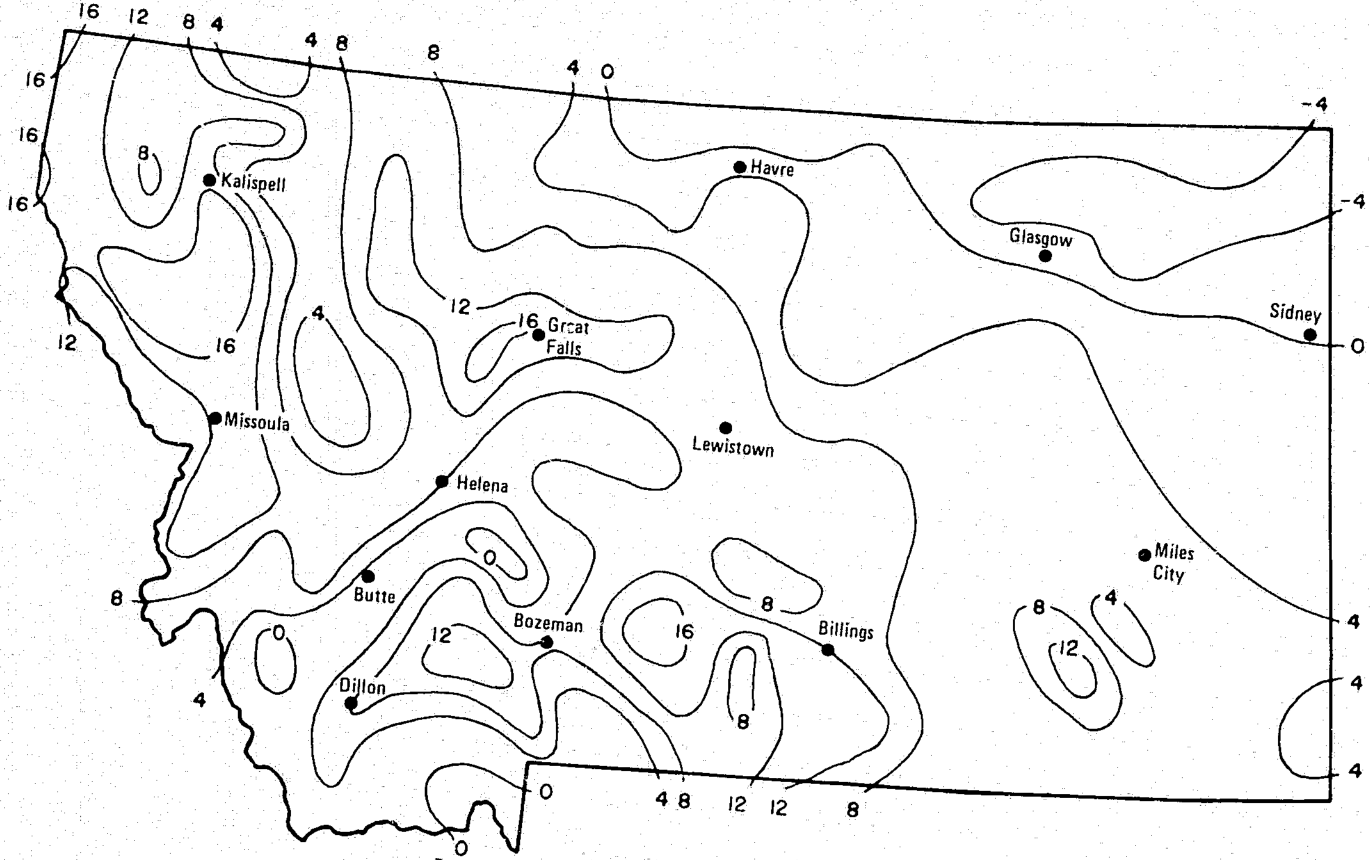

FIGURE 5.—Average minimum temperature (°F), 1931-52. (Adapted from Climatic Summary of the United States, Montana, U.S. Dept. Com. No. 60-24, 1960.)

particularly along the Continental Divide, the Bitterroot Mountains, and the Absorka Mountains. Smaller areas are also found in the Crazy Mountains, the Little Belt Mountains, and at elevations above 6,000 feet in the north and 7,500 feet in the south. It includes approximately 4,735,700 acres.

The precipitation varies from 20 to 50 inches annually, most of which falls as snow. The growing season is less than 60 days. The soils are variable in texture, color, and depth depending on parent material and topography, but most of the depleted sites have fine-textured soils. Generally, they are loose and fluffy when disturbed by plowing, but they may become hard after setting through the winter.

Sheep, big game, and some cattle utilize the herbage during the summer months. In the past, some areas have been overused to the extent that few productive grasses remain, and erosion has become a serious problem. These areas are important watersheds. Therefore, a satisfactory cover should be maintained to retard erosion, increase water infiltration, and improve the waterholding capacity of the soil so that water release to downstream users can be extended later into the summer.

Growth and seed production of desirable native forage plants are limited by the short growing season, low temperature, and other adverse climatic factors, and revegetation by natural means is slow and undependable.

Although the subalpine type is extensive in Montana, relatively little testing or range planting has been done. The inaccessibility and harshness of the site and the relatively low economical returns have discouraged work on revegetation. Nevertheless, experimental studies have shown that this type can be improved and that mechanical seeding offers the best method of revegetating depleted sites.

In these studies, establishment success and plant vigor were directly related to competition from native species as affected by seedbed preparation. More plants established, and they were more vigorous where the seedbed had been plowed and disked as compared with the check treatment. Plant vigor was also affected by site. On south exposures the plants were taller, had greater basal area, and yielded more herbage than plants on the level and north exposures. On the north exposure, they were generally lower in vigor than those on level exposures.

Planting by drilling was generally more reliable than planting by broadcasting; however, broadcast seeding was successful at Carrot Ba-'.. Plantings were most successful where the seed was covered with soil and the soil was firmed or packed after

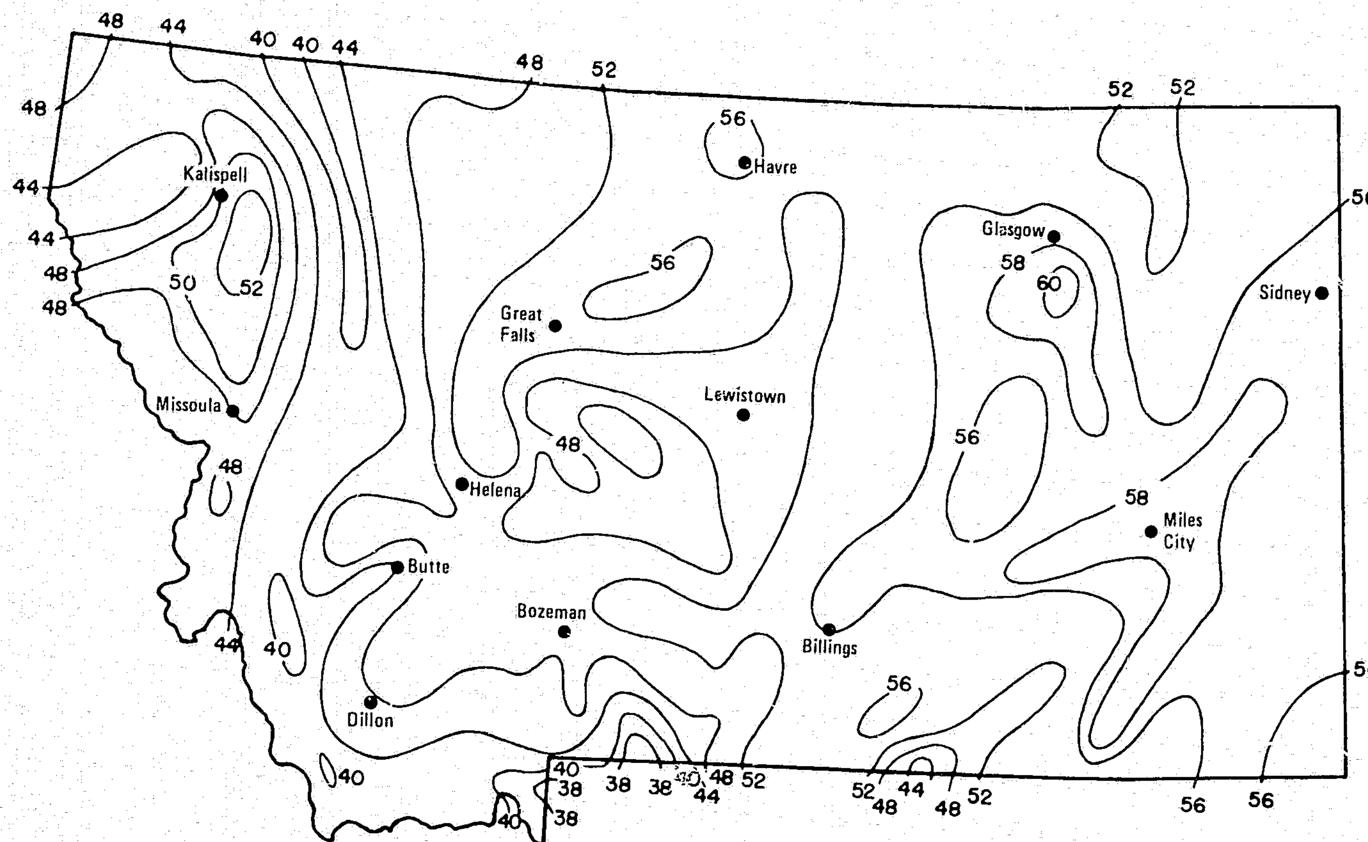

FIGURE 6.—Average minimum July temperatures (°F). 1931-52. (Adapted from Climate Summary of the United States, Montana. U.S. Dept. Com. No. 60-24, 1960

planting. In deep-furrow seedings, the plants were more vigorous in the furrow bottoms and on furrow slopes where they were shaded from the afternoon sun.

Generally, mulches in combination with fertilizers improved seedling establishment. Branches and felled trees that shaded the ground also improved establishment.

In each study of the subalpine type, *Bromus inermis* and *Alopecurus pratensis* responded well and appear widely adapted to the subalpine conditions. They were both able to spread, *A. pratensis* by seed and *B. inermis* by rhizomes, to adjoining plots. Other species that appeared adapted to the more favorable sites were *Bromus erectus*, *Poa pratensis*, *Agropyron trachycaulum*, *A. subsecundum*, *A. dasystachyum*, *A. smithii*, and *Dactylis glomerata*. Several species started well but were short lived, or their stands were seriously reduced within 5 years after planting. They were *Agropyron inerme*, *A. sibiricum*, *A. spicatum*, *Agrostis alba*, *Arrhenatherum elatius*, *Bromus carinatus*, *Festuca idahoensis*, *F. scabrella*, *Poa ampla*, *P. compressa*, *Melilotus officinalis*, *Trifolium fragiferum*, *T. repens*, and *T. pratense*.

Carrot Basin

Study location.—Located at the head of Sage Creek drainage, a tributary to the Gallatin River, Gallatin County, sec. 1, T.-10 S., R.3 E. (location 1, fig. 10).

Elevation.—9,000 feet.

Average precipitation.—Annual, 25 inches; April-September, 43 percent (estimated).

Soil.—Red sandy clay loam over sandstone and shale. Soil depth varies from several feet to bare rock.

Topography.—Rolling slopes dissected by gullies, slopes up to 30 percent.

Type of vegetation.—Subalpine forest and grassland.

Dominant and associated species.—*Pinus albicaulis* and *Abies lasiocarpa* are the dominant trees, and *Lomatium dissectum*, *Claytonia lanceolata*, *Agoseris glauca*, *Dodecatheon* spp., *Delphinium bicolor*, *Melica spectabilis*, *Poa* spp., *Festuca idahoenis*, and *Agropyron subsecundum* occur in the grasslands.

Previous use.—Apparently overgrazed. Denuded soils and snowbank areas were prevalent throughout the basin.

Study.—Carrot Basin planting methods.

Date planted.—July 19, 1952.

Procedures.—Six seedbed treatments were compared: one was plowed with moldboard plow then disked once over with a tan-

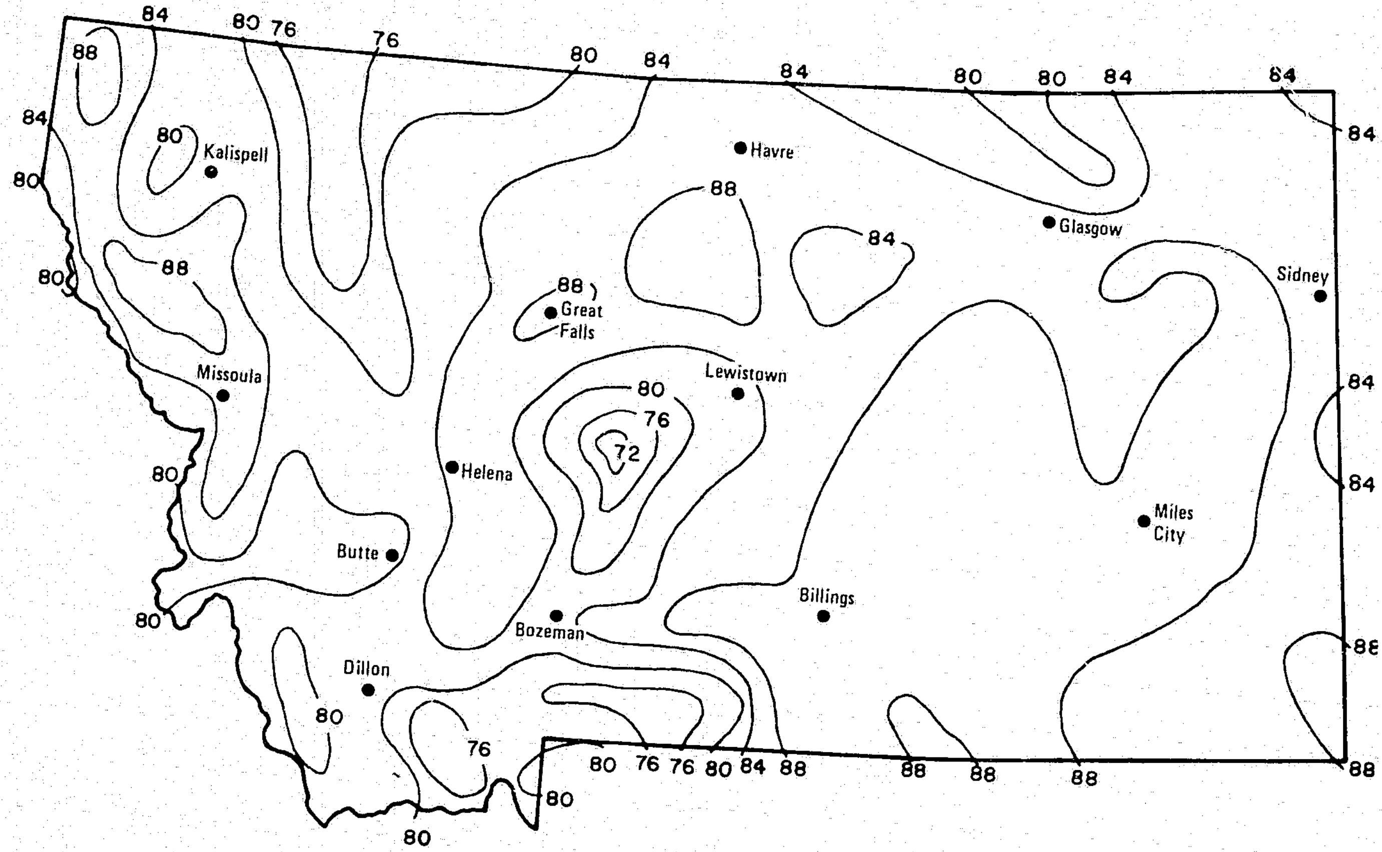

FIGURE 7.—Average minimum July temperatures (°F), 1952-60. (Adapted from Climatic Summary of the United States, Montana, U.S. Dept. Com. No. 60-24, 1960.)

dem disk. Treatments 2, 3, and 4 were disked once, twice, and three times over respectively with the tandem disk. Treatment 5 was disked once over with a horse-disk, and treatment 6 was an untreated check.

Summary of results.—Results of this study were published (Gomm 1962). Plowing-disking was the superior seedbed treatment as measured by control of native vegetation, seedling emergence, plant vigor, and herbage yield. Reduction of native vegetation by cultivation increased the number of established seedlings, and the vigor of seeded plants was directly affected by the method and degree of cultivation (table 2). Average leaf heights in August 1953 increased from 3.9 inches on nontreated soil to 6.5 inches on the plowed and disked seedbed, and production increased from 97 to 1,319 pounds air-dry herbage per acre.

Broadcasting produced stands equal to those planted by drilling.

Alopecurus pratensis and *Bromus inermis* were generally adapted for planting at this site. On the more favorable sites *Bromus erectus*, *Poa pratensis*, and *Agropyron subsecundum* also appeared adapted.

TABLE 2.—*The effect of seedbed treatments on the reduction of native vegetation and on the establishment, leaf height, and herbage yield of grasses seeded at Carrot Basin*[1]

Seedbed treatment	Ground cover density of native vegetation 1952-53	Plants per square foot 1952	Plants per square foot 1953	Basal area occupied 1956	Leaf height 1953	Air-dry herbage per acre 1954	Air-dry herbage per acre 1958
	Pct	*No.*	*No.*	*Pct.*	*Inch*	*Lb.*	*Lb.*
Check	36.2a	0.3a	0.1a	0.8a	3.9a	7a	97a
Plowed and disked	7.1d	5.0c	4.2c	13.4d	6.5c	599b	1,319c
Disked with tandem disk:							
3 times	12.0cd	5.4c	3.8c	9.8c	5.8bc	518b	1,094b
2 times	12.6cd	4.5bc	3.3c	8.1c	5.6bc	492b	998b
1 time	22.6b	2.7b	1.4ab	2.9b	4.8ab	68a	--
Horse-disked	21.4bc	3.0b	1.9b	2.5ab	5.0b	110a	--

[1] Within columns, values followed by the same letter are not significantly different at the 5-percent level. Values are averages of *Bromus inermis* and *Alopecurus pratensis*.

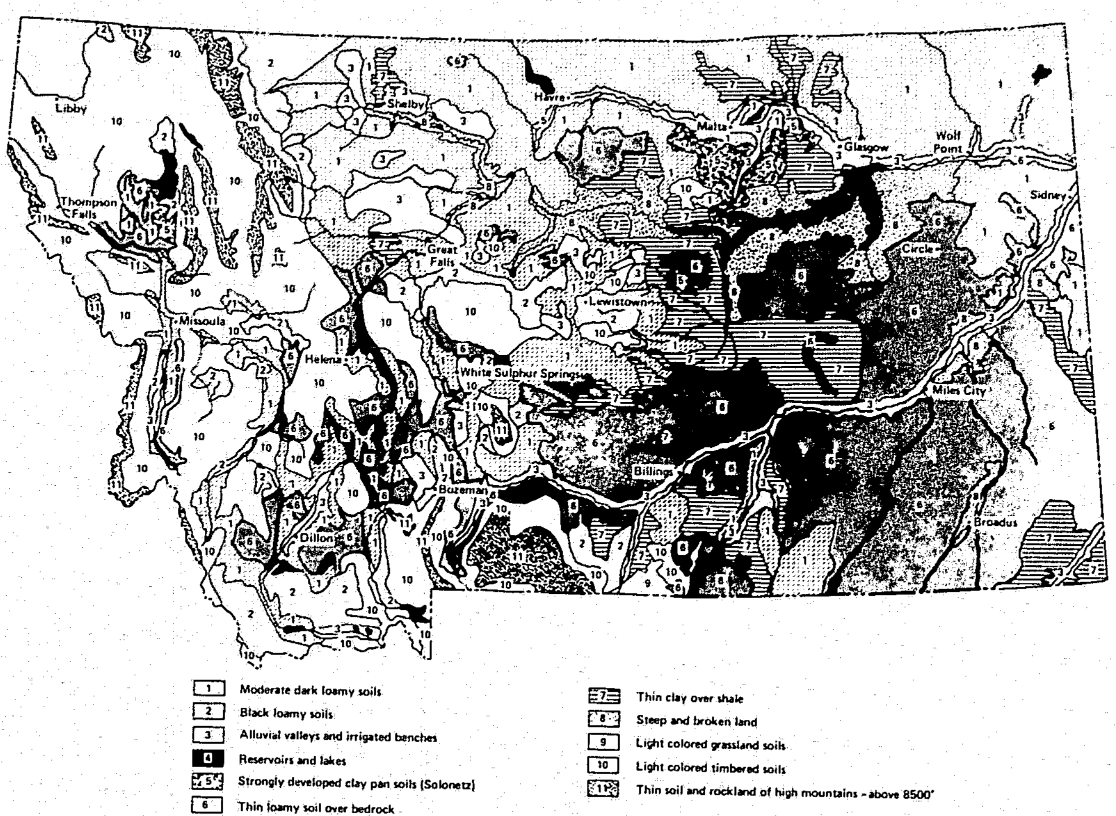

FIGURE 8.—Generalized soils of Montana. (Adapted from Generalized Soil Map of Montana, January 1960. 5, R-15. 703. U.S. Dept. Agr. Soil Conserv. Serv. and Mont. Agr. Expt. Sta.)

Generally, the grasses established best, developed fastest, and yielded most on the south exposures and least on the north exposures.

Study.—Carrot Basin adaptation nursery.

Date planted.—July 1952; September 1952.

Procedures.—Twenty-two grasses and *Astragalus falcatus* were planted into a plowed-disked seedbed. Seeds were drilled one-half to three-fourth inch deep in rows 20 inches apart and 20 feet long. There were three rows per plot without replication of treatment. July and September plantings of each species were made adjacent to each other.

Summary of results.—Results of this study were published (Gomm 1962). Based on ratings made in 1956, the species were grouped according to their apparent adaptation (table 3). Group I included those species which significantly increased their stands and were considered adapted to the site. They were *Alopecurus pratensis* and *Bromus inermis.* In group II six other species, *Agropyron smithii, A. subsecundum, A. trachycaulum, Bromus marginatus, Dactylis glomerata,* and *Poa pratensis* maintained their stands except for minor variations. These grasses were considered adapted to the more favorable sites.

Groups III and IV included those species that failed and are probably not adapted to the area. The soil at this site, however, was extremely loose when observed in 1956 and the relatively poor initial stands of some species could be attributed in part to a loose seedbed.

Lazyman Hill

Study location.—Located east of the Gravelly Range Road at the top of Lazyman Hill, Beaverhead National Forest, Madison County, NW1/4 sec. 9, T. 10 S., R. 2 W. (location 2, fig. 10).

Elevation.—9,350 feet.

Average precipitation.—Annual, 20 inches; April-September, 40 percent.

Soil.—A residual, mellow, dark-brown, silty loam high in organic matter apparently developed from red shale material. The "A" horizon is 6 to 8 inches deep with few rocks. Rocks become more abundant below 8 inches.

Topography.—A general 11-percent slope to the west-southwest near the summit of the mountain range.

Type of vegetation.—Subalpine forest and grassland.

Dominant and associated species.—*Festuca idahoensis, Geum triflorum, Agropyron trachycaulum, Poa alpina,* and *Achillea*

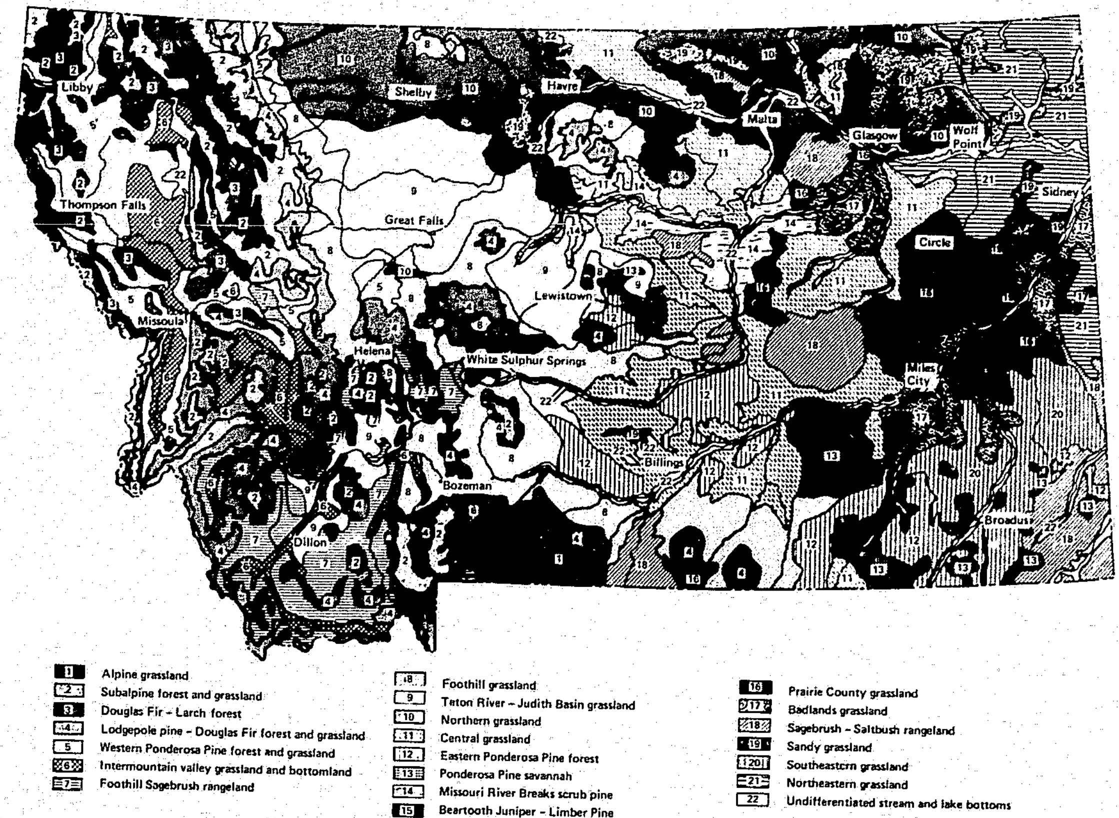

FIGURE 9.—Distribution of type of vegetation, Montana.

lanulosa are prevalent in the open grassland area. *Pinus albincaulus* is prevalent on the northern slopes nearby.

Previous use.—Rangeland grazed by sheep periodically from July 1 to September 1 each year. The study area is adjacent to a stock driveway.

Study.—Lazyman Hill adaptation nursery.

Date planted.—July 7, 1942.

Procedures.—Thirty-eight species were planted in plots 6 by

TABLE 3.—*Stand and persistence of grasses from spring and fall seeding in 1952 at Carrot Basin*

Species	Seeded, July		Seeded, September	
	Stand 1953	Stand 1956	Stand 1953	Stand 1956
	Pct.	*Pct.*	*Pct.*	*Pct.*
I. All plantings successful:				
Alopecurus pratensis	50	80	40	80
Bromus inermis	30	35	60	75
II. Initial stands maintained:				
Bromus marginatus	10	30	60	60
Dactylis glomerata	6	20	70	50
Agropyron smithii	30	20	1	5
A. subsecundum	10	10	1	1
A. trachycaulum	6	6	2	6
Poa pratensis	1	1	8	6
III. Fair to good initial stands but failed by 1956:				
Agropyron desertorum	24	1	4	0
A. intermedium	40	10	50	5
A. intermedium (Amur)	16	0	50	0
A. trichophorum	20	1	1	0
Bromus erectus	10	1	70	5
B. carinatus	8	0	70	1
Festuca arundinacea	1	0	70	0
Phleum pratense	2	1	75	1
IV. Poor initial stands or failed completely:				
Alopecurus arundinacee	6	0	0	0
Arrhenatherum elatius	2	1	1	1
Elymus junceus	2	0	1	0
Festuca ovina	1	1	0	1
F. ovina duriuscula	10	1	10	1
Poa ampla	0	1	0	1
Astragalus falcatus	0	0	0	0
Agropyron elongatum	0	0	0	0

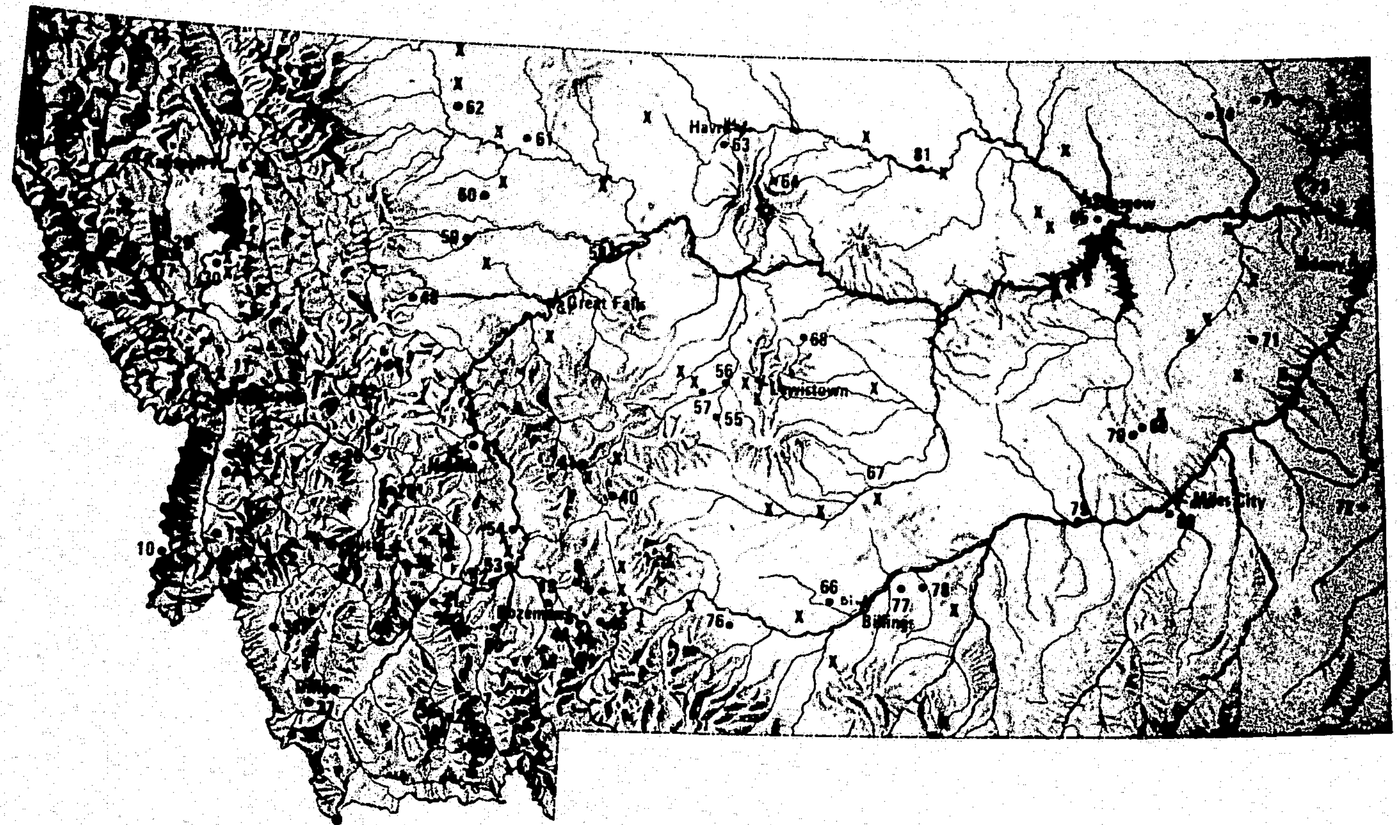

FIGURE 10.—Location of experimental plantings. (Base map by E. S. Smyrl, Dept. Earth Sci., Mont. State Col., Bozeman, Mont.)

14 feet. Three rows per plot were spaced 2 feet apart. Furrows 1 inch deep were dug with a three-cornered hoe, and seeds were scattered in the furrows so that depth of planting ranged from 1/2 to 1 inch. After planting, the furrows were raked and the soil pressed with the rake. Before seeding, the ground was broken from native sod in September 1940. Because of the live sod, clods, and roots present in the spring of 1941, the area was disked and floated during the summer of 1941. At planting time, in 1942, some old root clods remained, but most of them were rotted and broken. No live grass clumps remained.

Summary of results.—The results of this study from 1942 to 1951 were published (Peterson 1953). The species have been grouped according to stand changes over a 14-year period (table 4).

Group I (species that maintained their stand throughout the 14-year period) were *Bromus inermis* (Common and Parkland), *B. erectus, Alopecurus pratensis, Agropyron dasystachyum, Poa pratensis, Elymus junceus* and *Festuca rubra.* Of this group, *A. pratensis* and *B. inermis* appeared best adapted to the site and had spread to adjoining plots. Apparently *E. junceus* and *F. rubra* declined because of heavy competition from *A. pratense* and *B. inermis.* All the other species in groups II, III, and IV had died out or could not compete with *A. pratensis* and *B. inermis* at this site.

Group II included species that maintained their stands well through 9 years but declined rapidly in the 10th. In this group were *Festuca ovina, Agropyron cristatum* (Fairway), *Bromus carinatus, Agropyron intermedium, A. trachycaulum, A. subsecundum, A. trachycaulum violaceum, Hordeum brevisubulatum, Elymus virginicus,* and *E. sibiricus.* Group III included species that maintained their stands for 4 years but failed by the 9th, and group IV species, showed severely reduced stands within the first 4 years.

The study was plowed out in 1956. The plowing was poorly done and *B. inermis* and *A. pratensis* had reestablished themselves by 1963.

Round Hill

Study location.—Located about 1 mile southwest of Lazyman Hill on the Gravelly Range of the Beaverhead National Forest, Madison County (location 3, fig. 10), sect. 7, T.10 S., R.2W.

Elevation.—8,600 feet.

Average precipitation.—Annual, 20 inches; April-September, 40 percent.

TABLE 4.—*Establishment and persistence of grasses and legumes planted July 1942 at Lazyman Hill, a subalpine grassland site*

Species	Stand 1942	Stand 1950	Stand 1955
	Pct	*Pct.*	*Pct.*
I. Successful plantings:			
Bromus inermis	100	100	95
B. inermis - Parkland	97	100	95
Agropyron dasystachyum	100	90	90
Poa pratensis	76	95	80
Alopecurus pratensis	92	100	80
Bromus erectus	97	100	60
Elymus junceus	100	80	50
Festuca rubra	98	80	40
II. Plantings maintained 9 years:			
Agropyron cristatum	96	80	25
A. intermedium	100	60	0
A. pauciflorum (A. trachycaulum) [1]	100	80	1
A. subsecundum	100	100	1
A. violaceum (A. trachycaulum) [1]	100	100	1
Bromus carinatus - native	93	60	1
Elymus sibiricus	92	50	0
E. virginicus	96	60	1
Festuca ovina duriuscula	96	95	1
Hordeum brevisubulatum	100	50	1
III. Good stands for 4 years then failed:			
Agropyron desertorum	100	20	20
A. smithii	95	40	1
A. spicatum	100	10	0
Elymus dahuricus	100	40	1
Festuca idahoensis	82	20	1
F. scabrella	80	10	1
Phleum pratense	100	20	1
Lotus corniculatus	86	10	0
IV. Good initial stand but failed within the first 4 years:			
Agropyron inerme	98	0	0
A. sibiricum	100	0	0
Agrostis alba	91	0	0
Arrhenatherum elatius	95	0	0
Dactylis glomerata	100	0	0
Festuca elatior	92	0	0
Poa ampla	83	0	0
P. compressa	65	0	0
Melilotus officinalis	100	0	0
Trifolium fragiferum	96	0	0
Trifolium pratense	100	0	0
T. repens	100	0	0

[1] Names in parentheses are the correct species names.

Soil.—Light-brown clay-bearing mass apparently derived from shalelike parent material.

Topography.—Variable slopes from 10 to 40 percent to the east, south, west, and northwest.

Type of vegetation.—Subalpine forest and grassland.

Dominant and associated species.—*Agropyron spicatum, A. trachycaulum, Festuca idahoensis*, and species of *Geranium, Aster, Potentilla, Galium, Achillea, Poa, Invesia, Lupinus, Cerastium*, and *Chrysothamnus.*

Previous use.—Heavily grazed by sheep. The area is grassland near springs used for watering.

Study.—Round Hill summary of plantings.

Date planted.—June 1937 and October 1949.

Procedures.—Several seeding treatments were made over several years.

General results.—Although some plantings were not complete failures, the results were, however, generally unsatisfactory. The most important findings are as follows:

1. Contour furrows plowed with a walking hand plow at 9-foot intervals were not deep enough to stop erosion and allow establishment of grasses on the poor soils of these bare 30 to 40 percent slopes.
2. Handmade furrows 3 to 5 inches deep at 2 to 3 foot intervals were only slightly effective when planted to grasses.
3. Check dams constructed of burlap bags filled with soil and impregnated with seed failed because of excessive runoff. Seedlings grew out through the bags. This might be an effective method of establishing grass on check dams under less severe conditions.
4. Broadcast plantings on unprepared bare soil failed completely regardless of species. The failure was attributed to lack of soil covering the seed and the lack of moisture in the hard dry soil during the seedling stage.
5. Although hay mulch of *Agropyron cristatum* failed to produce seedlings, the hay-mulch method, held in place with cotton netting, may be suitable for small exposed areas. The failure to produce seedlings was attributed to nonviable seed in the hay.
6. Furrows influenced the establishment and vigor of seedlings. Plants were best on banks shaded from the afternoon sun and poorest on the opposite bank.
7. Large tractor-made contour trenches aggravated the erosion problem. They filled in so that water accumulating in the

trench washed through the banks at low spots, thus causing erosion to the shale material below.

8. *Bromus inermis, B. inermis* (Parkland), *Arrhenatherum elatius, Agropyron cristatum,* and *Bromus carinatus* produced the best stands in the order named.

9. *Agropyron trachycaulum, A. spicatum, Festuca ovina, Poa pratensis, Melilotus officinalis,* and *Medicago falcata* gave fair stands in trenched areas.

10. *Agropyron intermedium* planted in rows established a fair stand in the first year, but the plants were dwarfed.

11. *Oryzopsis hymenoides* and *Poa bulbosa* failed to become established and to maintain themselves in contour furrows. These two species established only a few seedlings during the first year.

Geyser Cone

Study location.—Located in the Gravelly Range of the Beaverhead National Forest, 30 miles south of Ennis, and 4 miles north of Black Butte Mountain, near Monument Ridge, Madison County, W1/2 sect. 27, T.10S., R.2W. (Location 4, fig. 10).

Elevation.—Approximately 9,000 feet.

Average precipitation.—Annual, 21 inches; April-September, 40 percent.

Soil.—Sandy clay-loam derived from red shale.

Topography.—Gullies with north and south facing slopes of 0 to 35 percent.

Type of vegetation.—Subalpine forest and grassland.

Dominant and associated species.—*Pinus albicaulus, P. flexilis,* and *Abies lasiocarpa* are the dominant trees. *Festuca idahoensis* is the dominant grass that is found in mixture with *Geum triflorum, Lupine* spp., *Agoseris glauca,* and *Ivesia* spp.

Previous use.—Possibly overgrazed before 1930; largely protected from grazing since 1930; snowbank areas.

Study.—Geyser Cone summary of plantings.

Procedures and results.—Five studies were made to determine adapted species and methods of seeding severely depleted sites of this area.

These studies are reported as follows:

1. Species, method, and fertilizer study - 1957
2. Native grass hay mulch - 1958
3. Species test - 1959
4. Species test - 1960
5. Species test - 1961

Species, method, and fertilizer study-1957.—Ten seedbed treatments were applied in plots 10 by 25 feet; five species of grass were each seeded in two rows 1 foot apart, and five fertilizer treatments were applied across planting treatments. Treatments included the following:

A. Planting treatments:

1. Plowed September 9, 1957, summer-fallowed, and planted September 4, 1958

2. Plowed and planted to wheat September 9, 1957, then planted to grass September 4, 1958

3. Plowed September 9, 1957, planted July 7, 1958

4. Sprayed with 2,4-D (2 pounds per acre) July 7, 1958, planted September 4, 1958

5. Plowed, planted, and covered with sawdust 1/4 inch deep September 9, 1957

6. Contour furrow 4 inches deep, 5 furrows per plot, planted to grass September 9, 1957

7. Transplant 2-inch sod plugs of *Bromus inermis* September 9, 1957

8. Plow and drill to grass September 9, 1957

9. Excavate a hole 2 by 6 feet by 1 foot deep and fill with fertile valley soil before planting to grass September 9, 1957

10. Check - no seedbed or planting treatment

B. Species - *Agropyron trachycaulum, Alopecurus pratensis, B. inermis* (seed and transplants), *Festuca rubra*, and *Poa pratensis.*

C. Fertilizers and rates per acre:

1. Nitrogen - 100 pounds N

2. Phosphorus - 200 pounds P_2O_5

3. N + P - 100 pounds N and 200 pounds P_2O_5

4. Complete - 100 pounds N and 200 pounds P_2O_5 and the following elements:

S - 100 pounds sulfur
B - 20 pounds sodium borate
Cu - 50 pounds copper sulfate
Fe - 50 pounds ferrous sulfate
Mg - 50 pounds magnesium sulfate
Mn - 50 pounds manganous sulfate
Mo - 1 pound ammonium molybdate
Zn - 50 pounds zinc sulfate

Results to 1960 were summarized and published (Hull *et al* 1962).

In 1958 the valley soil produced the greatest number of plants per foot, and July seedings appeared to be superior on residual soils. There were no apparent differences among the other seeding treatments.

Although fertilizers did not affect plant emergence, differences in plant color were evident. Nitrogen-treated plants were dark green while those not receiving nitrogen were light green. The minor elements in the complete fertilizer had no visual effect on plant growth or development.

Generally, *Bromus inermis* and *Alopecurus pratensis* had the most uniform stands and the most seedlings per foot of row space. *Festuca rubra*, however, appeared equally as good by total number of plants, but they were in bunches with large void areas in the row. It is possible that greater care in planting *F. rubra* would have improved its stand.

Most of the *B. inermis* transplants became established. The number of established plants was not affected by fertilizer treatment, but those that received nitrogen were greener, taller, and more robust than those that received no nitrogen.

In 1959, the July seedings continued to be the superior treatments with good to fair stands of all species except *Poa pratensis*. The success of established stands was also dependent on site conditions, with northern exposures having the best and southern exposures having the poorest stands.

Transplants of *B. inermis* were also fair to good depending upon the site. Some transplants at all sites had winterkilled, but survival was highest on the north exposure and lowest on the south exposure.

Winter snow came unusually early during 1961 before herbage production was sampled. However, plowing and drilling in July continued to be the superior seeding method and *A. pratensis* and *B. inermis* continued to be well established.

Native grass hay mulch–1958.—In the fall of 1958 mature *Agropyron subsecundum*, heavy with seed, was harvested at the Crockett Lake study area. The hay was scattered on a bare unprepared seedbed. In July 1959, a thick stand of seedlings had emerged, which persisted through 1960 and 1961. The plants were small, however. In 1962 many of them had died but those remaining appeared more vigorous than they had in 1961. Production, however, was low.

Species test–1959.—Five species, *Agropyron* spp. (Arctic), *Medicago sativa* (Rambler), *Hesperochloa kingii*, and *Melilotus officinalis* (PI-187985-L57 and Madrid) were planted in the spring of 1959. Of these, only *H. kingii* showed promise of establishing. Scattered plants of *H. kingii* continued to persist through 1962, but none of the other species survived.

Species test–1960.—On September 7, 1960, five grass species, *Agropyron intermedium*, *A. subsecundum*, *Bromus inermis*, *Alopecurus pratensis*, and *Hesperochloa kingii*, were planted in three replications. Replications 1 and 2 were located on a west exposure with 20 percent slope while replication 3 was on a south exposure with 48 percent slope. Species treatments were split by applying a straw mulch to half of each treatment.

By October 7, 1960, *A. intermedium* showed good germination and emergence, but the other grasses had not emerged. In 1961 and 1962 only a few of each of the grasses were found and all the plantings were considered unsuccessful. Apparently, mulching with straw did not improve the stands.

Species test–1961.—On June 28, 1961, seven grasses and seven legumes were planted. The grasses were *Agropyron* spp. (Arctic), *A. inerme*, *A. intermedium*, *Bromus inermis*, *Bromus* spp. (Alaska), *Hesperochloa kingii*, and *Alopecurus pratensis*. The legumes were *Medicago falcata* (Orenberg), *M. sativa* (Vernal), *Onobrychis viciaefolia*, *Trifolium pratense* (Zigzag), *Astragalus semibilocularis*, *A. falcatus*, and *A. cicer*.

In the fall of 1961 good seedling stands of *A. intermedium*, *B. inermis*, and *Agropyron* spp. (Arctic) had emerged. Occasionally, scattered seedlings of the other grasses were also found. In 1962 the grasses continued to appear as seedlings with a slight reduction in stand.

Of the legumes only *O. viciaefolia* had good stands emerge in 1961. A few scattered plants of *M. falcata* (Orenberg) and *A. cicer* were also found. In 1962 only a few of the *O. viciaefolia* seedlings remained.

Red Spots

Study location.—Located at the head of Ruby Creek and Red Creek in Gravelly Range of the Beaverhead National Forest, Madison County, sect. 21, 22, 27, 28; T.10S., R.2W. (location 4, fig. 10).

Elevation.—8,500 to 9,500 feet.

Average precipitation.—Annual, 21 inches; April-September, 40 percent.

Soil.—Red clay loam to red shale.

Topography.—5 to 80 percent slopes to the southeast, east, and northeast.

Type of vegetation.—Subalpine forest and grassland.

Dominant and associated species.—*Festuca idahoensis* and species of *Lupinus*, *Carex*, and *Ivesia*.

Previous use.—Depleted range from sheep grazing; driveway in snowbank areas.

Study.—Red Spots snowbank plantings.

Date planted.—August 16 to September 20, 1948, and August 20 to September 20, 1949.

Procedures.—A mixture of seed was planted at 20 pounds per acre with a cyclone hand broadcaster. Seeding was done on areas of various sizes where the seedbed had been variously treated. Species were included in the mixture in the following proportions:

Species	*Parts*
Agrostis alba	3
A. tenuis	1
Bromus inermis	20
Dactylis glomerata	2
Festuca rubra fallax	3
Phalaris arundinacea	1
Phleum pratense	5
Poa ampla	5
P. pratensis	5
Trifolium repens	2

Seedbed preparation included the following treatments:

1. Furrows were plowed on the contour spaced 3 to 12 feet apart depending on slope. The steeper the ground the closer the furrows. Contours were dammed at 6-foot intervals. Seeds were not covered after planting.

2. A 4-foot disk was pulled behind a D-4 tractor. Disking on the contour was unsuccessful because the slope was too steep and irregular to follow the contour. Seeds were not covered after planting.

3. A spiketooth harrow was pulled approximately along the contour scratching from 1 to 2-1/2 inches deep. Seeds were not covered after planting.

4. Unprepared seedbed. Seeds were not covered with soil after planting, but special areas were variously treated with sawdust or straw mulches and fertilized.

Results.—The areas that were plowed on the contour produced good stands of seedlings in the furrows especially where they were dammed. One area that had been plowed and the seed had been covered with a thin layer of sawdust was better than those without the sawdust treatment. Disked treatments were moderately successful. The harrowed and noncultivated treatments failed, but a few plants emerged. Their survival, however, was low.

In areas where soil was prepared to conserve water and where fertilizers were used, good stands of grass were established.

Straw mulching without fertilization had little effect on stand establishment, but with fertilizers, it gave good results.

Sawdust mulching without fertilization was detrimental to stand establishment, but sawdust with fertilizers gave good results.

By 1951, plowing with furrows on the contour was the most successful seedbed treatment, but native weeds were reestablishing on all disturbed areas.

By 1957 and again in 1963 *B. inermis* was the only species that appeared adapted to the area. It was well established in the bottoms of the contour furrows but was not spreading to areas between the furrows. Also the stands were thin; production was low; and only a few seed heads were produced.

Elk River

Study location.—Located south of the gully where the road crosses the main fork of Elk River in the Gravelly Range of the Beaverhead National Forest, Madison County, SE¼ sect. 16, T.11S., R.2W. (location 5, fig. 10).

Elevation.—8,700 feet.

Average precipitation.—Annual, 20 inches; April-September, 40 percent.

Soil.—Red clay intermixed and underlain with red shale.

Topography.—North-facing 30 to 60 percent slopes.

Type of vegetation.—Subalpine forest and grassland.

Dominant and associated species.—*Festuca idahoensis.*

Previous use.—Depleted sheep range; subject to deep snowdrifts.

Study.—Elk River snowbank plantings.

Date planted.—September 15, 1947.

Procedures.—*Bromus inermis* was planted in a ½-acre area at 10 pounds per acre with a cyclone seeder. The seedbed, which was practically denuded of vegetation, was brush-dragged before and after planting.

Part of the area was fenced to exclude livestock. On the area that was not fenced, furrows were plowed on the contour before planting and trees were laid up and down the slope to divert the travel of sheep crossing the slope.

Summary of results.—In 1949, a few plants of *B. inermis* were found in the exclosure but the planting generally was not satisfactory. On the unfenced area sheep were allowed to graze, but despite their trampling, a fair stand of *B. inermis* grew in the contour furrows. Under the protection of the trees, a good stand of native grasses and *B. inermis* became established.

Douglas Fir-Larch Forest

This predominant forest type, located on the west slopes of the Continental Divide north of Missoula, Mont., encompasses approximately 4,787,000 acres. *Pseudotsuga menziesii* and *Larix occidentalis* are the main tree species. *Pinus albicaulis* becomes an important subspecies in the northwest corner of the State, and *Pinus contorta* becomes more important as a fire species to the south. Occasionally, *Thuja plicata*, *Abies grandis*, *Tsuga heterophylla*, and *Taxus brevifolia* are also found. The understory consists primarily of *Calamagrostis rubescens*, *Mahonia aquifolium*, and *Arctostaphylos* spp.

The elevation ranges from 3,000 to 6,000 feet; precipitation varies from 16 to 40 inches, and the growing season varies from 30 to 80 days.

The topography is generally too steep or too rough to be cultivated and seeded. Nevertheless, native and introduced grasses become readily established in cutover or burned areas.

The soil is a light-colored timbered soil derived from glacial till that contains a large percentage of rock fragments mainly from quartzite and argillite. Dolomite and limestone fragments are found in the lower subsoil. Soil series include Waite, Yeoman, Walters, and Whitefish.

Because of the general forest type and associated topography, revegetation to grass is not considered practical except following fires or logging. Species that appear from management plantings to be adapted include *Trifolium repens*, *T. hybridum*, *Phleum pratense*, *Poa pratensis*, *P. compressa*, and *Festuca elatior*. Hand broadcasting and aerial seeding have been successful. Seeding should be done as soon after the fire or logging as possible so that the seed will be covered with ash or sluffing soil.

Lodgepole Pine-Douglas Fir Forest and Grassland

This type of vegetation, covering over 9,735,000 acres, is the most widespread forest type in Montana. It is located on both sides of the Continental Divide in mountainous areas at elevations from 5,000 to 10,000 feet. Precipitation varies from 16 to 40 inches, and the growing season varies from 30 to 110 days.

Pinus contorta is the dominant tree species, especially in previously burned areas. In the north it grows in fairly pure stands at the higher elevations, while at the lower elevations it is found in association with *Pseudotsuga menziesii* and *Pinus ponderosa*. In the south it occurs primarily as pure stands, but may be intermixed with *P. menziesii*, *Populus tremuloides*, *Picea engelmanni*, and *Abies lasiocarpa*. *Vaccinium* spp., *Physocarpus malvaceus*, *Symphoricarpos* spp., *Sambucus microbotrys*, *Lupinus* spp., and *Calamagrostis rubescens* are often found as understory.

Open mountain grasslands and parks are found throughout the forest type where *Carex geyeri*, *Agoseris glauca*, *Festuca idahoensis*, and species of *Arnica*, *Aster*, and a number of other herbaceous plants are found. In some openings *Wyethia* spp. dominates the area. *Artmesia tridentata* may also become an important species on the drier sites.

Much of the cutover forest and associated grasslands have deteriorated through overgrazing by big game or livestock and are in need of more closely controlled management. Mechanical seeding is not recommended generally because natural recovery is usually successful. However, where the site is so deteriorated that most of the perennial grasses have been eradicated, or where erosion is a serious problem, artificial seeding should be considered. Experimental studies have given variable results from seedbed preparation treatments. In the Bridger Range near Bozeman, Mont., seedings failed when grasses were planted into dense stands of *Bromus tectorum*. Seedings also failed in the Selway Forest in Idaho where there was no seedbed preparation. Near Wise River, Mont., good stands were obtained where seed was broadcast on an unprepared but loose seedbed. At this site, however, seeded species were most abundant where native vegetation was least dense.

Conclusions drawn from the several studies done on open grasslands of this type indicate that (1) a seedbed should be prepared where the density of the native vegetation is great and where the topography is not too steep. Work should be done on the contour. (2) Drilling is the best planting method, but where drilling is impractical, broadcasting is suitable if the slope of the land and condition of the soil provide natural covering of the seed. Otherwise, some method of dragging should be used to cover the seed.

Several species appear well adapted for planting in the open grasslands of this type. Those that appear best adapted include

Agropyron intermedium, Alopecurus pratensis, Arrhenatherum elatius, Bromus erectus, B. inermis (Lincoln and Manchar varieties), *Elymus junceus, Festuca ovina duriuscula, Phleum pratense, Dactylis glomerata,* and *Poa compressa. Agropyron desertorum* (Nordan and Standard varieties) appeared good at some locations but did not maintain good stands particularly at the more moist sites where other introduced and native grasses crowded them out. *Medicago falcata* also appeared to establish good stands for a few years.

Introduced species produce good herbage yields in this type. Yields of 1 to 2 tons per acre can be expected from new plantings. As stands become older, production declines after the third and fourth growing season. However, in normal years 1,000 to 1,500 pounds of herbage can be expected.

Application of nitrogen fertilizer increased yields significantly at the Crockett Lake area. Residual effects expressed as increased herbage and change in species composition were present 12 years after the initial applications and as increased protein content from 4 to 5 years after application.

Wapiti

Study location.—Located near the Wapiti Road approximately one-half mile from the Wapiti-Taylor Fork junction in the Gallatin National Forest, Gallatin County, sect. 18, T.9S., R.4E.

Elevation.—Approximately 7,500 feet.

Average precipitation.—Annual, 20 inches; April-September, 50 percent.

Soil.—Clay loam; rock near surface at top of the ridge.

Topography.—5- to 10-percent slope to the east.

Type of vegetation.—Lodgepole pine-Douglas fir forest and grassland.

Dominant and associated species.—*Festuca idahoensis, Agropyron smithii, A. spicatum, Koeleria cristata, Chrysothamnus* spp., *Artemesia tridentata* and *Oxytropis sericea* are dominant species in the open grassland. *Pinus contorta* is the dominant tree in the nearly forest.

Previous use.—Overgrazed range by livestock and elk (wapiti).

Study.—Wapiti adaptation nursery.

Date planted.—June 5 and September 16, 1957.

Procedures.—The seedbed was prepared by disking and harrowing in October 1956. Twenty-five species of grasses and legumes were planted by drilling with a hand drill in plots 3 by 30 feet with three rows per plot spaced at 1-foot intervals.

Fall and spring seedings of each species were made adjacent to each other in a randomized block-split plot design with three replications.

Summary of results.—Plots planted in the fall of 1957 were rated as complete failures. The failures may have been from the lack of seedbed preparation just before planting and the resulting competition from weeds.

In the spring seeding, *Medicago falcata, Dactylis glomerata,* and *Melilotus officinalis* produced the best initial stands while *Agropyron spicatum* and *Poa pratensis* failed completely.

By 1961 stands of most species had improved. Those that appeared well adapted to the site included *Agropyron desertorum* (Standard and Nordan), *A. intermedium, Bromus inermis* (Lincoln and Manchar), *B. erectus, Elymus junceus, Festuca ovina duriuscula, Alopecurus pratensis,* and *A. arundinacea* (table 5). Those that established good to fair stands but failed to increase in stand were *Agropyron trichophorum, Dactylis glomerata, Festuca rubra, Medicago falcata,* and *Poa ampla.* The rest of the species generally failed, however, the few listed below produced fair yields.

Herbage yields were highest in 1959 for most species. They generally decreased in 1960 and 1961 but increased again in 1962. Only the 1959 yields and the 1959-62 averages are given in table 5. The highest producing species were *M. falcata* and *A. desertorum* (Nordan and Standard) in 1959, *A. desertorum* (Standard) in 1960 and 1962, and *F. ovina* in 1961.

Although *Agropyron elongatum* established a poor stand, it produced 1,500 pounds of herbage in 1959 and 919 for the 1959-62 average. Other species that established poor stands but maintained fair yields were *A. inerme, A. elatius, Stipa viridula,* and *Festuca arundinacea.*

Study.—Wapiti broadcast seedings.

Date planted.—October 6, 1956.

Procedures.—Part of the area was disked, harrowed, and broadcast seeded to a mixture of grasses. Species and seeding rate per acre were *Bromus inermis,* 3 pounds; *Agropyron intermedium,* 2 pounds; *Festuca ovina,* 1 pound; and *Poa ampla,* 1 pound.

Randomly located samples were harvested by species in each of four treatments (seeded grazed; seeded protected; native grazed; and native protected). The unprotected areas were grazed heavily in the fall and early spring by big game and horses.

Summary of results.—Samples harvested in 1959, 1961, and 1962 showed higher yields from protected areas of both the seeded and native stands (table 6). Increased yields were mostly

TABLE 5.—*Establishment and herbage yield of seeded species on deteriorated rangeland at Wapiti, a lodgepole-grassland site*

Species	Stand		Yield per acre, oven-dry	
	1957	1961	1959	1959-62 av.
	Pct.	*Pct.*	*Lb.*	*Lb.*
I. Successful plantings:				
Bromus inermis - Lincoln	53	92	2,267	1,390
B. inermis - Manchar	53	90	2,233	1,454
Alopecurus pratensis	51	88	2,100	1,328
Bromus erectus	55	85	1,600	1,147
Festuca ovina duriuscula	51	85	1,433	1,383
Alopecurus arundinacea	16	82	1,633	988
Agropyron desertorum - Stan.	51	80	3,466	2,028
A. intermedium	50	77	2,633	1,436
A. desertorum - Nordan	66	75	3,833	2,008
Elymus junceus	28	65	1,033	748
II. Fair to good stands but not increasing:				
Dactylis glomerata	85	65	1,333	843
Medicago falcata - Ladak	90	58	4,467	1,762
Agropyron trichophorum	43	50	2,266	1,148
Festuca rubra	46	47	1,100	827
Poa ampla	36	37	1,633	1,028
III. Poor stands established but yielded well:				
Agropyron elongatum	13	13	1,500	919
A. inerme	10	5	1,367	920
Arrhenatherum elatius	30	7	1,233	630
Stipa viridula	18	20	1,400	812
Festuca arundinacea	56	12	1,133	725
IV. Generally failed:				
Agropyron smithii	33	5	566	400
A. spicatum	0	4	367	466
Elymus triticoides	6	2	567	200
Poa pratensis	0	1	0	0
Melilotus officinalis	83	1	300	75
Least significant difference at 5-percent level	26	16	1,099	764

due to increases in production from the introduced and the native grasses. In unprotected areas the forbs increased in quantity each year and became an important part of the stand by 1962. In the seeded protected area the introduced grasses dominated the stand with very little invasion from native species.

Crockett Lake

Study location.—Located at the head of Dry Hallow in the Beaverhead National Forest approximately 1/5 mile south of the Gravelly Range Road, Madison County sect. 14 NW¼, T.8S., R.2W. (location 7, fig. 10).

Average precipitation.—Annual, 20 inches; April-September, 40 percent.

TABLE 6.—*Herbage yields of native and introduced plants on deteriorated rangeland as affected by grazing at Wapiti, a lodgepole grassland site*

Grazing treatment and species	Yield per acre		
	1959	1961	1962
	Lb.	*Lb.*	*Lb.*
Seeded protected, all introduced grasses	2,000	1,113	1,600
Native protected:			
Total	813	1,101	1,450
Agropyron smithii	34	48	200
A. spicatum	112	34	200
2Festuca idahoensis	346	508	600
Koleria cristata	38	31	200
All forbs	239	480	200
Chrysothamnus spp	44	0	50
Seeded grazed:			
Total	1,177	799	1,150
All introduced grasses	1,138	699	850
All forbs	19	58	150
All native grasses	20	22	150
Native grazed:			
Total	567	464	1,170
Agropyron smithii	26	37	150
A. spicatum	45	0	50
*Festuca idahoensis*1	327	194	500
Koleria cristata	78	42	100
All forbs	57	191	350
Chrysothamnus spp	34	0	20

Elevation.—7,500 feet.

Soil.—Silty loam high in organic matter. Fractured quartz rock occurs throughout the profile.

Topography.—5-percent slope to the west.

Type of vegetation.—Lodgepole pine-douglas fir forest and grassland.

Dominant and associated species.—*Festuca idahoensis, Agropyron subsecundum, A. spicatum, Geum triflorum, Agoseris glauca, Achillea lanulosa,* and *Cerastium* spp. are dominant with some *Artemesia tridentata* in the grasslands. *Pinus contorta* and *P. flexilis* dominated the adjoining timbered areas.

Previous use.—Rangeland in good-to-excellent condition grazed by cattle.

Study.—Crockett Lake fertilizer—species planting.

Date planted.—September 18, 1956.

Procedures.—A fine, firm seedbed was prepared by moldboard plowing and by disking. Ten species of grass were planted in a randomized block-split plot design with fertilizer as major plots and species as subplots. Species plots were 3 by 20 feet with three rows per plot spaced at 1-foot intervals. Seeding was done with a belt-type hand seeder. Fertilizer treatments were applied in September 1956, at three rates (500 pounds N with 225 pounds P_2O_5 per acre; 100 pounds N with 45 pounds P_2O_5 per acre; and check with no fertilizer.)

Summary of results.—All species established excellent stands ranging from 73 to 97 percent of rows occupied. Most of them continued to maintain or improve their stands through 1962 (table 7). *Festuca arundinacea* appeared the least adapted; stands reduced from 92 to 3 percent between 1957 and 1960. *Poa ampla, Festuca rubra, F. ovina, Agropyron desertorum,* and *A. trichophorum* also suffered some loss in stand while *Poa pratensis, Bromus inermis,* and *Alopecurus pratensis* filled in to nearly complete stands.

Significant differences caused by fertilizers occurred during establishment and in mature stands. Early in the study, interactions of species times fertilizers were significant but these differences disappeared as the stands matured. Generally as fertilizer rates increased, stands decreased. For example, *Festuca ovina duriuscula* decreased from 83 percent stand in 1957 to 14 percent in 1960 due to the high rate of fertilizers. At the other rates, it decreased from 90 to 70 percent then maintained its stand through 1962. At the high rate, it recovered to 75 percent in 1962, similar in stand to the other treatments.

TABLE 7.—*Stand, yield, and protein content of seeded grasses as affected by fertilization at time of planting*[1]

Species	Stand 1962	Yield per acre oven-dry herbage: No fert.	Med.	High	Protein per acre 1960-62: No fert.	Med.	High
	Pct.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Festuca ovina duriuscula	72	1,923	1,659	1,388	7.1	9.0	9.1
Bromus inermis (Lincoln)	100	1,828	2,356	2,937	9.6	9.1	9.7
Agropyron intermedium	97	1,611	2,625	3,044	8.3	9.0	10.8
Alopecurus pratensis	100	1,254	1,786	2,037	8.5	8.7	9.8
Agropyron desertorum (Nordan)	58	1,118	1,879	1,910	8.9	8.4	9.6
Poa ampla (Sherman)	39	1,037	973	1,378	7.8	[2] 9.8	8.5
P. pratensis (Troy)	100	1,007	1,424	1,955	7.6	8.9	8.5
Festuca rubra	63	852	736	1,481	9.1	9.2	9.9
Agropyron trichophorum	69	780	1,694	2,559	8.6	8.8	10.2
Mean.	78	[3] 1,268	1,681	2,077	8.4	9.0	9.6
Festuca arundinacea	3	481	295	492	8.2	[2] 9.0	9.4

[1] Planted and fertilized in September 1956. Fertilizer rates in pounds per acre were as follows:

	N	P_2O_5
High	500	225
Medium	100	45

[2] First 2 years only; yields were negligible in 1962.

[3] For comparison, native *Agropyron subsecundum* produced 904 pounds and native range, 794 pounds per acre.

Herbage yield differences were significant in 1959 among species but not among fertilizer treatments. In 1960, 1961, and 1962, however, yield differences among species and fertilizers as well as interactions were significant. Generally, yields declined in 1960 and 1961 and increased again in 1962. This appeared true for all fertilizer treatments. The difference among years might have been due to increased precipitation received in 1962.

Except for *F. ovina* and *F. arundinacea*, average yields for 1959-62 (table 7) showed increased herbage production with high fertilizer rates. Production of *F. ovina* declined with increased fertilizer. In all years the seeded grasses, with the exception of *F. arundinacea*, *F. rubra*, and *P. ampla*, produced more herbage than volunteer native *Agropyron subsecundum* or native range complex.

Stage of maturity did not appear to be affected by rates of fertilizers. Height measurements, however, were increased slightly with the application of fertilizer for all but the *Festuca* and *Poa* species.

Herbage samples harvested in 1960, 1961, and 1962 were analyzed for crude protein. Generally, protein increased with increased fertilizer rates (table 7). In 1960 differences in protein content were significant among species. *F. rubra* was higher in protein than the other grasses. But there was less difference among species at the high and medium rates than without fertilizer. In 1961 and 1962 differences in protein content were not significant among the species.

Residual effects from fertilizers influenced the protein content through 1960. By 1961 the residual effect of the medium rate did not increase the protein content of several grasses. The high rate, however, continued to show residual effects in 1961. In 1962 the protein content of the herbage was variable with no indication that any residual effect occurred from fertilizing at any rate.

Henley Ridge

Study location.—Located on the Jerry Creek allotment of the Wise River District, Beaverhead National Forest, located 3 miles west of Little Granulated Mountain, Beaverhead County, sect. 31, T. 2N., R.11W. (location 9, fig. 10).

Elevation.—7,500 feet.

Average precipitation.—Annual, 16-18 inches; April-September, 77 percent.

Soil.—Gravelly loam.

Topography.—1 to 10 percent to the southwest.

Type of vegetation.—Lodgepole pine-Douglas fir forest and grassland.

Dominant and associated species. —*Festuca idahoensis*, *Poa* spp., *Koleria cristata*, *Artemesia tridentata*, *Stipa columbiana*, and *Bromus carinatus* are dominant in the open grasslands. *Pinus contorta* is the main tree species in the surrounding forest. *Pseudotsuga menziesii* and *Abies lasiocarpa* are also found.

Previous use.—Overgrazed rangeland.

Study.—Henley Ridge adaptation planting.

Date planted.—October 11, 1946.

Procedures.—Ten species were broadcast seeded onto 1/20-acre plots at 20 pounds per acre. Seeds were not covered. Seeding was made on a 2 to 3 inch snowcover. Before the snowcover and planting, the area was double disked with a cutout disk.

Summary of results.—The initial seedling establishment was not observed. By the second year *Bromus inermis*, *Festuca arundinacea*, *F. ovina*, *Poa bulbosa*, and *P. stenantha* had established good stands while *Agropyron intermedium*, *Alopecurus pratensis*, and *Poa compressa* established fair stands. *Agropyron cristatum* and *Poa ampla* failed.

Native species of *Stipa columbiana* and *Bromus carinatus* formed good stands throughout the area. In an adjoining area planted to a mixture of *Agropyron cristatum*, *A. trachycaulum*, *B. inermis*, and *Phleum pratense*, good stands of *P. pratense* were established, while *B. inermis* and *A. trachycaulum* formed fair stands. *A. cristatum* was not found.

Bean Ridge and Grassy Granulated Mountain

Study location.—Located in the Wise River district of the Beaverhead National Forest, Beaverhead County, sect. 1 and 2, T.1N., R. 11W. (location 9, fig. 10).

Elevation.—7,500 to 8,000 feet.

Average precipitation.—Annual, 16-18 inches; April-September, 77 percent.

Soil.—A loose, stony loam.

Topography.—Variable slope and exposure.

Type of vegetation.—Lodgepole pine-Douglas fir forest and grassland.

Dominant and associated species.—*Festuca idahoensis*, *Poa* spp. *Koleria cristata*, *Artemesia tridentata*, *Stipa columbiana*, and *Bromus carinatus*. *Pinus contorta* is the dominant tree in the nearby timbered areas. *Pseudotsuga menziesii* and *Abies lasiocarpa* are also found.

Previous use.—Depleted rangeland grazed by livestock and big game.

Study.—Bean Ridge and Grassy Granulated Mountain Range Plantings.

Date planted.—Fall 1948.

Procedures.—A mixture of four grasses was broadcast seeded on unprepared seedbed over a 100-acre area. Grasses planted were *Bromus inermis*, *Dactylis glomerata*, *Poa pratensis*, and *P. bulbosa*.

Summary of results.—A good stand of seeded grasses established on the steep, loose, east-facing slopes where plants ranged from 10 to 25 plants per square yard. On level grassy parks, however, where the soil was relatively stable and the area was well occupied with dandelion and other weeds, few seeded grasses established.

Jerry Creek

Study location.—(Jimmy New Creek area) Wise River District, Beaverhead National Forest, Beaverhead County, sect. 11, T.2N., R.11W. (location 9, fig. 10).

Elevation.—7,800 feet.

Average precipitation.—Annual, 16-18 inches; April-September 77 percent.

Soil.—A loose, stony loam of moderate brown color eroded by sheet and shoestring gully erosion.

Topography.—60 percent slope to the southwest.

Type of vegetation.—Lodgepole pine-Douglas fir forest and grassland.

Dominant and associated species.—*Agoseris*, *Gayophytum*, *Polygonum*, *Pentstemon*, *Potentilla*, *Fragaria*, *Antennaria*, *Achillea*, *Lupinus*, *Poa*, *Bromus carinatus*, *Carex*, and *Chrysothamnus*. *Pinus contorta* is the dominant tree in the nearby forest. *Pseudotsuga menziesii* and *Abies lasiocarpa* are also found.

Previous use.—Depleted from heavy use by livestock and as a natural stock passageway.

Study.—Jerry Creek Allotment range plantings.

Date planted.—October 9-14, 1940.

Procedures.—A mixture of five grasses was planted by broadcasting at 5 pounds seed per acre over a 5-acre area. Because of the steep slope, no seedbed was prepared or the seeds covered. Included in the seeding were *Agropyron cristatum*, 4 parts; *Arrhenatherum elatius*, 1 part; *Bromus carinatus*, 2 parts; *Dactylis glomerata*, 1 part; and *Poa compressa*, 1 part.

Summary of results.—In the first growing season after planting, the seeded species were well distributed over the area. They were most abundant where the native vegetation was the least dense. In succeeding years, *D. glomerata* and *P. compressa* made the best growth. *Bromus inermis* (which must have been planted in the place of *B. carinatus*) made a fair showing, while *A. cristatum* and *A. elatius* were rather poor. Estimated herbage production in 1946 was 400 to 500 pounds per acre.

Little Granulated Mountain

Study location.—Located ¾ mile west of Jimmy New Creek, Wise River District, Beaverhead National Forest, Beaverhead County, sec. 10, T.2N., R.11W. (location 9, fig. 10).

Elevation.—7,550 feet.

Average precipitation.—Annual, 16-18 inches; April-September, 77 percent.

Soil.—Dark-colored pebbly loam. Much of the topsoil has been lost through sheet erosion, but the soil is fairly deep and productive. Subsoil consists of small rocks and pebbles.

Topography.—Four to 10 percent slope to the south.

Type of vegetation.—Lodgepole pine-Douglas fir forest and grassland.

Dominant and associated species.—*Agoseris, Polygonum, Potentilla, Frageria, Antennaria, Achillea, Lupinus, Poa, Festuca* and *Carex*. *Pinus contorta* is the dominant tree in the forest.

Previous use.—Depleted from heavy use and trampling by cattle and horses during the spring, summer, and fall.

Study.—Little Granulated Mountain range plantings.

Date planted.—October 14, 1940.

Procedures.—The area was double-disked with a light 6-foot horsedrawn disk to prepare a seedbed. Three mixtures of grasses were planted by broadcasting at 5 pounds of seed per acre onto 3-acre plots. Seven additional plots of grasses were planted singularly by broadcasting on 1/40-acre plots. No attempt was made to cover the seed. No provision was made to protect the seeded areas from grazing, but the number of animal units was reduced.

Summary of results.—In the first growing season all the seedings appeared well established. *Agropyron intermedium, A. cristatum, Arrhenatherum elatius, Bromus erectus, B. inermis, Dactylis glomerata, Elymus sibiricus*, and *E. virginicus* established stands with 12 or more plants per square yard. By the end of the second growing season, *D. glomerata* was considered the best established grass in the mixtures. *B. inermis* and *Poa compressa* also became well established in the mixtures. In the pure seedings, *A. intermedium, B. erectus*, and *P. compressa* were the most outstanding species.

By the sixth growing season, *P. compressa, D. glomerata*, and *Poa pratensis* (which had increased from impure seed) continued to appear well established with good stands. On the other hand, *A. cristatum* had become a minor component of mixtures, although it was a major part of the original mixture. *Bromus carinatus* was apparently lost from the seedings.

Throughout the study livestock utilized the grasses during the grazing season. Those species most heavily utilized were *D. glomerata*, *B. erectus*, *A. intermedium*, *B. inermis*, and *P. compressa*. *E. sibiricus*, *E. virginicus*, *A. cristatum*, and *A. elatius* were the least utilized.

General conclusions were:

Seedbeds should be prepared where the density of native vegetation is great. Double-disking appeared sufficient to prepare the seedbed, and work should be done on the contour.

Seedings should be protected from grazing until the seeded grasses are well established.

Of the species tested, *D. glomerata*, *P. compressa*, and *P. pratensis* were the best adapted. Those that showed some promise included *B. inermis*, *B. erectus*, *A. intermedium*, and *A. elatius*. *A. cristatum* apparently is either not adapted to the conditions of this site or it cannot compete with the more adapted species.

Selway

Study location.—Located on Cow Creek Ridge near Bear Creek Range Station, Selway National Forest in Idaho, sec.-9 and 10, T.31N., R.13E. Boise Meridian (location 10, fig. 10). Dry site: Near top of ridge 400 yards north of Pettibone Creek bridge; Moist site: ¾ mile up Pettibone Creek trail.

Elevation.—7,500 feet.

Average precipitation.—Annual, 20 inches; April-September, 45 percent.

Soil.—Coarse decomposed granite. The soil surface was raw and bare except for pine needles on the dry site. The moist site had the same soil but with more humus.

Topography.—Dry site: 60 to 70 percent slope to the south; moist site: 5 to 8 percent slope to the southwest.

Type of vegetation.—Lodgepole pine-Douglas fir forest and grassland.

Dominant and associated species.—*Pinus contorta*, *Calamagrostis rubescens*, *Carex geyeri*, *Poa* spp., and *Festuca idahoensis*; some *Danthonia spicata*, *Koeleria cristata*, and *Agropyron spicatum*. Also some *Bromus tectorum* had invaded.

Previous use.—Game range.

Study.—Selway adaptation plantings.

Date planted.—October 5, 1943.

Procedures.—Twenty species were planted in 15- by 30-foot plots on dry and moist sites. Seed was broadcast by hand on an unprepared seedbed and then covered by raking with a garden rake.

Summary of results.—The seedings failed. In the first growing season *Elymus* x *Secale* was the only species found on the dry site. On the moist site it only rated poor, and *Medicago falcata* was the only other species found. *M. falcata* produced a fair stand, but the plants were small and yellowish.

By 1947, only a few *Agropyron cristatum* plants were found on the dry site while a few plants of *A. cristatum, Arrhenatherum elatius, Bromus carinatus, B. erectus, B. inermis, Dactylis glomerata, Phleum pratenses,* and *Poa ampla* were found on the moist site.

Western Ponderosa Pine Forest and Grassland

Ponderosa pine is found on both sides of the Continental Divide. However, the "bull pine," *Pinus ponderosa* variety *scopulorum*, of eastern Montana is considered to be distinctly different from the western yellow pine of western Montana.

The vegetative type referred to here is of the western strain only and is located west of the divide except on the east slope in the north and in the Big Belt Mountains. It is found at elevations of 3,000 to 5,000 feet and includes approximately 4,965,000 acres. Precipitation varies from 12 to 30 inches, and the growing season ranges from 40 to 140 days. The soils are generally light-colored timbered soils or thin loamy soil over bedrock.

Pinus ponderosa is the dominant species. In the north it is in association with *Pseudotsuga menziesii, Larix occidentalis,* and *Pinus contorta. Calamagrostis rubescens* and *Carex geyeri* are found in the understory. The type predominates as forest but is intermixed with open grasslands and parks. Most of the lowlands have been cleared for cultivation.

The dominant species of grass of the grassland are believed to have been *Agropyron spicatum, Poa secunda,* and *Festuca idahoensis* in association with *Stipa comata, Poa* spp., *Elymus cinerius, Koeleria cristata, Aster* spp., *Solidago* spp., *Purshia tridentata,* and *Artemesia tridentata.*

Today, much of the uncultivated grasslands have been invaded by *Bromus tectorum* to the exclusion of most other grasses.

Because of the steep slopes associated with these depleted grasslands, revegetation by mechanical means is often hazardous and unsuccessful. Most commercially built equipment is inadequate for preparing seedbeds and removing the competing *B. tectorum* from the steep slopes.

The scarification of the soil caused by logging and the necessity of reestablishing cover following burns have prompted seedings within the forest type.

The grasslands associated with the ponderosa pine forests often grade into the Intermountain Valley grasslands. Studies that apply to these associated grasslands are discussed in the Intermountain Valley grasslands section (p. 75).

Conditions for revegetation in the forested type are generally favorable for natural recovery following logging or burns. Artificial seeding, however, becomes an important tool in healing the disturbed areas while the native grasses and associated plants become reestablished. Eventually, most of the seeded grasses will be crowded out and replaced by the native species or by *Poa pratensis* or *Phleum pratense* that appear naturalized to the area.

Where replacement of native species with introduced grasses is desired for forage production, the seedbed should be plowed. Drilling the seed is recommended. However, fair-to-good stands have been obtained by broadcast seeding. Failures from broadcasting the seed occurred particularly from spring seeding and generally where the broadcast seed was not covered.

Species that appeared well adapted to this type include native strains of *Calamagrostis rubescens*, *Festuca* spp., *Agropyron inerme*, and introduced strains of *Dactylis glomerata*, *Agropyron pungens*, *A. spicatum*, *Arrhenatherum elatius*, *Bromus erectus*, *B. inermis*, *Festuca ovina*, *Phleum pratense*, and *Poa pratensis*. On the drier sites *Agropyron desertorum* and *A. cristatum* did well, but they appeared to thin out as competition from native grasses increased.

Missoula

Study location.—Located 7 miles up Rattlesnake Creek from Missoula between the creek and the county road, Missoula County S1/2 sec. 19, T. 14N., R. 18W. (location 11, fig. 10).

Elevation.—3,800 feet.

Average precipitation.—Annual, 14 inches; April-September 58 percent.

Soil.—A dark-brown alluvial soil of a gravelly loam texture.

Topography.—0- to 5-percent slope, mostly to the south.

Type of vegetation.—Western ponderosa pine forest.

Dominant and associated species.—*Poa pratensis*, *Phleum pratense*, and species of *Carex* and *Trifolium*. The area was probably once occupied by *Pinus ponderosa* that dominates the surrounding forest.

Previous use.—Irrigated for native hay; probably claimed from the forest.

Study.—Summary of species adaptation nurseries; five nursery plantings were made from 1938 to 1941 to determine the effect of season of planting and cultivation for weed control on the establishment of seeded species. Plantings 3, 4, and 5 were duplicated. All weeded plots were treated by cultivating between the rows from planting time until 1942.

Planting No. 1

Date planted.—May 25 to June 3, 1938.

Procedures.–Twenty-one species were planted in 20-by 20-foot plots and two mixtures in 40-by 44-foot plots. Seeding was in handmade rows 18 inches apart. The two mixtures were simple legume-grass mixtures with the legumes and grasses seeded in alternate rows. Before planting, the area was plowed, harrowed, disked, harrowed again, and floated to prepare a good seedbed.

Planting No. 2

Date planted.—November 4, 1938; December 9, 1938; April 10, 1939; May 10, 1939.

Procedures.—Weeded plots: Seventy-seven species were planted in four row 8- by 16-foot plots. Each row was planted on different dates from November 1938 to May 1939. The rows were spaced 2 feet apart. Seed was scattered in handmade furrows and covered with one-half to three-fourths inch of soil depending on size of seed. Before planting, the area was plowed in the fall and harrowed to form a good seedbed.

Nonweeded plots: Sixty-three species were planted in a block adjacent to the weeded plots. Planting procedures were the same as for the weeded treatments.

Planting No. 3

Date planted.—April 10, 1939.

Procedures.—Eighteen species were planted in plots 4 by 16 feet with two rows per plot and 2 feet between rows. Seeds were scattered in handmade furrows and covered with 1/2 to 3/4 inch of soil. The seedbed was plowed and harrowed in the fall of 1938.

Planting No. 4

Date planted.—April 4, 1940.

Procedures.—The area was plowed and harrowed in 1939 and cultivated in the spring of 1940. Twenty species were planted in plots 4 by 16 feet with two rows per plot and 2 feet between rows. Seeds were scattered in handmade furrows and covered with soil.

Planting No. 5

Date planted.—October 17, 1941.

Procedures.—Twenty-one species were planted in plots 4 by 16 feet with two rows per plot and 2 feet between rows. Seeds were scattered in handmade furrows and covered with soil. The seedbed was plowed and harrowed in 1938 and cultivated in 1941.

Summary of results.—The weed-free plots established better stands than the weedy ones; however, several species consistently established and maintained good stands under weedy as well as weed-free conditions (table 8). Those that established most readily were *Poa pratensis, Agropyron desertorum, A. intermedium, A. pungens, Arrhenatherum elatius, Bromus erectus, B. inermis, Festuca ovina, Elymus junceus*, and and *A. cristatum.*

Many other species also established well under weed-free conditions. A few established well in some plantings but failed in others; most noticeable among them were *Festuca idahonesis, Agropyron inerme*, and *Poa compressa.*

The legume or broadleaf plants, as well as many of the grasses, were not able to establish and maintain stands. Group IV lists those species that established fair to good initial stands but failed or maintained poor stands under weed-free conditions. Group V includes those that established poorly or failed completely.

Although row plantings of *Phleum pratense* and *Poa compressa* rated poorly in some seedings, they were invaded from outside areas. By 1948 the plots were heavily invaded, primarily by *Phleum pratense* and *Poa pratensis.* Other invading species included *Alopecurus pratensis, Bromus inermis, B. tectorum, Poa compressa*, and *Achillea lanulosa.*

In mixture plots, *Medicago falcata* was lost except for a few plants; *A. cristatum* was good, and *B. inermis* was invading and

TABLE 8.—*Establishment of seeded species in the ponderosa pine forest type at Missoula as affected by weeding*

Species	Stand occupied per row			
	Weeded		Nonweeded	
	1939	1946	1939	1946
	Pct.	*Pct.*	*Pct.*	*Pct.*
I. Well established under weedy conditions:				
Poa pratensis	62	100	64	100
Agropyron desertorum	94	90	95	95
A. intermedium	99	70	99	95
A. pungens	96	100	93	95
Arrhenatherum elatius	97	85	98	95
Bromus erectus	98	100	97	95
B. inermis	82	95	98	95
Festuca ovina duriuscula	95	95	85	95
Elymus junceus	80	45	97	90
Agropyron cristatum	100	100	80	80
Poa compressa [1]	[1] 90	80	[1] 70	75
Agropyron inerme	80	80	87	75
A. trichophorum	91	95	100	75
Festuca idahoensis [1]	[1] 45	70	[1] 90	75
Poa ampla	85	85	80	75
Agropyron cristatum [1]	[1] 50	75	[1] 60	60
II. Fair to good stands established under weed free but only fair under weedy conditions:				
Bromus marginatus	77	15	84	60
Agropyron spicatum	91	80	99	55
Elymus cinereus	51	85	75	55
Dactylis glomerata	72	90	100	50
Agropyron subsecundum	87	85	100	52
A. sibiricum	92	25	89	50
A. smithii	87	40	90	50
A. spicatum [1]	[1] 40	60	[1] 60	50
Elymus glaucus	97	85	100	40
Festuca ovina sulcata	20	80	11	32
Agropyron dasystachyum [1]	[1] 100	90	[1] 30	30
A. ugamicum	95	50	99	25
Hordeum brevisubulatum	96	80	99	25
Poa juncifolia	51	95	74	25

Footnotes at end of table.

TABLE 8.—*Establishment of seeded species in the ponderosa pine forest type at Missoula as affected by weeding*—Continued

Species	Stand occupied per row			
	Weeded		Nonweeded	
	1939	1946	1939	1946
	Pct.	*Pct.*	*Pct.*	*Pct.*
III. Adapted under weed-free conditions only:				
Agropyron pauciflorum [1]	[1] 60	85	[1] 40	20
A. violaceum [1]	[1] 70	60	[1] 90	20
Elymus virginicus	97	80	98	20
Phalaris arundinacea	52	90	64	0
Phleum boehmeri	60	50	49	10
P. phleoides	66	85	36	15
Poa scabrella	45	55	92	5
Festuca rubra	55	80	[2]	[2]
F. arundinacea	100	80	99	5
Agropyron caninum	86	75	93	5
Stipa vaseyi robusta	83	70	[2]	[2]
Elymus triticoides	61	65	[2]	[2]
Stipa viridula	60	60	30	7
Elymus sibiricus	91	50	98	1
IV. Fair to good stands established initially but generally failed:				
Agropyron ciliare	80	0	92	5
A. elongatum	40	25	34	10
A. semicostatum	94	0	97	0
Agrostis alba	54	40	61	1
Alopecurus ventricosus	50	0	85	10
Avena barbata	92	0	100	0
Bouteloua gracilis	42	15	[2]	[2]
Bromis carinatus [1]	[1] 100	0	[1] 80	0
Elymus canadensis	82	1	100	20
E. dahuricus	93	15	96	10
E. giganteus	97	40	98	10
Elymus x *Secale*	75	0	[2]	[2]
Festuca elatior	87	1	99	1
Hordeum brevisubulatum [1]	[1] 86	0	0	1
H. bulbosum	98	0	99	1
Lolium perenne	97	0	98	0
Panicum antidotale	73	0	27	0
P. virgatum	65	25	[2]	[2]
Phleum pratense	75	30	90	1
Poa canbyi	49	40	75	10
P. nevadensis	47	0	80	5
P. secunda	53	0	55	5
P. stenantha	65	0	90	0

Footnotes at end of table.

TABLE 8.—*Establishment of seeded species in the ponderosa pine forest type at Missoula as affected by weeding*—Continued

Species	Stand occupied per row			
	Weeded		Nonweeded	
	1939	1946	1939	1946
	Pct.	*Pct.*	*Pct.*	*Pct.*
IV. Fair to good stands established initially but generally failed --Con.				
Lathrus maritimus	91	0	[2]	[2]
Lotus corniculatus	98	0	96	0
Medicago falcata	87	0	96	0
Melilotus officinalis	100	0	100	0
Trifolium fragiferum	81	0	95	0
T. hybridum	73	0	96	0
T. pratense	91	0	91	1
T. repens	91	0	94	0
V. Poorly established or failed:				
Agropyron riparium [1]	[1] 65	0	[1] 10	1
Andropogon scoparius	0	0	0	0
Bromis ciliatus	54	0	56	1
Elymus psuedoagropyron	0	0	2	0
Festuca scabrella	26	0	[2]	[2]
Koleria cristata	29	0	[2]	[2]
Oryzopsos hymenoides	31	0	41	0
Poa ampla	37	10	51	10
P. bulbosa	16	0	24	0
P. compressa	41	0	59	0
P. nervosa	42	0	[2]	[2]
P. spondylodes	27	0	52	0
Puccinellia nuttalliana	44	0	45	0
Sporobolus cryptandrus	30	0	7	0
Stipa comata	35	0	[2]	[2]
Astragalus chinensis	58	0	45	0
A. cicer	[1] 25	5	[2]	[2]
A. rubyi	40	0	4	0
Atriplex spp.	0	0	0	0
Lespedeza stipulacea	56	0	51	0
Lupinus spp. [1]	[1] 32	0	[1] 1	0
Lotus corniculatus	98	0	96	0
Medicago falcata	87	0	96	0
M. lupulina	0	0	[2]	[2]
Melililotus alba	53	0	53	0
M. officinalis	100	0	100	0
M. suaveolens	0	0	0	0
Erodium moschatum	1	0	0	0
Purshia tridentata	57	1	1	1

[1] Species planted October 17, 1941; values for 1943.

[2] Plots not planted.

filling between the rows. In mixture plots where *B. inermis* was the grass species, it was in nearly full stand.

Feronato

Study location.—Located 5 miles south and 2 miles west of Florence, Mont., Ravalli County, SW1/4 sec. 5, T. 9N., R. 20W. (location 12, fig. 10).

Elevation.—3,500 feet.

Average precipitation.—Annual, 15 inches; April-September, 55 percent.

Soil.—Light-brown gravelly sandy loam with granitic rock near the surface; slightly acid (pH 6.0 - 6.5).

Topography.—15 to 20 percent slope to the east.

Type of vegetation.—Western ponderosa pine forest.

Dominant and associated species.—*Pinus ponderosa* is the dominant tree species. *Salix* spp, *Rosa* spp, *Amelanchier* spp, *Mahonia aquiflorum* and *Arctostaphylos uva-ursi* are understory shrubs, and *Poa secunda, Koeleria cristata, Calamagrostis rubescens, Poa pratensis, Bromus tectorum* and *Stipa occidentalis* are the main grasses. *Carex* species are also found.

Previous use.—Cutover forest used for grazing.

Study.—Feronato adaptation planting.

Date planted.—November 9, 1945, and April 3, 1946.

Procedures.—The seedbed was prepared by bulldozing the surface just enough to peel off the existing vegetation.

Fall seeding: 16 species were planted in plots 6 by 20 feet. Four rows per plot 14 by 20 inches apart were made with a hoe. Seed at a "heavy" rate was scattered in the furrows and covered by raking.

Spring seeding: Seven species were planted by broadcasting on plots 9 by 27 feet. Previous to planting, the area was springtooth cultivated. The seed was not covered after planting.

Summary of results.—The spring-seeded plots were largely failures. These failures were attributed to the method of planting rather than to adaptability of species.

Only two of the fall-seeded species produced good stands the following year, and they maintained good stands through the next 4 years. Three other species also increased from fair to good stands during the same period. Ten grasses maintained or improved their stands and generally appeared adapted to the area. Of these species, *Agropyron intermedium*, produced the best stands in the fifth year, while *F. ovina* made the greatest stand increase over initial seedling establishment (table 9).

Species that failed or produced poor-to-fair stands in the 5

TABLE 9.—*Establishment of species planted in the fall on cleared timberland in the ponderosa forest type near Florence, Mont.*

Species	Stand per row		
	1946	1948	1950
	Pct.	*Pct.*	*Pct.*
Agropyron intermedium (Ree)	50	80	80
Dactylis glomerata	60	80	70
Bromus erectus	40	60	60
Festuca ovina duriuscula	25	50	60
Agropyron cristatum	65	60	60
A. trachycaulum	50	60	50
Alopecurus pratensis	50	60	50
Arrhenatherum elatius	50	50	50
Bromus inermis (Lincoln)	40	60	50
Dactylis glomerata (Aberystwyth)	30	40	40

years included fall plantings of *Eragrostis trichoides, Festuca arundinacea, F. idahoensis, Phalaris arundinacea, Phleum phleoides*, and *Medicago falcata* and spring plantings of *Phleum boehmeri, P. phleoides, P. pratense, Poa bulbosa, Lotus* spp., *Onobrychis vulgaris*, and *Trifolium subterraneum*.

Study.—Feronato logged forest planting.

Date planted.—November 9 and 14, 1945; April 3, 1946.

Procedures.—The study was designed to compare (1) spring versus fall planting on the establishment of six species and one mixture, (2) effect of covering seed by brush dragging versus no covering and (3) planting on soil prepared by peeling with a bulldozer blade, by tearing with a road ripper, and on unprepared soil. Seven grasses were each planted in three replicated plots in a complete randomized design. Fall-seeded plots were 16 by 66 feet (1/40 acre), and spring-seeded plots were 16 by 33 feet (1/80 acre). All seedings were made by broadcasting, and one-half of each plot was brush dragged to cover the seed.

Previous to planting in the fall, the seedbed was prepared by peeling the surface layer by bulldozing. In the spring, the species mixture was planted on plots prepared by (1) bulldozer blade, (2) road ripper, and (3) spring-tooth cultivator.

Summary of results.—Stands of most species were relatively poor, although moisture was apparently not the limiting factor. The methods of seeding were apparently not conducive to good establishment, but broadcasting in the fall was superior to broadcasting in the spring. Where brush dragging followed broadcasting of the seed fall treatments were almost the same. In the spring, however, broadcasting without dragging failed.

Ripping was the best method tested for preparing the seedbed.

From this and previous studies, the species that appeared best adapted to the area were *Dactylis glomerata* and *Agropyron intermedium* (tables 9 and 10).

Blacktail

Study location.—Located on the Sleeping Child Creek Range, Bitterroot National Forest, 11 miles southeast of Hamilton in Ravalli County, sec. 1 and 12, T. 4N., R. 20W. (location 13, fig. 10).

Elevation.—5,000 to 5,500 feet.

Average precipitation.—Annual 14 to 16 inches; April-September 56 percent.

Soil.—Sandy loam of granitic origin; fairly deep, although rocky beneath the surface.

Topography.—Slopes average about 50 percent; exposures vary from northeast to northwest.

Type of vegetation.—Western ponderosa pine forest.

Dominant and associated species.—*Pinus ponderosa*, *Pseudotsuga menziesii* are the dominant tree species. *Calamagrostis rubescens*, *Festuca idahoensis*, *Carex*, *Koeleria cristata*, and *Arctostaphylos uva-ursi* are found in understory or in openings.

Previous use.—The area was logged in 1939. About 30 to 40

TABLE 10.—*Establishment of grasses seeded by broadcasting in the fall and dragging on cutover timberland in the ponderosa pine type near Florence, Mont.*

Species	Stand establishment					
	Fall planted			Spring planted		
	1946	1948	1950	1946	1948	1950
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Dactylis glomerata	62	70	57	22	38	25
Agropyron intermedium	53	53	50	5	7	8
Bromus inermis (Lincoln)	23	32	27	22	23	17
Phleum pratense	25	43	25	28	22	8
Bromus erectus	47	53	20	20	13	4
Agropyron cristatum	25	30	20	12	10	10
Mixture (ripped area)	25	50	[1]	[1]	[1]	[1]

[1] Not observed.

percent of the ground surface was burned in slash disposal or torn up by the skidding operation.

Study.—Blacktail logged areas plantings Section 12 T4N T20W.

Date planted.—April 26, 1940.

Procedures.—No further seedbed preparation was done beyond logging. Six grasses, two legumes, and a mixture were broadcast at approximately 7 pounds of seed per acre in plots of approximately 0.2 acres except for *Agropyron intermedium* and *A. cristatum,* which were planted in plots of 0.02 and 26.5 acres, respectively.

Summary of results.—Precipitation from May through August of 1940 totaled 1.27 inches, only 28 percent of normal. Because of the dry weather, plant establishment was not as good as one might normally expect.

In 1941, seedlings of each grass were found. Apparently, these seedlings were from seed that had not germinated until fall. The two legumes germinated early in the 1940 season.

Exposure influenced the establishment of all species during the extremely dry summer. Plants established best on north and east exposures and poorest on the steeper west exposure. South exposures were not represented. Seedlings did best where boughs, stumps, or logs offered some protection from the direct rays of midday and afternoon sun.

While most plantings were on skid trails, burns, and disturbed areas, some seed was also sown on undisturbed areas where the average ground cover was about 25 percent. Nothing established on these undisturbed areas, but seedlings established well on the disturbed or burned portions of the area where competing vegetation was reduced. They even established on the compact soil in logging roads. The grasses established best on disturbed mineral soil and near the edge of burned spots where ashes and charcoal were thin. *Melilotus officinalis,* on the other hand, did best on burned spots, even in beds of heavy ash and charcoal. *M. officinalis* died out by 1946 and *Medicago falcata,* the only other legume planted, failed completely.

Agropyron cristatum established the best initial stand of the grasses and maintained a good stand through 1946. It was as vigorous as *Agropyron inerme, Arrhenatherum elatius, Bromus carinatus,* or *B. inermis* and surpassed all of them in numbers of seedlings per unit area. It also established good stands of seedlings on all but the steep, open, west-facing slopes. Even there, it established fair to good stands.

A. inerme also appeared well established, but it did not establish well on the west-facing slope.

A. intermedium, *A. elatius*, *B. carinatus*, and *B. inermis* were planted on the most severe exposure, the west-facing slope. Although stands were relatively poor, established plants of these species were vigorous. The severity of the site and the droughty condition during establishment undoubtedly were major factors in their poorer showing.

To determine the ability of the seeded species to compete with natives, intercept-line transects were established in 1942. Plant numbers and the basal intercepts were recorded (table 11). *A. inerme* maintained its stand through the 3-year period, 1942-44, while *Calamagrostis rubescens* and the shrubs increased. On the *A. intermediate* and *B. inermis* plots, the shrubs, mainly *Arctostaphylus uva-ursi*, increased. In the mixture plot, *A. cristatum* declined; *Medicago falcata* and *Melilotus officinalis* were lost from the stand, but *A. elatius* increased slightly. Of the native grasses, *Festuca idahoensis* increased considerably while *C. rubescens* maintained its stand. The shrubs increased both in numbers and in intercept.

Study.—Blacktail skid trail planting sec. 1, T. 4 N., R. 20 W.

Topography.—5 percent slope to the north.

Previous use.—The area was logged and the slash burned in 1939. The study area was part of a skid trail.

Date planted.—October 22, 1940.

Procedures.—Nine grasses were planted in plots of 6-square rods. The seed was broadcast with a "cyclone" seeder at a rate of 5 to 6 pounds per acre. No other seedbed preparation was made, and the seed was not covered after broadcasting.

Summary of results.—Good initial establishment of all species except *Agropyron intermedium* and *Elymus glaucus* was obtained (table 12). The distribution of plants on the plots, however, was spotty and their vigor was poor, but near the edge of the skid trail where plants became established on top soil, they were large and vigorous. This would indicate that the soil of the roadbed (raw subsoil) may be lacking in certain nutrients. It is also possible that the packed roadbed caused mechanical resistance to root growth or to moisture infiltration. The differences in numbers of plants between years are partly due to the spottiness of the stands and should be considered when evaluating the species for adaptability.

By the fourth growing season (1944) *Bromus erectus* appeared to have established the best stand. *Agropyron cristatum, A.*

inerme, *A. subsecundum*, and *Arrhenatherum elatius* also had good stands. Although *Agropyron intermedium* had fair to good stands, it was rather patchy. It did not appear as vigorous as the other well-established species. Only occasional unthrifty plants of *Bromus inermis*, *Elymus glaucus*, and *E. virginicus* were found.

In 1945 and 1946 the plantings generally rated lower than in

TABLE 11.—*Vegetational composition, number of plants, and interception of seeded and native plants on logged ponderosa pine type in the Blacktail area*

Seeded and observed species	Plants per 20 feet		Av. interception per 20 feet of transect	
	1942	1944	1942	1944
	No.	*No.*	*Ft.*	*Ft.*
Agropyron inerme:[1]				
A. inerme	6.4	5.8	0.40	0.46
Calamagrostis rubescens	4.2	8.0	.18	.29
Carex geyeri	1.6	1.0	.07	.06
Festuca spp	.4	2.2	.03	.05
Agropyron cristatum	.2	-	.04	-
Bromus carinatus	.2	.2	.02	.02
Others (shrubs)	.8	3.2	.04	1.01
Others (weeds)	2.0	-	.06	-
Agropyron intermedium:				
A. intermedium	7.0	10.5	.81	.44
Calamagrostis rubescens	4.0	2.0	.16	.03
Arctostaphylus uva-ursi	1.5	2.5	.19	.77
Poa spp	.5	1.5	.02	.04
Others (shrubs)	-	1.5	--	.05
Others (weeds)	-	.5	-	.02
Bromus inermis (Parkland):				
B. inermis	7.8	6.0	.39	.15
Calamagrostis rubescens	6.6	6.8	.25	.16
Arctostaphylus uva-ursi	5.2	3.8	.29	2.65
Poa spp	1.0	.2	.03	.002
Carex geyeri	-	.4	-	.006
Festuca spp	-	.2	-	.004
Others (shrubs)	1.1	1.4	.03	.23
Others (weeds)	.8	-	.02	-

Footnotes at end of table.

TABLE 11.—*Vegetational composition, number of plants, and interception of seeded and native plants on logged ponderosa pine type in the Blacktail area*—Continued

Seeded and observed species	Plants per 20 feet		Av. interception per 20 feet of transect	
	1942	1944	1942	1944[2]
	No.	*No.*	*Ft.*	*Ft.*
Mixture:[3]				
Arrhenatherum elatius	2.0	5.8	0.10	0.18
Bromus carinatus	3.0	4.0	.15	.18
Agropyron cristatum	3.0	1.2	.14	.04
Melilotus officinalis	.4	-	.01	-
Medicago falcata	.2	-	.01	-
Festuca spp	1.4	11.8	.04	.32
Calamagrostis rubescens	2.4	3.8	.08	.08
Carex geyeri	.8	.8	.04	.08
Others (shrubs)	3.8	9.5	.11	2.44

[1] Values are averages from five 20 foot transect lines, except for *Agropyron intermedium* that are from two 20 foot transect lines.

[2] The intercept is the distance along the transect line occupied by a plant.

[3] Mixtures included the following species in equal parts: *Agropyron cristatum*, *Arrhenatherum elatius*, *Bromus carinatus*, *Medicago falcata*, and *Melilotus officinalis*.

1944; *B. erectus*, *A. subsecundum*, *A. cristatum*, and *A. inerme* continued with good stands.

Grazing by livestock in 1944, 1945, and 1946 indicated that *Bromus erectus* was the most preferred. The other grasses were preferred in the following order: *Agropyron intermedium*, *Arrhenatherum elatius*, *Agropyron cristatum*, *A. inerme*, and *A. subsecundum*.

Hart Creek

Study location.—Located on the Hart Creek-Cameron Creek Ridge of the Bitterroot National Forest, Ravilli County, sec. 2, T. 2 N., R. 19 W. (location 14, fig. 10)

Elevation.—4,600 feet.

Average precipitation.—Annual, 16-18 inches; April-September, 56 percent.

Soil.—Woodrock loam series.

Topography.—0- to 30-percent slopes of south to west exposure.

Type of vegetation.—Western ponderosa pine forest.

Dominant and associated species.—*Pinus ponderosa, pseudot-*

suga menziesii, *Symphocarpos* spp., *Festuca idahoensis*, and *Calamagrostis rubescens*

Previous use.—Logged area with loose soil in skid trails.

Study.—Hart Creek skid trail plantings.

Dates planted.—September 22, 1943, and May 4, 1944.

Procedures.—In the fall planting, 44 species were planted in square rod plots, and in the spring 12 species were planted in irregular and uneven sized plots. The seed was broadcast by hand at the rate of 6 to 8 pounds per acre. One-half of each plot was raked to cover the seed. No further seedbed preparation was made to the skid trails before planting.

Summary of results.—Except for *Agropyron subsecundum*, most of the grasses planted in the fall established good to excellent stands on the raked plots in the first year. Generally, they were poorer on the unraked plots. Most of the legumes established poorly. *Trifolium fragiferum*, *T. hybridum*, and *T. repens* were the only ones that initially established good stands (table 13).

Except for *Elymus junceus*, all the spring-seeded species established good to excellent stands the first year.

Those that appeared to establish the best were *Agropyron smithii*, *Dactylis glomerata*, and *Festuca ovina*. Stands of

TABLE 12.—*Establishment of seeded grasses on a skid trail in the Blacktail area of the ponderosa pine forest type*

Species	Plants per square yard[1]		Stand rating[2]	
	1941	1943	1944	1946
	No.	*No.*		
Bromus erectus	17.6	39.5	G	7
Agropyron subsecundum	9.8	15.0	G	7
A. cristatum	4.8	13.4	G	6
A. inerme	5.2	6.5	G	6
Arrhenatherum elatius	8.8	12.0	G	5
Bromus inermis (Parkland)	9.6	5.0	P	4
Agropyron intermedium	2.2	2.7	F	4
Elymus glaucus	.8	1.2	P	4
E. virginicus	4.8	3.2	P	3

[1] Values are averages for 5-yard square quadrants in 1941 and four quadrants in 1943.

[2] Rating: G=good; P=poor; F=fair; numerical rating is on scale from 0 to 10 with 0=failure and 10=100-percent stand.

Agropyron spicatum, *A. trichophorum*, *Arrhenatherum elatius*, *Festuca idahoensis*, and *Poa pratensis* were also rated high.

By the ninth growing season, *A. subsecundum* and *A. cristatum* improved to fair stands. Those species that initially established fair to good stands and those that failed completely were grouped accordingly in table 13.

Although fall plantings were successful, spring plantings established better and generally maintained better stands.

Based on the results of these and other studies in the area, the following was concluded:

1. Three species appear particularly adapted, *Dactylis glomerata*, *Arrhenatherum elatius*, and *Festuca ovina*.
2. Each of the three species, in addition to being adapted to the Bitterroot area, are relatively easy to establish with broadcast seeding and are relatively shade tolerant.
3. *D. glomerata*, because of its high palatability, should be planted where grazing is light or well controlled.
4. Plantings on the drier sites should be restricted to *F. ovina*. This species, because of its lower palatability, would also be suitable to plant where *D. glomerata* might be too heavily grazed.

Cattle grazed heavily on most plots from 1946 to 1952. *Bromus erectus*, *T. hybridum*, *D. glomerata*, *Phleum boehmeri*, *A. trachycaulum*, and *A. elatius* were consistently heavily utilized. These species, however, were able to maintain good stands (table 13). Legumes were the most heavily utilized, being eaten to ground level. This repeated heavy grazing was undoubtedly a major factor in the stand reduction of the legumes and certain grasses.

Festuca idahoensis, *F. ovina*, *A. spicatum*, and *A. dasystachyum* appeared to be the least preferred.

Utilization of *Calamagrostis rubescens* was generally light to moderate. Adjacent to and within the seeded plots cattle used about 30 to 35 percent of its total herbage. In undisturbed stands, however, utilization was estimated at less than 15 percent.

Obviously, the skid trails tended to attract livestock and game to these areas since they were also used as access trails to other areas. Consequently, they were more heavily trampled and grazed than would normally be expected.

Reimel Creek

Study location.—Located in Ravalli County, sec. 22 and 26, T. 1 N., R. 19 W. (location 15, fig. 10). Three sites: *A*, north side of section 22 at the mouth of a small draw, *B*, 1/4 mile south

TABLE 13.—*Establishment of species planted on skid trails at Hart Creek in the ponderosa pine forest type and the utilization of herbage by cattle*

Species	Stand [1] 1944	Stand [1] 1952	Utilization, 3-year av.
	Rating	*Rating*	*Percent*
I. Good to excellent stands maintained for 9 years:			
Dactylis glomerata	8	9	78
D. glomerata [2]	9	9	88
Agropyron smithii	6	8	47
Festuca ovina duriuscula	5	8	5
F. ovina [2]	9	10	21
Agropyron spicatum	7	7	42
A. spicatum [2]	9	8	8
Arrhenatherum elatius	7	7	63
Agropyron trichophorum	6	7	53
Festuca idahoensis	5	7	3
Agropyron trachycaulum	8	6	63
A. trachycaulum [2]	9	6	30
Elymus glaucus	6	6	25
Phleum pheoides	6	6	60
Poa ampla	7	6	23
P. ampla [2]	9	6	25
P. compressa	6	6	42
P. pratensis	6	6	27
P. pratensis [2]	9	10	52
Bromus erectus [2]	8	7	83
Trifolium hybridum [2]	10	7	80
II. Fair stands maintained through 9 years:			
Agropyron desertorum	6	5	42
A. inerme	6	5	27
A. subsecundum	1	5	43
Bromus erectus	6	5	23
Festuca arundinacea	6	5	42
Phleum boehmeri	8	5	80
P. pratense	6	5	45
Agropyron intermedium [2]	9	5	25
A. intermedium	8	4	48
A. cristatum (Fairway)	2	4	31
A. cristatum (Fairway) [2]	9	4	30
A. dashstachyum	8	4	8
Bromus inermis	6	3	

Footnotes at end of table.

TABLE 13.—*Establishment of species planted on skid trails at Hart Creek in the ponderosa pine forest type and the utilization of herbage by cattle.*—Continued

Species	Stand[1] 1944	Stand[1] 1952	Utilization, 3-year av.
	Rating	*Rating*	*Percent*
III. Fair to good stands established but failed within 9 years:			
Agropyron trachycaulum violaceum	6	0	50
Agrostis alba	4	2	85
Alopecurus pratensis	4	2	20
Bromus cerinatus	3	0	73
B. marginatus	8	1	50
Elymus junceus	3	0	35
E. virginicus	4	0	25
Elymus x Secale	3	0	-
Festuca elatior	4	0	75
Poa bulbosa	3	0	88
Trifolium fragiferum	6	0	90
T. repens	6	0	85
IV. Poor establishment to complete failure:			
Lotus corniculatus	0	0	-
Medico falcata	1	0	-
M. lupulina	2	0	-
Melilotus alba	1	0	-
M. alba (Alpha)	0	0	-
M. officinalis	2	0	-
M. officinalis (Madrid)	1	0	-
M. suaveolens	1	0	-

[1] Stand ratings based on scale of 0 to 10 where 0 is failure and 10 is 100 percent.
[2] Planted May 4, 1944; other species were planted September 22, 1943.

of *A* at the mouth of a large draw, *C* 1/4 mile south of *B* on a steep slope, in section 26.

Elevation.—3,500 to 4,000 feet.

Average precipitation.—Annual, 16 to 18 inches; April to September, 56 percent.

Soil.—Sites *A* and *B* are well-drained alluvial deposits of decomposed granite. Site *C* is coarse and raw decomposed granite.

Topography.—Sites *A* and *B* have 0- to 5-percent slope to the west. Site *C* has 40- to 60-percent slope to the south and west.

Type of vegetation.—Western ponderosa pine forest.

Dominant and associated species.—*Agropyron spicatum*, *Festuca idahoensis*, and *Pinus ponderosa; Poa pratensis* and *Bromus tectorum* have invaded.

Previous use.—Sites *A* and *B* were logged and used as "jammer" locations; Site *C* was a skid trail.

Study.—Reimel Creek logged area planting.

Date planted.—September 28, 1943.

Procedures.—Twenty-four species were planted by broadcasting at 6 to 8 pounds of seed per acre. Twenty-one different species were planted on sites *A* and *B*, and 17 on site *C*. The plots were irregular to fit the outline of the seeding areas and varied from one-fiftieth to one-tenth acre. Plots were not replicated. No seedbed treatment was made except as occurred in logging.

Summary of results.—Initial establishment of most species was good to excellent. *Elymus* x *Secale* and *Poa bulbosa* were the only ones planted at the favorable sites that were poor the first year. At the dry site, however, establishment was less successful (table 14).

In the first growing season at the more favorable sites, species that established best and showed the most promise were *Alopecurus pratensis*, *Festuca ovina*, *F. arundinacea*, and *Phleum pratense*. At the dry site, only three, *Agropyron dasystachyum*, *A. inerme*, and *A. cristatum*, established good stands.

By 1952, the ninth growing season, *Festuca ovina*, *Alopecurus pratensis*, *Phleum pratense*, *Agropyron intermedium*, *A. spicatum*, *A. trachycaulum*, *A. cristatum*, *A. inerme*, and *Lotus corniculatus* continued to maintain good stands at the favorable sites (table 14). By then *Elymus* x *Secale*, *Poa ampla*, *P. bulbosa*, and *Medicago falcata* rated poor to complete failures, and heavy infiltrations of *Poa pratensis* had nearly covered these plots.

At the dry site all the seeded grasses except *Elymus* x *Secale* were able to maintain their initial stand or increase in stand. By 1952 the best stands were made by *A. cristatum*, *A. inerme*, *F. ovina*, *A. intermedium*, *A. spicatum* and *A. trachycaulum*. All the legumes, however, had failed.

In adjoining large-scale seedings on logged-over areas, some excellent stands of *Agropyron cristatum*, *Dactylis glomerata*, and *Arrhenatherum elatius* were obtained in mixture seedings made on the steep west slopes.

Grazing by cattle and horses on the seeded species was heavy to destructive, which undoubtedly reduced stands. Species that were repeatedly heavily grazed from 1946 through 1952 included all the legumes and *A. pratensis*, *B. carinatus*, *E. junceus*, *F. arundinacea*, *P. pratense*, *A. trachycaulum*, and *A. intermedium*. At times *A. cristatum*, *A. inerme*, and *A. spicatum* were also heavily grazed. The least preferred was *F. ovina*, *A. dasystachyum*, and *P. ampla*. In general, the species were more heav-

TABLE 14.—*Establishment of species planted on logged areas in the ponderosa pine forest type at Reimel Creek*

Species	Stand ratings [1]			
	Favorable sites, A and B		Dry site, C	
	1944	1952	1944	1952
Good stands maintained at both favorable and dry sites for 9 years:				
Agropyron cristatum	[2]	6	6	8
A. inerme	8	6	5	8
Festuca ovina duriuscula	9	10	4	8
Agropyron intermedium	6	7	2	7
A. spicatum	8	7	2	7
A. trachycaulum	8	7	4	7
Fair to good stands maintained at the favorable sites for 5 years but not at the dry site:				
Agropyron dasystachyum	8	4	6	4
Alopecurus pratensis	9	8	[3]	[3]
Elymus junceus	7	4	2	2
Festuca arundinacea (Alta)	9	5	[3]	[3]
Phleum pratense	9	8	[3]	[3]
Lotus corniculatus	6	6	2	0
Medicago lupulina	8	5	4	0
Bromus carinatus	6	2	[3]	[3]
Poa ampla	8	0	3	0
Medicago falcata	8	2	0	0
Poorly established or failed completely:				
Agropyron smithii	[3]	[3]	2	4
Elymus x *Secale*	1	0	7	0
Poa bulbosa	0	0	0	0
Melilotus alba	[3]	[3]	0	0
M. officinalis	[3]	[3]	7	0
Trifolium fragiferum	8	0	[3]	[3]
T. hybridum	7	0	[3]	[3]
T. repens	8	0	[3]	[3]

[1] Stand rating scale based on 0 to 10 where 0 is failure and 10 is 100 percent.
[2] No value recorded.
[3] Not planted.

ily utilized at the more favorable, leveler sites than at the steeper, dry site.

Livestock appeared to concentrate on the seeded plots and used the skid trails as access trails that aggravated erosion through some plots. For best control of the soil, the least palatable species should be considered for seeding areas where concentration of livestock is expected.

Study.—Reimel Creek skid trail planting sec. 26, T. 1 N., R. 19 W.

Topography.—0- to 5-percent slope to the west.

Previous use.—Logged and grazed.

Date planted.—May 3, 1944.

Procedures.—Nine species were planted by broadcasting at 5 to 10 pounds of seed per acre. Plots were various shapes and sizes depending on the nature of the skid trail. No seedbed preparation was done, but a part of each plot was raked to cover the seed.

Summary of results.—Good stands of all species except *Agropyron smithii* and *Elymus junceus* established in the seedling year. Since these two species were able to maintain fair stands through the 9-year period, the relatively poor establishment may have been from poor-quality seed. Good to excellent stands of the other seeded grasses were maintained through the 9-year period. *Festuca ovina* and *Arrhenatherum elatius* produced the best stands. *Bromus erectus*, *Agropyron spicatum*, *A. cristatum*, and *Poa ampla* also rated good. *Melilotus officinalis* failed after the third growing season.

Raking increased seedling establishment of all species, but in the succeeding years, the differences between raked and nonraked plots were not considered significant.

Thompson Falls

Study location.—Located at Thompson Falls, Cabinet National Forest, Sanders County, sec. 5, T. 21 N., R. 29 W. (location 16, fig. 10).

Elevation.—2,600 feet.

Average precipitation.—Annual, 20 inches; April-September, 40 percent.

Soil.—Brown sandy loam possibly from glacial origin; sizable rocks present on the more hummocky areas; some areas completely free of rock.

Topography.—A general slope of 5 to 8 percent to the south; undulating to hummocky; probably a temporary lake at one time.

Type of vegetation.—Western ponderosa pine forest.

Dominant and associated species.—*Pinus ponderosa, Pinus contorta, Pseudotsuga menziesii, Calamagrostis rubescens, Festuca idahoensis, Prunus virgiana,* and species of *Poa, Achillea, Trifolium, Spiraea, Rosa, Arctostaphylos, Amelanchier, Bromus tectorum, Hypericum perforatum,* and *Poa pratensis* are aggressive invaders.

Previous use.—A fire in 1910 burned this area after it had been logged. Before seeding, the area was primarily regrown to *P. menziesii* and *P. contorta.*

Study.—Thompson Falls administrative plantings.

Date planted.—April 26, 1939, and December 7, 1939.

Procedures.—Three plantings were made as follows:

1. A 5-acre tract was cleared of timber and the slash burned. This area was planted by broadcasting 25 pounds of seed per acre. The seed included:

Species	*Pounds*
Agropyron desertorum	10
Phleum pratense	5
Dactylis glomerata	5
Arrhenatherum elatius	2.5
Medicago falcata	2.5

Bromus carinatus was also broadcast on some burned areas. After planting, parts of the burned areas were raked to cover the seed; part was left untreated.

2. Six species were planted in rows 40 feet long. Each row crossed the following seedbed conditions: (a) Burn, (b) litter and doff 1 inch deep, (c) litter 1 inch deep through which poles had been skidded, (d) litter removed by raking, (e) grass, and (f) mossy area. Rows were made with a hoe and the seed was planted 1/2 to 3/4 inches deep.

3. Three seedbed treatments were made in a well-grassed area. They were (a) plowed and double disked, (b) disked five times, and (c) double harrowed. Four species (*Agropyron desertorum* - Standard, *Bromus inermis, Arrhenatherum elatius,* and *Medicago falcata*) were broadcast seeded and covered by harrowing.

Summary of results.—None of the species established when seeds were broadcast without further treatment. However, on burned areas that had been raked following seeding fair to good stands of *Arrhenatherum elatius, Dactylis glomerata,* and

Phleum pratense were well established 5 years after planting (table 15).

In companion studies *D. glomerata* appeared to be well adapted after 10 years; *B. inermis* and *P. pratense* were also well established. Although stands of *A. elatius* were poor early in some of the plantings, they improved. The plants were large and vigorous and they were spreading to other areas. To the contrary, *A. cristatum*, which produced good stands at the beginning of the study, thinned out as stands became older and the individual plants became thin, pale, and low in vigor. Stands of *B. carinatus* were considered failures and *M. falcata* failed to become established.

Poa pratensis readily invaded the seedings and became a major species in the cover. *Festuca idahoensis* was also abundant.

Introduced species were more successfully established following seedbed preparation that removed competition from existing vegetation. Plowing and double disking was more effective than disking five times. Harrowing alone was relatively ineffective in establishing these grasses.

Study.—Thompson Falls planting date study.

Date planted.—October 10, 1939, November 10, 1939, April 2, 1940, May 2, 1940.

TABLE 15.—*Establishment of species planted in rows at Thompson Falls administrative site*

Species	Stand on different conditions of seedbed [1]									
	Burned		Skidded		1-inch litter		Litter removed		Native grass	
	1943	1948	1943	1948	1943	1948	1943	1948	1943	1948
	Ratings									
Agropyron cristatum (Std)	P	O	P	O	P	O	P	O	P	O
Arrhenatherum elatius	G	G	F	G	F	P	P	F	P	O
Bromus carinatus	P	O	P	O	P	O	P.	O	P	O
Dactylis glomerata	E	G	G	G	F	P	F	P	P	O
Phleum pratense	G	F	F	P	P	P	P	P	P	O
Medicago falcata (Ladak)	O	O	O	O	O	O	O	O	O	O

[1] Stand rating where O=failure, P=poor, F=fair, G=good, and E=excellent.

Procedure.—The seedbed was plowed and disked in April 1939. In early October 1939, it was again disked and dragged to remove *Pteridium aquilinum* and other weeds that had not been killed by the earlier treatment.

Thirty-four species were planted in single rows 16 feet long by drilling at four different dates. Seeds were planted 1/2 and 3/4 inch deep depending on size of seed. In 1940, four additional legumes were planted.

The seedbed was moist at time of each seeding. However, from May 3 to July 10, 1940, there was an extended dry period.

Summary of results.—The date of planting significantly affected the establishment of the different species. The dry season following the May planting undoubtedly was a major cause for the failure of that planting. In general, stands were better from fall or early spring seedings.

The species were grouped according to their apparent adaptability based on initial establishment and establishment at the end of 6 years (table 16). Of the 38 species, 16 appeared to be well adapted to fall seeding while 12 of the 16 appeared adapted to fall and early spring planting. Groups IV and V generally appeared nonadapted.

Study.—Thompson Falls adaptation plantings.

Date planted.—October 5, 1945.

Procedures.—Twenty-four grasses and two legumes were planted by seeding through a Planet Junior drill in rows 8 inches apart. The seed was planted 1/2 to 3/4 inch deep, depending on size of seed, at about 7 pounds of seed per acre. Seed of *Medicago falcata* was innoculated before planting.

The plots, 7 by 20 feet, were replicated three times in a completely randomized design.

Before planting, the seedbed had been prepared by plowing and harrowing in June 1945. On October 4, 1945, it was cultivated with a spring-tooth cultivator four times over and harrowed. Clumps of grass sod were then raked and hauled from the study area and the soil was smoothed with a plank float.

On July 8, 1946, the plots were cultivated to remove a dense cover of *Pteridium* spp., *Poa pratensis*, *P. compressa*, and annual weeds. Some of the seeded plants were pulled with the weeds.

Summary of results.—The competition from weeds early in this study undoubtedly reduced the success of some seeded species, and the injury from weeding might have affected establishment more than the lack of adaptation to climate and location.

TABLE 16.—*Establishment of species at Thompson Falls in the ponderosa pine type as affected by planting date*

Species	Stand from planting dates							
	10/10/39		11/10/39		4/2/40		5/2/40	
	1940	1945	1940	1945	1940	1945	1940	1945
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
I. Established best on all dates:								
Festuca ovina duriuscula	75	95	96	95	8	70	0	50
Bromus erectus	100	95	100	95	98	95	46	35
Agropyron pungens	100	100	98	90	70	50	44	25
A. caninum	96	75	98	35	64	30	10	20
A. cristatum	100	95	100	95	96	85	10	10
A. spicatum	100	95	98	90	98	90	28	10
Bromus inermis (Parkland)	98	60	100	50	98	25	22	10
II. Established well from fall and early spring but failed from late spring planting:								
Agropyron desertorum	100	95	100	90	100	90	8	0
A. inerme	100	95	100	85	82	30	8	0
Arrhenatherum elatius	93	90	100	85	96	55	4	1
Dactylis glomerata	95	95	100	95	80	50	4	0
Agropyron subsecundum	100	55	100	35	94	15	12	5
III. Established well from fall plantings only:								
Agropyron trichophorum	98	40	98	40	26	25	0	15
Poa ampla	98	90	96	80	2	20	0	0
P. compressa	94	70	84	70	0	20	0	0
Stipa viridula	89	70	82	50	0	1	0	1
IV. Established well initially but failed soon after:								
Agropyron ugamicum	100	20	100	40	76	20	6	15
A. dasystachyum	90	0	99	0	0	0	0	0
Bromus ciliatus	100	0	100	1	22	1	0	0
Elymus glaucus	99	20	94	30	97	20	0	0
E. junceus	99	20	100	0	90	0	2	0
E. sibiricus	89	0	75	0	60	0	0	0
E. triticoides	94	1	92	1	2	0	0	0
Hordeum brevisubulatum	92	0	98	0	84	0	2	0
Poa juncifolia	62	0	88	0	2	0	2	0
Medicago falcata	90	0	76	0	95	0	60	0
Melilotus officinalis	68	0	96	0	66	0	24	0

Footnotes at end of table.

TABLE 16. —*Establishment of species at Thompson Falls in the ponderosa pine type as affected by planting date.* —Continued

Species	Stand from planting dates							
	10/10/39		11/10/39		4/2/40		5/2/40	
	1940	1945	1940	1945	1940	1945	1940	1945
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
V. Generally failed or failed completely:								
Agrostis alba	0	30	0	30	0	20	0	20
Festuca elatior	42	0	92	0	25	0	0	0
Poa bulbosa	0	0	0	0	0	0	0	0
P. scabrella	0	0	0	0	0	0	0	0
Astragalus cicer	[1]	[1]	[1]	[1]	0	0	0	0
Lespedeza stipulacea	0	0	0	0	0	0	0	0
Lotus corniculatus	0	0	0	0	0	0	0	0
Melilotus alba	[1]	[1]	[1]	[1]	0	0	0	0
M. suaveolens	[1]	[1]	[1]	[1]	0	0	0	0
Trifolium fragiferum	0	0	0	0	0	0	0	0
T. repens	0	0	0	0	0	0	0	0

[1] Not planted.

Species that established well were primarily those that appeared adapted from earlier studies. *Medicago falcata,* however, that had not established in earlier studies established a good stand and maintained itself through the first 5 years of this study but nearly died out within 18 years because of gopher activities.

Several varieties of *Bromus inermis,* and *B. erectus, Agropyron intermedium,* and *Festuca ovina duriuscula* increased or maintained excellent stands throughout the study (table 17).

The poor initial establishment of *B. inermis* and *F. ovina* might have been caused from competition early in the study. These species were able to maintain their stands and generally increased in the succeeding years.

During the third growing season (data not shown in the table) *M. falcata, Bromus inermis,* and *Arrhenatherum elatius* were outstanding. These species established good to excellent stands, had good seed production, and were increasing between the rows. They also appeared effective in competing with *P. pratensis* and other invading weeds. *Bromus erectus* and *Agropyron cristatum* also produced good stands but did not appear to compete as well with the invading *P. pratensis.*

Although *Festuca ovina* did not rate high in the row plots, border areas that had been broadcast with *F. ovina* and lightly covered by raking formed a thick mat of vigorous plants with heavy heads.

By the fifth growing season *Bromus inermis*, *B. erectus*, *Phleum pratense* and *Medicago falcata* had the best stands. These species and *Festuca ovina* (based on the response of the border seeding) were also considered to be effective in controlling

TABLE 17.—*Establishment of fall-planted species at Thompson Falls in the ponderosa pine type*

Species	Stand		
	1946	1950	1963
	Pct.	*Pct.*	*Pct.*
I. Good stands maintained through 18 years:			
Bromus inermis (Commercial)	10	50	100
B. inermis (Lincoln)	70	90	100
B. inermis (Parkland)	20	40	90
B. erectus	60	80	90
Agropyron intermedium	70	65	90
Festuca ovina duriuscula	20	25	90
II. Fair to good stands maintained through 1950 but failed or had poor stands in 1963:			
Phleum pratense	90	85	10
Medicago falcata	50	80	5
Arrhenatherum elatius	70	70	1
Agropyron inerme	60	60	0
A. cristatum	80	55	0
Poa ampla	50	50	0
Agropyron trichophorum	70	35	0
III. Poorly established or failed completely:			
Dactylis glomerata	1	5	0
Eragrostis curvula	1	0	0
E. trichodes	1	0	0
Elymus junceus	30	0	0
Festuca arundinacea	10	10	10
F. idahoensis	20	20	0
Phalaris arundinacea	0	0	0
Phleum boehmeri	10	5	0
P. phleoides	20	20	5
Sorghastrum nutans	0	0	0
Stipa viridula	1	1	0
Sanguisorba minor	1	0	0

competition. The border seeding of *F. ovina* was uniform throughout with very little *Poa pratensis* present. Some *Equisetum*, however, was able to grow in competition with *F. ovina*.

Henry Creek

Study location.—Located in the Cabinet National Forest 4 miles east of Plains between Henry Creek and Deemer Creek, Sanders County, S1/2 sec. 29, T. 20N., R. 25W. (location 17, fig. 10).

Elevation.—4,000 feet.

Average precipitation.—Annual, 15 inches; April to September 40 percent.

Topography.—30 percent north-facing slope.

Type of vegetation.—Western ponderosa pine forest.

Dominant and associated species.—*Pinus ponderosa*, *Calamagrostis rubescens*, *Festuca idahoensis*, *Stipa columbiana*, and *Lupinus* spp.

Previous use.—Forest timberland burned by wildfire in July 1944.

Study.—Henry Creek burn planting.

Date planted.—November 3, 1944.

Procedures.—Burned-over forest land, 225 acres, was seeded to a mixture by airplane broadcasting at 5 pounds per acre. Species included were *Agropyron cristatum*, *Dactylis glomerata*, *Poa pratensis*, *P. bulbosa*, *Bromus inermis*, *Phleum pratense*, and *Melilotus officinalis*.

Summary of results.—Establishment success varied depending on the soil and the competing vegetation. Where the fire was not hot and the native grasses were not killed, the establishment of the seeded species was poor or they failed. Poor stands were also observed on shallow rocky ridges. Where native vegetation was killed and where the soils were good, the seeded grasses established good to excellent stands.

Species composition varied throughout the seeded area. Those species that appeared best established were *D. glomerata*, *P. bulbosa*, *P. pratensis*, and *P. pratense*. Plants of *A. cristatum*, *B. inermis*, and *M. officinalis* were scattered through the stand but were a minor part of the cover. Yields estimated in 1946 varied from 1,715 to 2,194 pounds of dry herbage per acre. In 1948, yield samples averaged 2,135 pounds per acre.

Intermountain Valley Bottom lands and Grasslands

This type is interspersed throughout several mountainous types occurring near streams or old streambeds and benchlands. In some locations it intergrades into open grasslands of the forest types, and in others it intergrades into foothill grasslands and foothill sagebrush rangelands. Elevation varies from 2,000 feet in northwestern Montana to 7,000 feet in the southwest. Precipitation varies from 12 to 20 inches, and the growing season varies from 30 to 145 days. Soils vary in origin and texture from moderately dark-colored and black loams to alluviated valley and gravelly benchland soils.

In the lowlands and near marshes or streams, meadow grasses, sedges, and other grasslike plants are dominant species. On the drier sites and benchlands, species of *Stipa*, *Fescue*, and *Agropyron* are dominant. *Artemesia tridentata*, and *Chrysothamnus* spp. are often found in association but generally are not major species.

Today, most of the 3,478,000 acres in this type are irrigated for crops and hay meadows. Some marshy areas along stream bottoms are grazed by livestock, while some drier benchlands have at one time or another been cropped with cereal grains.

Where drylands have been abandoned, *Bromus tectorum* has invaded. *Centaurea* spp. has also invaded, principally through the Bitterroot Valley area. In the low, moist areas *Poa pratensis* and other naturalized species have invaded. Where drainage is poor, *Distichlis stricta* and *Sarcobatus vermiculatus* dominate.

This type is conveniently divided into three subareas: (1) high-mountain-valley-bottom lands east of the Continental Divide at the Missouri River headwaters; (2) western valley benchlands west of the divide as the Clark River headwaters, including the Bitterroot and Flathead Rivers; and (3) the northwestern corner, which includes the Kootenai River drainage.

1. *High mountain valleys*.—Growing conditions are generally favorable for grass production in these areas. However, alkali is sometimes found in some of the poorly drained bottom lands. Several introduced species including *Poa pratensis*, *Agropyron repens*, *Bromus inermis*, and *Phleum pratense* have become naturalized and are generally found. These species also invade old seedings or abandoned croplands. To introduce other forage species the competing vegetation must be thoroughly controlled by plowing. Generally, spring planting by drilling has been

superior to fall planting. However, good stands have been obtained from fall seedings.

Other species that appear well adapted include *Agropyron cristatum*, *A. desertorum*, *A. intermedium*, *A. smithii*, *Alopecurus pratensis*, *Arrhenatherum elatius*, *Bromus erectus*, *Dactylis glomerata*, *Elymus junceus*, *Festuca ovina duriuscula*, *Poa stenantha*, *Stipa viridula*, *Medicago falcata*, *Trifolium hybridum*, and *Lotus corniculatus*.

In studies of herbage yields, 1 to 2 tons per acre were produced. The highest yielding species in the second growing season were *B. inermis*, *B. marginatus*, *D. glomerata*, *A. desertorum*, and *A. trachycaulum*.

Since most of these studies were of short duration, several species that appeared adapted may have failed or decreased in stand over a longer period due to, primarily, competition from native and the better adapted introduced species.

2. *Western valley benchlands.*—Precipitation is variable. In the drier areas of the Bitterroot and lower Flathead, irrigation has been necessary to insure production of cultivated crops. Where irrigation water is not available, dry farming has often failed, and much of this marginal land abandoned. *Bromus tectorum*, other annual weeds, and several aggressive perennial weeds have invaded. *Centaurea maculosa*, *Linaria dalmatica*, *Euphorbia esula*, *Hypericum perforatum*, and *Cirsium arvense* are particularly obnoxious invaders.

In the upper Flathead area, precipitation is higher and generally adequate for good production of dryland crops. Competition from native and invading species necessitate thorough preparation of the seedbed. Sometimes control of weeds with herbicides is necessary before seeding.

Plowing with a moldboard plow gave the best results in methods of seedbed preparation. Disking was not effective in controlling *B. tectorum*. However, stands of grass were better from disked than from nontreated seedbed. Burning of *B. tectorum* without further seedbed treatment also failed to be an effective method of seedbed preparation, although the burning treatment reduced plant cover by 80 percent.

Variable success was obtained from planting grasses into stubble of grain crops. The success of this method appeared more dependent upon the competition from *B. tectorum* during establishment of the seeded grasses than upon the species of grain. However, better stands were generally obtained following rye than following sudangrass or broomcorn millet. The best stands of grass using the preparatory cropping system were obtained following grazing treatments of the preparatory crop, while cutting the grain for hay was better than where harvested for seed. When the grain was harvested as seed, cultivation before planting to grass the next spring increased stand establishment from two to four times that of grasses planted into noncultivated stubble. Highest yields of hay and seed from preparatory crops were obtained when the seedbed was plowed in the fall as compared with plowing in the spring.

Planting by drilling in the spring generally gave better stands than planting in the fall. *Agropyron desertorum*, *A. inerme*, *A. intermedium*, *A. sibiricum*, *A. spicatum*, *A. smithii*, *Dactylis glomerata*, *Elymus glaucus*, *E. junceus*, and *Festuca ovina*, however, established stands about equally well when seeded in either season.

The optimum depth of planting varied with the different species. *A. desertorum* planted in the fall established its best stands when drilled at depths of 1/4 to 3/4 inch. *F. ovina* and *Poa ampla* established best when planted at 1/4 to 1/2 inch deep, but stands of *Bromus erectus* and *E. junceus* were reduced when planted at shallow depths. In dry years, seeds planted in the fall failed to germinate at shallow depths until the following spring, whereas seeds planted 1 inch deep germinated.

At the drier sites species that appeared well adapted to this type and established good stands over a period of 17 years included *Agropyron desertorum*, *A. elongatum*, *A. inerme*, *A. intermedium*, *A. smithii*, *A. trichophorum*, *Bromus erectus*, *B. inermis*, *Elymus junceus*, *Festuca arundinacea*, *F. ovina*, *Poa ampla*, *P. compressa*, *P. pratensis*, *Stipa viridula*, and *Medicago falcata*.

Herbage yields varied with precipitation and by species. In dry years *A. desertorum* produced about 900 pounds per acre and was generally the highest producing grass. In years of high precipitation the yields were up to 3,200 pounds per acre, but in these wet years yields of *A. intermedium* and mixtures of *A. desertorum* and *M. falcata* were higher.

Fertilizers increased herbage yields from old grass stands and yields increased with increasing rates of nitrogen. Residual effects from fertilization were also effective in increasing yields for at least two growing seasons.

At the more moist sites near Flathead Lake, species that appeared well adapted were *A. desertorum* (Standard and Nordan), *A. elongatum*, *A. intermedium*, *Alopecurus pratenses*, *Bromus inermis*, (Lincoln and Manchar), *Dactylis glomerata*, *Festuca arundinacea*, *Phleum pratense*, and *Medicago falcata*. Mixtures of grasses with *M. falcata* yielded more (averaging four tons per acre) than grasses seeded alone. Grass yields increased with irrigation, but *M. falcata* and *M. falcata* in grass mixtures yielded more on dryland.

3. *Northwestern area*.—Grasslands in this area are characterized by gravelly benchlands along the Kootenai River and its tributaries. From the benchlands the relief raises sharply from 2,000 to 3,000 feet to mountains 5,000 to 7,000 feet high. Because of the low water-holding capacity of gravel, the soils appear more droughty than the more loamy soils in other areas. Much of both the bottomlands and the benchlands are irrigated or subirrigated. Therefore, areas for dryland pastures and seeded rangeland are relatively small.

Bromus tectorum has invaded most of the dryland pasture sites and *Aristida longiseta* is prevalent on the steeper slopes. *Hordeum pusillum* and *Calamovilfa longifolia* are also important species. In the bottomlands and more moist sites *Poa pratensis* and *P. compressa* are dominant species.

The presence of native and invaded species requires thorough seedbed preparation to remove competition before introducing new species. Moldboard plowing is the most effective method.

Seeding in the spring appeared slightly better than planting in the fall, although fall seeding also produced good stands of most species.

Species that appeared well adapted included *Agropyron desertorum*, (Standard and Nordan), *A. intermedium*, *A. sibiricum*, *A. smithii*, *A. trachycaulum*, *A. trichophorum*, *Bromus inermis* and *Festuca arundinacea*. Others that have produced good stands include *Agropyron inerme*, *Dactylis glomerata* and *Elymus junceus*.

Yields of adapted species are average for Montana dryland conditions with 3/4 to 1-1/2 tons of herbage per acre.

Gallatin Gateway

Study location.—Located 8 miles south of Gallatin Canyon, Gallatin County sec. 28, T. 3S. R. 4E. (location 18, fig. 10).

Elevation.—5,300 feet.

Average precipitation.—Annual, 17 inches; April to September, 65 percent.

Soil.—Classified as river wash, free from rock in upper 12 inches; clay loam underlain by large rock and gravel.

Topography.—Two-percent slope to northeast.

Type of vegetation.—Intermountain valley bottom land.

Dominant and associated species.—*Agropyron smithii*.

Previous use.—Abandoned cropland.

Study.—Yield and adaptation studies.

Date planted.—May 18, 1941.

Procedures.—Nine grasses were planted in 2- and 3-acre plots by drilling on plowed seedbed. Depth of seeding was not well regulated, consequently some seeds were planted to 2 inches deep. An additional 11 grasses were planted in small plots with a hand seeder.

Summary of results.—Stands were generally good. However, some of the small-seeded species were planted too deep resulting in their poor stands during the seedling year. This was particularly noticeable for *Poa pratensis*, which is naturalized to the area. All species produced better stands during the second year, and all but *Andropogon scoparius* appeared adapted to the site (table 18).

In the second growing season *Bromus marginatus*, *B. inermis*, *Dactylis glomerata*, *Agropyron cristatum* (Fairway), and *A. trachycaulum* were the highest yielding of those species harvested.

Belgrade

Study location.—Located on subirrigated bottom lands 15 miles northwest of Bozeman, Mont., T. 1S. R. 1E. (location 19, fig. 10).

Elevation.—4,800 feet.

Average precipitation.—Annual, 17 inches; April-September, 56 percent.

Soil.—Highly calcareous and subirrigated; apparently deficient in iron.

Topography.—Level river bottom.

Type of vegetation.—Intermountain valley bottom land.

Dominant and associated species.—*Agropyron smithii*, *Poa pratensis*, and species of *Carex* and *Juncus*.

Study.—Belgrade adaptation nursery.

Date planted.—October 1950.

Procedures.—Ten grasses were planted in plots 3 by 16 feet. The seedbed was prepared by plowing and harrowing.

Summary of results.—Good stands of all species but *Agropyron elongatum* and *A. smithii* established in the seedling year, 1950. The following year stands declined slightly but appeared well established. *Festuca arundinacea* (Alta), *Phalaris arundinacea*, and *Phleum pratense* maintained full stands while *Agropyron*

TABLE 18.—*Establishment and yield of grasses planted at Gallatin Gateway*

Species	Stand 1941	Stand 1942	Yield per acre, 1942 Seed	Yield per acre, 1942 Herbage
	Pct.	*Pct.*	*Lbs.*	*Lbs.*
Bromus marginatus	100	100	[1]	5,815
B. inermis (Parkland)	75	90	126	5,160
Dactylis glomerata	100	100	275	4,308
Agropyron cristatum (Fairway)	95	100	215	3,545
A. trachycaulum	90	100	242	3,455
Phleum pratense	[1]	100	126	2,925
Festuca elatior	60	100	162	2,557
F. rubra	[1]	60	[1]	763
Elymus junceus	35	100	0	468
Agropyron cristatum (Standard)	70	100	[1]	[1]
Elymus canadensis	87	100	[1]	[1]
Phalaris arundinacea	100	100	[1]	[1]
Agropyron inerme	50	90	[1]	[1]
A. spicatum	60	90	[1]	[1]
Poa ampla	15	90	[1]	[1]
P. secunda	15	75	[1]	[1]
Festuca ovina duriuscula	20	50	[1]	[1]
Bouteloua curtipendula	18	25	[1]	[1]
Poa pratensis	12	25	[1]	[1]
Andropogon scoparius	0	0	[1]	[1]

[1] Data not available.

intermedium, A. desertorum, A. cristatum, Elymus junceus, and *Poa ampla* maintained nearly full stands.

P. arundinacea plants were yellowish, and appeared chlorotic. They responded to iron in tests with various minor elements.

In 1952, the planting was plowed out.

Vigilante

Study location.—Located east of the Ruby River road where it crosses Lazyman Creek 1 mile south of Vigilante Range headquarters, SW1/4 sec. 34, T. 9S., R. 3W. (location 20, fig. 10).

Elevation.—6,200 feet.

Average precipitation.—Annual, 13 inches; April-September, 77 percent.

Soil.—Loamy soil from alluvial deposits.

Topography.—2 to 3 percent slope to the west.

Vegetational type.—Intermountain valley bottom land.

Dominant and associated species.—*Poa pratensis* and species of *Carex* and *Symphoricarpos*.

Previous use.—Hay meadow, may have been cleared from *Salix* and *Artemesia tridentata*.

Study.—Vigilante adaptation nurseries.

Date of planting.—October 27, 1938; May 3, 1939; May 26, 1939; May 9, 1940, and September 25, 1941.

Procedures.—In the 1938 and 1939 plantings, 72 species were planted in rows spaced 2 feet apart in plots 12 by 16 feet. Three rows were planted in the fall. Adjacent to the fall planting, 2 rows were seeded May 3, 1939, and one row, May 26.

In the 1940 planting, 22 species were planted in plots 6 by 16 feet with three rows per plot spaced 2 feet apart.

In 1941, 10 species were planted.

The seedbed for all plantings was moldboard plowed and cultivated or harrowed to form a seedbed relatively free from native plants.

Summary of results.—Species were grouped according to their response and apparent adaptability (table 19). Group I included ten species that appeared well adapted to the site and that established equally well from spring and fall plantings. Of this group, *Bromus erectus*, *B. inermis*, *Agropyron cristatum*, *A. desertorum*, and *A. pungens* appeared to be the best adapted. A second group, group II, also appeared well adapted to the site but established better from spring planting than from fall.

Species in group III were planted only in the spring, and those in Group IV were planted only in the fall. These species also appeared well adapted to the site, but response comparisons between seasons of planting were not possible.

Groups V and VI established good initial stands, but because of their characteristic length of life or because they were unable to compete, they failed within their first 4 years of growth. Species that failed in their initial establishment and failed to establish in succeeding years were listed in group VII.

Species included in these last three groups could generally be considered nonadapted. However, germination tests of *Elymus pseudoagropyron* showed no viability in the seed. The poor initial stands of *Poa pratensis* and *P. stenantha* might also have resulted from poor seed or from planting too deep since they recovered and established good stands by 1943.

Most species established good to excellent stands the first year and maintained their stands through the next 3 years.

TABLE 19.—*Establishment of species at a mountain meadow site: A summary of 4 plantings near Vigilante Experiment Range Headquarters, 1938-41*

Species	Stand, spring seeded 1939-40	Stand, spring seeded 1943	Stand, fall seeded 1939-42	Stand, fall seeded 1943
	Pct.	*Pct.*	*Pct.*	*Pct.*
I. Established about equally well from spring and fall seeding and maintained good stands:				
Bromus erectus	100	100	100	100
B. inermis	99	100	98	100
Agropyron cristatum (Fairway)	100	95	94	100
A. desertorum (Standard)	100	95	95	100
A. pungens	98	100	84	100
Bromus inermis (Parkland)	99	95	78	91
Arrhenatherum elatius	98	80	97	93
Agropyron subsecundum	98	50	98	91
Alopecurus pratensis	71	85	60	65
Poa pratensis	7	80	10	100
II. Established best from spring seeding and maintained good stands:				
Elymus junceus	100	100	52	51
Phleum pratense	95	100	18	77
Festuca ovina duriuscula	65	95	16	70
Trifolium hybridum	92	80	36	48
Medicago falcata	100	75	40	53
Dactylis glomerata	100	70	60	78
Agropyron smithii	92	60	58	[1]
A. trichophorum	100	50	66	31
III. Planted only in the spring of 1940 and maintained good stands:				
Agropyron intermedium	[2] 100	100	[3]	[3]
Bromus carinatus	[2] 98	82	[3]	[3]
Astragalus cicer	[2] 56	60	[3]	[3]
Poa stenantha	[2] 20	60	[3]	[3]

Footnotes at end of table.

TABLE 19. — *Establishment of species at a mountain meadow site: A summary of 4 plantings near Vigilante Experiment Range Headquarters, 1938-41* — Continued

Species	Stand, spring seeded		Stand, fall seeded	
	1939-40	1943	1939-42	1943
	Pct.	*Pct.*	*Pct.*	*Pct.*
IV. Planted only in the fall of 1941 and maintained good stands:				
Agropyron pauciflorum	[3]	[3]	[4] 93	90
Stipa viridula	[3]	[3]	[4] 98	88
Agropyron dasystachyum	[3]	[3]	[4] 80	85
Hordeum brevisubulatum	[3]	[3]	[4] 70	80
Festuca scabrella	[3]	[3]	[4] 63	75
Poa compressa	[3]	[3]	[4] 32	60
V. Fair to good stands maintained through 1942 but failed in 1943:				
Elymus dahuricus	100	1	98	[1]
Agropyron ugamicum	90	1	98	[1]
Festuca elatior	99	1	88	[1]
Agropyron dasystachyum	99	1	90	[1]
A. caninum	100	1	100	[1]
Elymus virginicus	97	1	92	[1]
Agropyron inerme	100	1	92	[1]
Elymus sibiricus	100	1	92	[1]
Agropyron sibiricum	86	1	40	[1]
Trifolium pratense	100	1	52	[1]
Agropyron spicatum	96	1	48	[1]
VI. Good initial stands established but failed by the 3d year:				
Agropyron ciliare	98	1	98	0
A. semicostatum	87	1	88	0
Bouteloua gracilis	66	0	2	0
Bromus ciliatus	31	0	64	0
B. marginatus	100	0	74	0
Elymus giganteus	93	1	[3]	[3]
E. glaucus	97	1	53	22
E. triticoides	84	1	[3]	[3]

Footnotes at end of table.

TABLE 19.—*Establishment of species at a mountain meadow site: A summary of 4 plantings near Vigilante Experiment Range Headquarters, 1938-41* —Continued

Species	Stand, spring seeded		Stand, fall seeded	
	1939-40	1943	1939-42	1943
	Pct.	*Pct.*	*Pct.*	*Pct.*
Festuca idahoensis	60	1	0	8
Hordeum bulbosum	99	1	[3]	[3]
Lolium perenne	100	0	84	0
Oryzopsis hymenoides	50	0	44	1
Panicum virgatum	72	0	44	0
Phalaris arundinacea	61	1	29	28
Poa bulbosa	50	0	5	4
P. canbyi	71	1	30	0
Astragalus rubyi	73	1	26	0
Lespedeza stipulacea	98	0	0	0
Lotus corniculatus	96	0	76	0
Medicago lupulina	93	0	[3]	[3]
Melilotus alba	91	0	8	0
M. officinalis	100	1	76	0
M. suaveolens	99	0	[3]	[3]
Trifolium fragiferum	86	0	45	0
VII. Poorly established or failed completely:				
Agrostis alba	5	1	0	0
Elymus pseudoagropyron	0	0	0	0
Festuca ovina sulcata	1	0	0	0
Koleria cristata	0	0	0	0
Phleum boehmeri	5	1	0	10
P. phleoides	0	0	0	23
Poa ampla	7	1	2	0
P. juncifolia	0	1	0	2
P. nervosa	4	0	2	0
P. nevadensis	6	1	[3]	[3]
P. scabrella	6	0	[3]	[3]
P. secunda	1	0	4	0
P. sphondylodes	1	15	[3]	[3]
Lathyrus maritimus	42	0	32	0

[1] Data not available.
[2] Planted May 9, 1940; values for 1940.
[3] Not planted.
[4] Planted September 21, 1941; values for 1942.

After the third growing season, many of them failed (group VI) primarily due to heavy competition from invading *Poa pratensis*, *Phleum pratense*, *Taraxacum officinale*, *Bromus inermis*, and *Agropyron repens*.

The 2-foot space between rows undoubtedly favored invasion into the plots and eventually crowded out some of the otherwise adapted species. Seeding these species in more closely spaced rows may have prevented or at least deferred the rate at which the plots were invaded and ultimately overrun.

Study.—Vigilante nursery planting.

Previous use.—Plot areas were previously planted to *Lespedeza stipulacea* and *Lathyrus maritimus* that had failed.

Date planted.—May 24, 1941.

Procedures.—Four strains of *Agropyron desertorum* were planted in rows 16 feet long. One row of each selection was seeded in each of three blocks. Rows were spaced 2 feet apart. Seeding was done by making furrows 3/4 inch deep with a garden hoe, spreading the seed in the furrow, and covering by raking lightly.

Summary of results.—All strains produced good stands ranging from 95 to 100 percent in 1943 and all appeared equally adapted to the site.

Although the strains appeared to differ in height, average air-dry weights of herbage showed little difference between the strains yielding from 1-1/4 to 1-3/4 tons per acre the second and third year after planting. Weights were taken from herbage clipped 2 inches above ground July 9, 1942, and August 1, 1943.

Waterloo

Study location.—Located in Madison County, T. 1S., R. 5W. (location 21, fig. 10).

Elevation.—4,900 feet.

Average precipitation.—Annual, 8 inches; April-September, 86 percent.

Soil.—Silt loam, saline.

Topography.—River bottom land.

Type of vegetation.—Intermountain valley bottom land.

Dominant and associated species.—*Agrostis alba* and *Distichlis stricta*, invaded by *Agropyron repens* and *Sonchus arvensis*.

Previous use.—Pasture and meadow.

Study.—Waterloo adaptation nursery.

Date planted.—June 4, 1952.

Procedure.—Forty-one grasses were planted in plots 3 by 20 feet with three rows per plot spaced 1 foot apart. Species treatments were replicated three times in a randomized block design.

Summary of results.—Initial stands were fair to good. Species that established best were *Arrhenatherum elatius*, *Festuca arundinacea*, *F. rubra*, *F. elatior*, *Agropyron elongatum*, *Bromus inermis*, *Elymus junceus*, *Agropyron desertorum*, *Bromus erectus*, *Dactylis glomerata*, and *Phalaris arundinacea*. Those that established fair stands were *Agropyron intermedium*, *A. sibiricum*, *A. subsecundum*, *A. trachycaulum*, *A. trichophorum*, *Agrostis alba*, *Alopecurus pratensis*, *Bouteloua curtipendula*, *Elymus glaucus*, *E. triticoides*, *Panicum virgatum*, and *Phleum pratense*. Those that established poor stands or failed completely were *Agropyron cristatum* (Fairway), *A. inerme*, *A. smithii*, *A. spicatum*, *Bouteloua gracilis*, *Bromus marginatus*, *Elymus canadensis*, *Festuca ovina duriuscula*, *Oryzopsis hymenoides*, *Poa ampla*, *P. bulbosa*, *P. compressa*, *P. pratensis*, and *Stipa viridula*.

Reed Ranch

Study location.—Located on the east side of the Bitterroot Valley approximately 6 miles northeast of Stevensville, Ravalli County, sec. 16, T. 9N. R. 19W. (location 22, fig. 10).

Elevation.—3,400 feet.

Average precipitation.—Annual, 12 to 13 inches; April-September, 51 percent.

Soil.—*Smooth slope and upland bench sites:* Clay loam to depth of 5 to 9 inches underlain with a compact light-colored clay; *Bottom land site:* dark-colored loam to a depth of 9 inches underlain with sandy loam and gravel.

Topography.—*Smooth slope:* 10 to 15 percent slope to the south, *Upland bench:* 1-percent slope to the west; *Bottom land:* 1 percent to the northwest.

Type of vegetation.—Intermountain valley grassland.

Dominant and associated species.—*Bromus tectorum*, *Agropyron smithii*, and species of *Ledipium*, *Phlox*, and *Poa*.

Previous use.—Cultivated, partially planted to appletrees and abandoned; heavily grazed by sheep.

Study.—Reed Ranch adaptation plantings.

Date planted.—March 11-14, 1941.

Procedures.—*Smooth slope and upland bench:* Fifteen 1/10-acre plots and five 1/50-acre plots were planted to pure stands, and five 1/10-acre plots were planted to mixtures of species. A strip across the ends of the plots was spring-tooth harrowed before planting. The 1/10-acre plots were seeded with a one-horse single-disk drill, and the 1/50-acre plots were seeded by hand with a Planet Junior seeder. Drilling averaged between 3/4 and 1 inch deep.

Bottom land: Seven species of grass and three mixtures were planted in 1/10-acre plots. The procedure in seeding was the same as for the plots on the smooth slope.

Summary of results.—Smooth slope: Heavy stands of *Bromus tectorum* and annual weeds decreased the success of seedling establishment. In the untreated areas initial establishment was poor and all species but *Agropyron cristatum* failed the next year.

Establishment on the harrowed plots was better with good establishment of *Agropyron dasystachyum, A. trichophorum, A. cristatum, Bromus erectus,* and *Elymus glaucus.*

Species with fair stands were *Agropyron desertorum, A. inerme, A. intermedium, A. spicatum, Arrhenatherum elatius, Bromus inermis, Elymus* x *Secale, Melilotus officinalis,* and *M. suaveolens.* Those that failed completely were *Agropyron subsecundum, Elymus junceus, E. sibiricus, Festuca Scabrella, Poa ampla, P. compressa, Medicago lupulina, M. falcata,* and *Melilotus alba.*

By the second growing season the stands had largely failed. *A. cristatum, A. inerme, A. trichophorum, A. intermedium, B. erectus,* and *Elymus* x *Secale* were the only species found on the harrowed plots with only poor stands left. Except for *A. inerme* and *Elymus* x *Secale,* these same species were found the third season and appeared to be holding their own against the cheatgrass. Besides competition from *B. tectorum,* grasshoppers and rodents had heavily infested the area damaging the seeded stands considerably.

Upland bench: Establishment on the upland bench was considerably better than on the southern exposed slope. On the untreated area, initial stands were fair to good while stands were generally good on the harrowed area.

In 1942, the second growing season, stands had generally failed on the untreated area. On the harrowed area stands were generally reduced and several species completely failed. By the third growing season, the species that continued to maintain fair stands were *A. cristatum, A. intermedium, A. spicatum, A. trichlphorum, B. inermis,* and *E. glaucus.* The decreased stands were attributed to the heavy stand of cheatgrass and competition from grasshoppers and rodents.

Bottom land: On the untreated area, stands were generally fair the first year, while stands on the harrowed area were generally good. By the second season, all species had largely failed and the bottom land plantings were the least successful of the three sites. The failures were attributed to heavy stands of *B. tectorum* and annual weeds.

Antrim Study Area

Study location.—Located at the junction of Eight-mile Road and the East-Side Road, Ravalli County, SE1/4 NW1/4 sec. 7, T. 10N. R. 19W. (location 23, fig. 10).

Elevation.—3,300 feet.

Average precipitation.—Annual, 13 inches; April-September, 51 percent.

Soil.—A light-colored loam with a few rocks in the upper 6 inches; underlain by stone and rock (Lolo gravelly loam).

Topography.—2 to 3 percent slope to the west.

Type of vegetation.—Intermountain valley grassland.

Dominant and associated species.—Invading *Bromus tectorum* is the dominant grass. Plants native to the area include *Agropyron spicatum*, *Festuca idahoensis*, *Koleria cristata*, and species of *Poa*, *Stipa*, and *Carex*.

Previous use.—Broken from native range many years ago and planted to an apple orchard. The orchard failed and the site was put into wheat. At times it was irrigated and finally abandoned. It was then invaded by a dense stand of *B. tectorum* and used as a spring-lambing pasture.

Study.—Antrim adaptation studies.—Several adaptation studies were planted from 1943 to 1948. The description and procedure for each study are given separately, but the results of all are summarized in tables 20, for spring, and 21, for fall seedings. Where several selections of a species were planted, an average was computed for that species.

Study.—Antrim adaptation study No. 1.

Date planted.—April 12-13, 1943, and November 1, 1943.

Procedures.—Fifty-five species and strains were planted in 5 by 19-foot plots. Three rows per plot were spaced 18 inches apart with a 6-inch border between plots. Seeds were scattered in furrows made with a 3-cornered hoe and covered. Before seeding, the study area was plowed and harrowed. The soil was mellow and moist at planting time.

Summary of results.—Generally, good stands were obtained in the seedling year from spring planting with the exceptions of *A. ciliare*, *A. elongatum*, *A. semicostatum*, *A. smithii*, *A. sub-*

TABLE 20.—*Establishment of spring-seeded species on cheatgrass-infested abandoned cropland near Florence, Mont.*

Species	Year planted	Stand establishment			
		Seedling year	1947	1950	1959
		Pct.	*Pct.*	*Pct.*	*Pct.*
Good stands maintained 12 years or longer:					
Agropyron trichophorum	1943	95	100	[1]	100
Do.	1946	75	85	90	[1]
Do.	1948	85	[2]	90	100
Bromus erectus	1943	95	90	[1]	100
Do.	1946	85	95	85	[1]
Do.	1948	90	[2]	95	97
Bromis inermis	1943	100	90	[1]	100
Do.	1948	95	[2]	100	100
Phleum pratense	1943	95	25	[1]	100
Do.	1948	90	[2]	95	97
Poa compressa	1943	90	50	[1]	100
Do.	1948	45	[2]	85	100
Medicago falcata	1943	100	90	[1]	90
Festuca ovina duriuscula	1943	90	80	[1]	90
Do.	1946	35	55	95	[1]
Agropyron cristatum	1943	95	90	[1]	80
Do.	1946	80	92	80	[1]
Do.	1948	75	[2]	90	90
Agropyron smithii	1943	10	30	[1]	80
Do.	1948	85	[2]	95	100
Festuca arundinacea	1943	90	45	[1]	50
Do.	1948	100	[2]	100	90
Elymus junceus	1943	20	95	[1]	50
Do.	1946	82	80	70	[1]
Do.	1948	90	[2]	97	60
Agropyron elongatum	1943	10	40	[1]	50
Do.	1948	72	[2]	90	88
A. intermedium	1943	95	90	[1]	50
Do.	1946	85	95	90	[1]
Do.	1948	92	[2]	97	100
Alopecurus arundinacea	1948	100	[2]	100	100
A. pratensis	1948	100	[2]	100	100
Agropyron amurense	1948	90	[2]	100	100
Lotus corniculatus	1948	100	[2]	95	90
Medicago sativa (Ranger)	1948	100	[2]	95	90
Phleum boehmeri	1948	80	[2]	80	85
Vicia tenuifolia	1948	90	[2]	75	80
Phleum phleoides	1948	70	[2]	70	75
Agropyron desertorum	1946	80	92	80	[1]
Do.	1948	87	[2]	96	77

Footnotes at end of table.

TABLE 20. —*Establishment of spring-seeded species on cheatgrass-infested abandoned cropland near Florence, Mont.* —Continued

Species	Year planted	Stand establishment			
		Seedling year	1947	1950	1959
		Pct.	*Pct.*	*Pct.*	*Pct.*
Good stands maintained 12 years or longer—Con.					
Onobrychis vulgaris	1948	90	[2]	100	50
Festuca rubra	1948	90	[2]	95	50
Good stands maintained 5 years or more but some seedings failed or maintained poor to fair stands in 12 years:					
Poa ampla	1943	100	95	[1]	30
Do.	1946	25	32	40	[1]
Do.	1948	45	[2]	73	30
Stipa viridula	1943	95	95	[1]	30
Do.	1946	28	38	40	[1]
Agropyron inerme	1943	93	100	[1]	20
Do.	1946	45	45	55	[1]
Do.	1948	80	[2]	95	30
Elymus cinereus	1943	80	80	[1]	1
Do.	1948	90	[2]	100	50
Agropyron spicatum	1943	95	[2]	90	1
Do.	1946	60	70	70	[1]
Do.	1948	77	[2]	93	33
Festuca idahoensis	1943	90	70	[1]	1
Do.	1948	50	[2]	60	92
Poa bulbosa	1943	90	[2]	[1]	1
Do.	1948	90	[2]	95	1
Dactylis glomerata	1943	100	40	[1]	1
Do.	1948	98	[2]	97	54
Bromus marginatus	1943	100	60	[1]	0
Do.	1948	85	[2]	92	0
Agropyron sibiricum	1943	85	85	[1]	0
Do.	1948	90	[2]	100	90
A. trachycaulum	1943	100	75	[1]	0
Do.	1948	95	[2]	95	70
Poa juncifolia	1943	85	95	[1]	0
Do.	1948	40	[2]	85	30
Elymus glaucus	1943	95	80	[1]	0
Do.	1948	80	[2]	90	1
Agropyron dasystachyum	1943	95	90	[1]	0
Do.	1948	75	[2]	85	10

Footnotes at end of table.

TABLE 20. — *Establishment of spring-seeded species on cheatgrass-infested abandoned cropland near Florence, Mont.* — Continued

Species	Year planted	Stand establishment			
		Seedling year	1947	1950	1959
		Pct.	*Pct.*	*Pct.*	*Pct.*
A. caninum	1943	95	40	[1]	0
Do.	1948	100	[2]	95	0
A. riparium	1943	90	90	[1]	0
Bromus carinatus	1943	95	50	[1]	0
Bouteloua curtipendula	1943	40	50	[1]	0
Sanguisorba minor	1948	100	[2]	100	40
II. Good stands maintained 5 years or more but some seedings failed or maintained poor to fair stands in 12 years--Con.					
Poa stenantha	1948	80	[2]	95	1
Elymus canadensis	1948	100	[2]	95	0
E. virginicus	1948	80	[2]	95	0
E. giganteus	1948	80	[2]	90	0
Trifolium repens	1948	100	[2]	85	0
Lolium remotum	1948	100	[2]	75	0
Poa longifolia	1948	70	[2]	65	0
Lolium perenne	1948	100	[2]	60	0
Bromus tomentellis	1948	60	[2]	60	0
Good initial stands established but failed or maintained poor to fair stands in 5 years:					
Arrhenatherum elatius	1943	100	30	--	[1]
Elymus x *Secale*	1943	100	25	--	0
Agropyron ugamicum	1943	95	20	--	0
Medicago lupulina	1943	100	10	--	0
Elymus sibiricus	1943	90	[1]	--	0
Do.	1948	[1]	--	5	0
E. dahuricus	1943	95	[1]	--	0
Phalaris arundinacea	1943	90	[1]	--	0
Agrostis alba	1943	95	0	--	0
Poorly established or failed completely:					
Agropyron ciliare	1943	15	1	[1]	0
A. semicostatum	1943	15	0	[1]	0
Do.	1948	0	[2]	0	0

Footnotes at end of table.

TABLE 20.—*Establishment of spring-seeded species on cheatgrass-infested abandoned cropland near Florence, Mont.* —Continued

Species	Year planted	Stand establishment			
		Seedling year	1947	1950	1959
		Pct.	*Pct.*	*Pct.*	*Pct.*
A. subsecundum	1943	5	45	[1]	0
Festuca scabrella	1943	40	35	[1]	1
Do.	1948	6	[2]	5	4
Hesperchloa kingii	1943	20	20	[1]	0

[1] Not available.
[2] Planted in 1948.

secundum, Elymus junceus, Festuca scabrella, and *Hesperochloa kingii* (table 20). Of these species, *A. elongatum, A. smithii,* and *E. junceus* increased to fair or good stands within the succeeding 5 years. Species that established good stands in the seedling year but declined to a poor rating or failed by the fourth growing season included *Agropyron ugamicum, Agrostis alba, Arrhenatherum elatius, Elymus dahuricus, E. sibiricus, Elymus* x *Secale,* and *Medicago lupulina.*

Agropyron trichophorum, Bromus erectus, and *B. inermis* were some of the most consistent species in establishing and maintaining good stands.

From 1950 to 1959, sheep had grazed the area. Species that maintained good stands through this period of grazing included: *Agropyron cristatum, A. smithii, A. trichophorum, Bromus erectus, B. inermis, Festuca ovina, Phleum pratense, Poa compressa,* and *Medicago falcata* (table 20). Earlier in 1946 two of these species, *P. pratense* and *P. compressa,* appeared to be dying out, but since have reestablished themselves. Other species that maintained fair stands through the 17 years were *Agropyron elongatum, A. inerme, A. intermedium, Elymus junceus,* and *Festuca arundinacea.* By then all others had either failed completely or were present only as scattered plants.

Establishment was generally poorer from fall seeding than from the spring (tables 20 and 21). Only two species, *Agropyron smithii* and *Elymus junceus,* established better seedling stands from the fall seeding. In succeeding years, however, their spring-seeded stands increased and were equal to the fall seeded. Species that produced fall-seeded stands about equal to the

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TABLE 21.—*Establishment of species planted in the fall on chestgrass-infested abandoned cropland*

Species	Year planted	Stand establishment		
		Seedling year	1947	1950
		Pct.	*Pct.*	*Pct.*
Good stands maintained for 5 to 7 years:				
Festuca ovina duriuscula	1943	90	65	100
Do.	1944	57	52	90
Do.	1945	60	60	75
Agropyron smithii	1943	70	60	100
Do.	1944	25	10	15
A. cristatum	1943	70	75	95
Do.	1944	77	87	85
Do.	1945	90	90	90
Elymus junceus	1943	70	50	90
Do.	1944	33	17	57
Do.	1945	60	50	60
Agropyron intermedium	1943	95	80	90
Do.	1944	87	90	80
Do.	1945	90	65	90
A. spicatum	1943	70	75	90
Do.	1944	45	45	80
A. riparium	1943	30	25	90
Medicago falcata	1943	70	90	90
Do.	1945	90	90	90
Agropyron trichophorum	1943	30	50	85
Do.	1944	55	40	90
Do.	1945	80	70	70
Bromus inermis	1943	30	40	85
Do.	1944	30	10	30
Do.	1945	80	60	100
Agropyron trachycaulum	1943	50	70	85
Do.	1944	35	10	10
Poa ampla	1943	70	80	80
Do.	1944	53	30	25
Do.	1945	80	80	75
Agropyron sibiricum	1943	60	75	80
Do.	1944	45	20	5
Bromus erectus	1943	20	55	75
Do.	1944	60	70	55
Do.	1945	80	70	80
Agropyron inerme	1943	70	70	75
Do.	1944	30	40	70
Do.	1945	50	90	65

Footnotes at end of table.

TABLE 21.—*Establishment of species planted in the fall on cheatgrass-infested abandoned cropland* — Continued

Species	Year planted	Stand establishment		
		Seedling year	1947	1950
		Pct.	*Pct.*	*Pct.*
I. Good stands maintained 5 to 7 years--Con.				
Stipa viridula	1943	50	30	70
Do.	1944	15	20	20
Do.	1945	55	63	53
Arrhenatherum elatius	1943	20	30	70
Do.	1944	50	15	50
Do.	1945	70	75	60
Agropyron elongatum	1943	30	40	65
A. dasystachyum	1943	40	75	50
Do.	1944	45	45	50
A. caninum	1943	30	50	50
Do.	1944	55	20	35
Elymus glaucus	1943	80	60	50
Do.	1944	25	5	1
Phleum pratense	1943	30	20	50
Agropyron desertorum	1945	90	90	90
Festuca arundinacea	1943	50	20	40
Do.	1944	35	10	1
Do.	1945	70	75	60
Fair stands maintained for 5 years or more:				
Dactylis glomerata	1943	80	50	30
Do.	1944	33	8	12
Do.	1945	75	75	45
Poa juncifolia	1943	20	30	35
Festuca idahoensis	1943	30	15	30
Do.	1944	30	10	5
Do.	1945	50	40	15
Sanguisorba minor	1945	80	75	25
Fair to good stands established initially but generally failed within 5 years:				
Elymus x *Secale*	1943	95	30	1
Medicago lupulina	1943	80	1	0
Eragrostis curvula	1945	70	1	0
Lotus corniculatus	1945	70	50	0

Footnotes at end of table.

TABLE 21.—*Establishment of species planted in the fall on cheatgrass-infested abandoned cropland*—Continued

Species	Year planted	Stand establishment: Seedling year	Stand establishment: 1947	Stand establishment: 1950
		Pct.	*Pct.*	*Pct.*
Poa bulbosa	1944	65	10	0
Bromus marginatus	1943	50	20	0
Do.	1944	45	20	10
Phleum boehmeri	1944	50	1	1
Phalaris arundinacea	1945	60	70	1
Poorly established or failed completely:				
Agropyron ciliare	1945	0	0	0
A. semicostatum	1943	0	0	0
A. subsecundum	1943	1	1	0
Agrostis alba	1943	5	1	20
Bouteloua curtipendula	1943	5	[1]	1
Bromus carinatus	1943	10	25	5
Elymus cinereus	1943	0	1	0
E. dahuricus	1943	20	1	1
E. sibiricus	1943	20	1	0
Eragrostis tricoides	1945	30	1	0
Festuca scabrella	1943	1	0	0
Hesperchloa kingii	1943	20	0	0
Phleum phleoides	1945	30	10	1
Poa compressa	1943	20	15	15
Secale montanum	1945	[1]	[1]	30
Sorghastrum nutans	1945	5	0	0
Onobrychis vulgaris	1943	10	1	1
Do.	1944	35	10	1

[1] Data not available.

spring seeded were *Agropyron cristatum*, *A. inerme*, *A. intermedium*, *A. sibiricum*, *A. smithii*, *A. spicatum*, *Dactylis glomerata*, *Elymus glaucus*, *Festuca ovina*, *Elymus* x*Secale*, and *Medicago lupulina*. Apparently, none of the fall-seeded species maintained their stands any better than the spring seeded.

Study.—Antrim adaptation study No. 2.
Date planted.—October 7, 1944.
Procedures.—Eight species and four mixtures were planted.

Each of the eight single species was planted on the spring plowed, spring-seeded area of preparatory cropping planting. No further seedbed preparation was done. Each plot extended across stubble of Horsford barley, Compana barley, fall rye, and spring rye. Plots were 32 by 136 feet. Each of the eight single species was again planted on the fall plowed, spring-seeded area extending across stubble of Victory oats, Compana barley, and Horsford barley. Each plot was 28 by 96 feet.

The mixture plots were planted on the fall-plowed, fall-seeded area that had been planted to fall rye. Each plot, 32 by 390 feet, extended across the rye plots that had been variously harvested for hay, for grain, and for grazing. The fall plantings were made with a one-horse drill with rows spaced 7 inches apart. Seeding was 1/2 to 3/4 inch deep. Different harvesting systems were imposed only in the mixture seedings of the fall rye preparatory crop.

Summary of results.—Good stands established on the area cut for hay and especially good on the area that sheep had grazed. On the area harvested for grain, competition from thick stands of volunteer rye and cheatgrass suppressed establishment and only a few weak seedlings of *Agropyron cristatum* and *Festuca ovina* were found.

In the seedling year 1945, stands ranged from poor to good with *Agropyron cristatum, A. intermedium, Bromus erectus*, and *Poa ampla* establishing the best stands. By 1950, the sixth growing season, these species continued to maintain good stands. *Festuca ovina* had increased from 57 to 90 percent, and *Elymus junceus* had improved from 33 to 57 percent (table 21). *Dactylis glomerata* and *Agropyron smithii* were consistently poor from this planting, but they had established much better stands in other plantings.

Results from the mixtures were recorded only for the sixth growing season. At that time none of the mixtures utilized the site more fully than the dominant species in single seedings. Mixtures that contained *Festuca ovina* and *Agropyron cristatum* were dominated by *F. ovina*. Subordinate species in the mixtures were *Elymus junceus, B. erectus, Medicago falcata, Agropyron intermedium*, and *A. smithii*.

Study.—Antrim adaptation planting No. 3.

Previous use.—This area was previously part of the fall-plowed, spring-seeded part of a preparatory planting that had been in oats and barley.

Date planted.—October 9, 10, 11, 1944.

Procedures.—No further seedbed preparation was done. Twenty-seven species were hand drilled with a Planet Junior seeder. Three other species, *Agropyron caninum*, *Arrhenatherum elatius*, and *Elymus dahuricus* were planted by scattering the seed in handmade furrows and covering with soil. These species were heavily awned that prevented seeding through a drill. Rows were spaced 8 inches apart in 12 1/2- by 32-foot plots.

Summary of results.—Stands were generally fair to good in the seedling year for most of the species (table 21). *Agropyron intermedium* produced the best stand while *A. smithii*, *E. dahuricus*, and *Stipa viridula* produced poor stands, and *Poa compressa* failed completely. By the sixth growing season, several of the grasses improved their stands. Those with good stands were *Agropyron cristatum*, *A. inerme*, *A. intermedium* *A. spicatum*, *A. trichophorum*, *Elymus junceus*, and *Festuca ovina*. The species that had relatively poor stands or had failed by the sixth year included *Agropyron sibiricum*, *A. smithii*, *A. trachycaulum*, *Bromus inermis* (Parkland), *B. marginatus*, *Dactylis glomerata*, *E. dahuricus*, *E. glaucus*, *Festuca arundinacea*, *F. idahoensis*, *Phleum boehmeri*, *P. phleoides*, *Poa ampla*, *P. bulbosa*, and *P. compressa*.

In the seedling year cheatgrass was relatively heavy in the seeded plots. It comprised from 35 to 75 percent of the cover. Rye was scattered through the plots making up from 1 to 40 percent of the cover. Where competition from cheatgrass and rye was particularly heavy, stands of seeded grasses declined.

Study.—Antrim adaptation planting No. 4.

Date planted.—October 26, 1945.

Procedures.—Twenty-seven species were seeded in 3- by 20-foot plots with three rows per plot and 1 foot between rows. Seeding was made by drilling with a Planet Junior hand seeder at a rate high enough to insure good stands if germination was good.

The seedbed was prepared by burning the cheatgrass. It was moldboard-plowed and harrowed several times. At time of seeding, the soil was dry to over 2 inches deep with little moisture below 2 inches.

In 1946, the plots were cultivated and hand weeded on May 8, May 22, and July 23.

Summary of results.—Generally, good stands of most species were established in the seedling year but *Bromus inermis*, *B. inermis* (Parkland), *Eragrostis trichodes*, *Phleum boehmeri*, *P.*

phleoides, and *Sorghastrum nutans* were poor. Since these species, except *E. trichodes* and *S. nutans*, either maintained or improved their stands through the next 4 years, their poor stands were probably more from poor seed or seedbed conditions than from nonadaptability to the site.

Besides *E. trichodes* and *S. nutans*, one other species, *Eragrostis curvula*, which produced a good stand of seedlings the first year, died out the second year. These species were considered not adapted.

B. inermis (Lincoln) improved its stand to 100 percent by the fifth year. Other species that appeared particularly well adapted were *Agropyron cristatum*, *A. intermedium*, *Bromus erectus*, *Stipa viridula*, and *Medicago falcata*. A second group of species produced good stands in the fifth year but appeared to be decling. These included *Agropyron inerme*, *A. trichophorum*, *Arrhenatherum elatius*, *Dactylis glomerata*, *Festuca arundinacea*, and *Poa ampla*. *Elymus junceus* also produced a fairly good stand and was generally maintaining itself.

Study.—Antrim adaptation planting No. 5.

Date planted.—April 8, 1946.

Procedures.—Ten species of grass were planted in plots 15 by 66 feet in each of two replicated blocks. The seed was drilled with a one-horse drill with rows spaced at 7-inch intervals. Species of *Festuca* and *Poa* were seeded at 1/4- to 1/2-inch depths and the others at about 3/4 inch. Seeding rates were 8 pounds per acre for *Agropyron cristatum*, *Festuca ovina*, and *Poa ampla*. *Bromus erectus* was seeded at 15 pounds per acre and all the others at 12 pounds. The seedbed was prepared by plowing and harrowing in the fall and spike-tooth harrowing again in the spring before planting. At seeding time the soil surface was dry but fairly moist at the 1-inch depth.

Summary of results.—Initial stands were good for five seeded species: *Agropyron cristatum*, *A. intermedium*, *A. trichophorum*, *B. erectus*, and *Elymus junceus*, but *Agropyron inerme* and *A. spicatum* produced fair stands, while *F. ovina*, *P. ampla*, and *Stipa viridula* were relatively poor. Stands of most species improved in the succeeding years. By the fifth growing season, *A. cristatum*, *A. intermedium*, *A. spicatum*, *A. trichophorum*, *B. erectus*, *E. junceus*, and *F. ovina* had established good stands. Of these grasses *F. ovina* had greatly improved its stand, while *E. junceus* declined slightly. *A. inerme*, *P. ampla*, and *S. viridula* improved slightly but were rated fair.

Study.—Antrim adaptation study No. 6.

Date planted.—April 28, 1948.

Procedures.—Forty-eight species and strains were planted in plots 5 by 16 feet with three rows per plot spaced 18-inches apart leaving a 6-inch border between plots. Seeds were scattered by hand in furrows made with a hoe and covered with soil. The large-sized seeds were covered with 3/4 to 1-1/2 inches of soil, and the small seeds with 1/4 to 3/4 inch of soil. The soil was firmly packed with a hand rake. The plots were cultivated and weeded during the first 2 years as needed to remove competition from cheatgrass.

Summary of results.—Good to excellent stands were established in the seedling year for most species (table 20). *Festuca idahoensis*, *Poa ampla*, and *P. compressa* established fair stands. These species were planted about 1 inch deep instead of the desired 1/4- to 1/2-inch depth. The relatively deep seeding probably contributed to the reduced stands. In the second and third years, the stands of all strains were maintained or improved.

Damage to leaves from early frost was observed in 1949. Species most heavily damaged were *Agropyron inerme*, *A. intermedium*, *Bromus erectus* and *Dactylis glomerata*. *Poa ampla* and *P. compressa* showed only slight traces of damage.

Strain differences were observed in 1948 and 1959 as follows:

Agropyron cristatum: Commercial was the greenest and produced more heads than the other strains, while P-7406 produced the fewest heads but was more leafy. P-61 failed to form a sod.

A. dasystachyum: W-7801 produced the most heads, but P-1822 was more leafy and green. Both strains were badly infested with leaf rust.

A. elongatum: Few heads were produced on either strain. P-111 plants were larger and leafier, while P-2326 was greener. P-111 produced finer stalks in 1959.

A. inerme: P-7412 was the greener, produced more heads, and had the larger plants.

A. intermedium: P-2327 and Ree were about equal. Both were green. Plants were very large and leafy with very few heads. P-14 plants were smallest and were drier than the others. P-14 also produced a very heavy sod in 1959, while the other strains produced loose sod.

A. smithii: P-727 was the leafiest, very robust, and bluish in appearance. It had no leaf rust. 065-456 and P-9373, on the other hand, were heavy with leaf rust. 065-456 was light green, and P-9373 was bluish. 065-456 produced a heavy sod, while P-727 formed a light sod, and P-9373 formed a very light sod.

A. spicatum: P-6409 was small and spindly, while P-7845 and P-737 were large, leafy, and mostly green. Leaf rust was present on all three strains. By 1959, P-7845 had produced a light sod.

A. trachycaulum: P-2535 produced more seed heads than any other wheatgrass. The plants were large and bunchy and produced twice the forage as P-1711. The commercial strain produced only a few plants, but they were large and leafy and similar to P-2535.

A. trichophorum: The Mandan strain produced larger, greener plants than P-41, but it stooled much less. Its plants resembled the Ree strain of *A. intermedium* but were slightly smaller.

Bromus erectus: P-4684 was the more leafy and had no smut on heads. Most of the heads on P-2336 were smutty.

B. inermis: Manchar produced much larger plants than the other strains. Lincoln was greener and formed a heavy sod in 1959.

B. marginatus: P-3368 produced numerous heads with good seed. Plants were as large and leafy as Manchar smooth brome. P-3972 produced short, leafy plants with only a few heads, all of which were smutty.

Dactylis glomerata: All strains were similar — all were large and leafy.

Elymus cinereus: The Aberdeen strain produced numerous heads with good seed. Some plants were bright green. These were infected with leaf rust. Bluish-colored plants were also infected, but the infection was not as heavy.

E. junceus: D-19 appeared to be a little greener than the strain from Nebraska. They were equal in leafiness and stooling. Neither strain produced seed heads.

Festuca arundinacea: Differences between Alta and Ky 31 were not apparent. Both produced a few heads and their plants were large and leafy.

F. idahoensis: P-6435 produced dark-green plants that were mostly large and leafy, but the presence of several small plants indicated delayed germination. The color and coarseness of leaves resembled *F. rubra.* Stands of P-6187 were spotty, and plants were small compared with P-6435. Most of them were bluish. In 1959 many seedlings of P-6187 were establishing in the open areas.

Poa ampla: All strains were very bluish. P-9803 was leafier and more vigorous. P-2716 produced large and small plants in equal proportions. The other strains, P-837 and P-6303, produced small plants. In 1959 many plants of all strains appeared dead.

P. compressa: The commercial strain produced larger, leafier, and greener plants. Plants of P-410 were fine leafed and yellowish; they were also of poor vigor. By 1959 the commercial strain formed a dense stand and appeared to be the more vigorous spreader. P-410 was a light spreader.

Study.—Antrim adaptation study No. 7.

Previous use.—The study area was previously part of an *Agropyron cristatum* study that had been established to test row spacings and rates of seeding.

Date planted.—April 29, 1948.

Procedures.—The area was plowed and harrowed April 22, 1948. Plowing was done to 10 inches deep. Thirty species were planted by scattering seed in furrows prepared with a hoe. Covering and firming was done with a hand rake. Depth of covering varied from 1 to 1-1/2 inches for the large seeds and from 1/4 to 3/4 inch for the small-seeded species. Plots were 5 by 16 feet with three rows 18 inches apart having a 6-inch border between plots.

Summary of results.—Good to excellent stands were established by all species except for *Agropyron semicostatum, Elymus sibiricus,* and *Festuca scabrella* that generally failed (table 20). By 1950, the third growing season, all species but *Lolium perenne, L. remotum,* and *Trifolium repens* had maintained or improved their original stands. These three species still maintained good stands but had declined markedly. By 1959, the 12th year, these same species plus *Agropyron caninum, Bromus tomentellis, Elymus canadensis, E. gigantens, E. glaucus, E. sibiricus, E. virginicus, Poa bulbosa, P. longifolia, P. stenantha,* and *T. repens* had either failed completely or were present only as traces. *F. scabrella,* also present only as four plants, continued to maintain itself near its original stand of six plants.

Species that had declined markedly but still maintained fair stands were *Agropyron cristatum, Festuca rubra, Lotus corniculatus, Onobrychis vulgaris,* and *Sanguisorba minor.*

Those species that appeared well adapted to the area were *Agropyron amurense, A. sibiricus, Alopecurus arundinacea, A. pratensis, Phleum boehmeri, P. phleoides, P. pratense, Medicago sativa,* and *Vicia tenuifolia* (table 20).

By 1959, *A. amurense* had spread to adjoining plots, and plots of *L. corniculatus, M. sativa,* and *O. vulgaris* were heavily infested with *Bromus tectorum.* Grazing by sheep had been particularly heavy on *F. scabrella, M. sativa, O. vulgaris,* and species of *Phleum,* and *Poa. L. corniculatus* was only lightly grazed, while *V. tenuifolia* had been ignored.

Several of the Antrim adaptation studies were harvested between 1946 and 1949. Averages of three and four harvests (table 22) show some variation by species depending on year planted. However, those that consistently produced high yields were *Agropyron intermedium, A. cristatum (desertorum), Festuca ovina duriuscula,* and *Bromus erectus. Poa ampla* also produced high yields in two of three studies.

In mixture plots containing *A. cristatum, E. junceus,* and *F. ovina, F. ovina* accounted for 2,034 pounds per acre and *A. cristatum* 107, while *E. junceus* contributed only a trace amount. In another mixture, *F. ovina* accounted for 1,143 pounds while *A. cristatum* yielded 603 pounds and *B. erectus* 190 pounds of the total weight.

Antrim preparatory cropping studies.—As a method for preparing a seedbed with the possibility of recovering part of the cost, techniques of preparatory cropping were studied in which several grain crops were planted and harvested before planting grasses into the stubble. Descriptions and procedures of these studies follow.

TABLE 22.—*Herbage yields of grasses from abandoned cropland infested with cheatgrass near Florence, Mont.*

Species	Average yields per acre, air-dry weight		
	1946-49 [1]	1946-49 [2]	1947-49 [3]
	Lbs.	*Lbs.*	*Lbs.*
Poa ampla	[4] 499	1,668	2,349
Agropyron intermedium	1,571	1,994	2,289
A. spicatum	[5]	[5]	2,257
Stipa viridula	[5]	[5]	[6] 2,123
Festuca ovina duriuscula	903	1,370	2,009
Agropyron inerme	[5]	[5]	1,894
A. trichophorum	[5]	[5]	1,800
A. cristatum	1,394	1,656	1,740
Bromus erectus	1,165	1,170	1,55[illegible]
Elymus junceus	610	1,068	1,194
Agropyron smithii	[5]	[6] 2,140	[5]

[1] Planted 1943 in grain stubble following preparatory crops.
[2] Planted 1944 in grain stubble following preparatory crops.
[3] Planted 1946.
[4] Yields for 1946 (1 year only).
[5] Data not available.
[6] Yields for 1949 (1 year only).

Study.—Antrim preparatory crop planting No. 1.

Date planted.—April 13, May 19, June 7, October 28, 1943.

Procedures.—One acre of ground was plowed and harrowed April 12, 1943. One-fourth of it was seeded to *Agropyron cristatum* and one-fourth to spring rye. On May 19, one-sixth was seeded to sudangrass and one-sixth to Proso millet. On June 7, three varieties of sorghum were seeded in plots 20 by 27 feet. The rest of the area was left unseeded. On October 28, after harvesting the grain, nine species of grass were seeded across the preparatory crop plots, represented by rye, fallow, millet, and sudangrass. *A. cristatum* was also seeded across the four preparatory crop plots.

Summary of results.—Good stands of rye, millet, and sudangrass were produced. Rye headed out at about 5 feet high and yielded 1.5 tons of hay per acre in July and 20 bushels of grain per acre. Millet was also good, but *Bromus tectorum* was thick. The millet was about 18 inches tall in August and yielded 1-1/2 tons per acre. Sudangrass also looked good; it was 18 inches tall and yielded 1 ton per acre. The grain sorghums were about 18 inches tall in September, but they were killed by frost before the seed matured. *A. cristatum* established good stands of seedlings whether planted in the spring or fall. Following the preparatory crops, good to fair stands of grass were established. The stands were better following spring rye and sudangrass and poorer following millet. In 1946 *A. cristatum* yielded 689 pounds per acre and in 1947, 1,160 pounds.

Study.—Antrim species establishment following preparatory crops.

Date planted.—October 28, 1943.

Procedures.—Nine species were planted across the four preparatory cropping treatments (sudangrass, millet, fallow, and rye) of planting No. 1. Plots were 8 by 115 feet. Each species was planted in a randomized block design. Seeding was made into undisturbed stubble with a one-horse drill at 8 to 10 pounds per acre. Rows were spaced 7 inches apart.

Summary of results.—Seedings were recorded on all cropping treatments from 1944 to 1947 but only on the rye treatments in 1948 and 1950. Species generally appeared to become established best following rye, while establishment was about equal on each of the other treatments. The initial seedings were generally good following rye but only poor to fair following the other treatments (table 23).

Agropyron cristatum consistently established well following

TABLE 23.—*Effect of preparatory crops on the establishment of forage species planted in stubble*

(Values are average stand estimates 1944-50)

Species	Preparatory crops			
	Fallow	Spring rye	Millet	Sudan-grass
	Pct.	*Pct.*	*Pct.*	*Pct.*
Agropyron cristatum	50	72	50	47
A. intermedium	23	68	17	11
A. smithii	20	35	42	42
Bromus erectus	43	54	18	13
Dactylis glomerata	58	51	13	18
Elymus junceus	15	55	7	7
Festuca ovina duriuscula	15	44	1	5
Poa ampla	12	14	7	7
Medicago falcata	20	27	15	25
Average	28	47	19	19

all four crops, while *A. intermedium* and *Elymus junceus* and *Festuca ovina* established well only following the rye. *Bromus erectus* and *Dactylis glomerata*, established fairly well on both the fallow and the rye treatments. *Agropyron smithii* was the only species that appeared to establish best following the millet or sudangrass treatments.

The differences among the cropping treatments on the establishment of forage species were partially attributed to the amount of cheatgrass present. Rye stubble was practically free from weeds and cheatgrass, while the fallow plots had scattered weeds, cheatgrass, and sudangrass, and the millet plots had many cheatgrass plants.

Study.—Antrim preparatory crop study No. 2.

Procedures.—The study was designed in a rather complex fashion with soil preparation, seeding, and harvesting treatments as follows:

1. One and one-half acres - fall plowed and harrowed; fall seeded to rye (1943), one-third cut for hay (July 7, 1944), one-third cut for grain (July 27, 1944), and one-third grazed.

2. Three-fourths acre - fall plowed (1943), left rough over winter, harrowed four times in the spring (1944) and seeded as follows:

a. One-fourth acre - Victory oats - one-half cut for hay, July 7, 1944.

b. One-fourth acre - Compana barley - one-half cut for grain, July 27, 1944.

c. One-fourth acre - Horsford barley.

3. 1 acre - spring plowed (1944) and seeded (spring 1944).

a. One-fourth acre Horsford barley - one-half cut for hay, July 7, 1944.

b. One-fourth Compana barley.

c. One-eighth acre fall rye - one-half cut for grain July 27, 1944.

d. One-eighth acre spring rye.

e. One-fourth acre crested wheatgrass.

Summary of results.—Fairly good yields of grain and hay were harvested following a relatively good moisture year. The two barley varieties produced similar amounts of grain. Compana, however, produced considerably more hay, and yields of both hay and grain were greater from fall plowing than from spring plowing (table 24).

On the grazed part of fall rye both the rye and cheatgrass

TABLE 24.—*Grain and hay yields from preparatory cropping systems on cheatgrass-infested abandoned cropland near Florence, Mont.*

Seeding treatment and crop	Yield per acre	
	Grain	Hay
	Bushels	*Pounds*
Fall plowed-fall seeded (Oct. 1943):		
Fall rye	23.0	2,290
Fall plowed-spring seeded (April 1944):		
Compana barley	44.5	1,840
Horsford barley	43.0	1,240
Victory oats	---	1,880
Spring plowed-spring seeded (April 1944):		
Spring rye	17.5	1,600
Compana barley	34.5	2,040
Horsford barley	31.5	1,200
Fall rye	---	800
Spring plowed-spring seeded (April 1945):		
Compana barley	36.3	3,210
Horsford barley	21.4	2,160
Thatcher spring wheat	9.5	2,700

were grazed closely in the spring then allowed to regrow. By July 11, the rye was 3 feet tall and cheatgrass was 12 to 18 inches with many seed heads. At that time the cheatgrass was green and in the flowering stage, but that in the surrounding fields was ripe and dry. By fall, grasshoppers had cleanly stripped all the heads from the cheatgrass, which apparently prevented seed from maturing since there were only a few new seedling plants. Although the grazed part of the study was relatively free from cheatgrass, the action of the grasshoppers was probably more responsible for the results than the grazing by sheep in the spring. Grasshoppers completely destroyed the seed heads of Victory oats.

Agropyron cristatum seeded in 1944 yielded 1,017 pounds per acre in 1946 and 1,375 pounds per acre in 1947.

Study.--Antrim preparatory cropping planting No. 3.

Date planted.—April 7, 1945.

Procedures.—The ground was plowed and seeded in the spring by drilling to Thatcher spring wheat and Compana and Horsford barley. Before plowing, the area was burned in the fall of 1944 removing all the litter. Seeding was with a 10-foot single-disk Van Brunt grain drill.

The study was made to determine the effect of the different preparatory crops on seedbed preparation and cheatgrass infestation. Perennial grasses were planted October 13, 1945.

Summary of results.—Good stands of all three grains were obtained. Compana barley produced considerably more seed and hay than either of the other grains and both barleys yielded more seed than did wheat, but Thatcher wheat yielded more hay than Horsford barley.

Cutting the grain early for hay, controlled *Bromus tectorum.* But when it was left to be harvested for seed 2.5 times as many *B. tectorum* seedlings emerged in the fall as on the hayed area, and the following spring 3.7 times as many seedlings emerged. Grasses planted on the two treatments established 1.6 times as many seedlings on the area cut for hay as on that cut for seed.

Most of the *B. tectorum* seed that fell on the soil surface germinated and established plants that fall with little holdover of seed until spring. Where fall cultivation of the soil buried the seed, however, at least some of it wintered over and germinated the next spring. This finding indicates that spring cultivation destroyed more cheatgrass than fall cultivation, also that fall planting on fall-cultivated seedbeds enabled seeded grasses to start and compete with cheatgrass better than those planted in the spring on fall-cultivated soils. The advantage or disadvantage of fall versus spring seeding of grasses would not necessarily depend on the time of cultivation since moisture during the seedling stage appears to be the critical factor. However, where adequate moisture is present and cheatgrass seeds are buried by spring plowing, reduced competition by spring cultivation may produce better stands than fall seeding.

Study.—Antrim mixture study following preparatory crops planting.

Date planted.—October 13, 1945.

Procedures.–Agropyron cristatum and two mixtures were seeded in plots 15-1/2 by 225 feet. Two plots of each were seeded, one on each of the areas cut for grain and for hay. Each plot extended across all three grains used in preparatory crop study No. 3 (Thatcher wheat, Compana barley, and Horsford barley).

Seeding was with a one-horse drill pulled by a tractor. Rows were spaced 8 inches apart. The drill was set to seed 1 inch deep, but because of unevenness of the soil surface, depths from 0 to 1-1/2 inches occurred. Seeding was at 5 to 8 pounds per acre. At time of seeding, the soil was dry to 1-1/2 inches.

Summary of results.—Nearly twice as many seedlings of the seeded species became established on the area where the grain was cut for hay as where it was harvested for seed (table 25). This advantage for the hayed treatment continued through the first years of the study. However, by the fifth year the stands from both harvest treatments were approximately equal.

The *A. cristatum* plot was consistently better than either of the mixtures in seedling numbers and in percent stand throughout the study period. It was also the dominant species in the two mixtures. *Festuca ovina* improved consistently in stand and appeared as though it would become an important component of the mixtures as it had done in other mixture studies. *Agropyron intermedium* and *Medicago falcata* generally maintained their stands but did not appear to be as aggressive as *F. ovina.*

Approximately two-thirds of the seedings observed in the first year died out by the second year for reasons unknown. In the succeeding years, stands of species increased consistently with the possible exception of *Agropyron trichophorum,* which was present only as a trace.

Herbage from mixture No. 1, harvested in 1948, produced 4,148 pounds per acre. Of the total yield, *M. falcata* contributed 2,443 pounds; *A. intermedium,* 1,106 pounds; and *A. cristatum,* 599 pounds.

TABLE 25.—*Establishment of seeded species in mixtures following different preparatory cropping methods on cheatgrass infested abandoned cropland near Florence, Mont.*

Species and mixture planted	Cut for grain				Cut for hay			
	Plants, per square yard		Stand		Plants, per square yard		Stand	
	1946	1947	1948	1950	1946	1947	1948	1950
	No.	*No.*	*Pct.*	*Pct.*	*No.*	*No.*	*Pct.*	*Pct.*
Agropyron cristatum	54.9	15.0	50	80	77.4	24.0	90	90
Mixture No. 1 (total):	16.2	5.5	40	60	35.1	14.2	60	60
A. cristatum	8.0	3.2	20	30	15.0	6.7	25	30
A. intermedium	7.5	2.1	15	20	15.0	7.0	30	20
Medicago falcata	.7	.2	5	10	5.1	.5	5	10
Mixture No. 2 (total):	18.9	5.0	30	50	27.0	6.8	20	40
Agropyron cristatum	--	3.5	20	25	20.2	4.0	15	20
A. trichophorum	--	.2	1	1	1.0	0.5	1	1
Arrhenatherum elatius	--	.5	5	5	2.6	.5	1	5
Festuca ovina	--	.8	5	20	3.2	1.8	5	15

Study.—Antrim cheatgrass burning study.

Date planted.—October 18, 1946.

Procedures.–*Agropyron cristatum* was seeded following various burning and soil preparation treatments from June 7 to August 9.

Summary of results.—Fall burning of cheatgrass followed by drilling the seed did not produce satisfactory stands. On the unburned area, the only method that produced a satisfactory stand was a plowing-disking-drilling treatment. All the other methods generally failed.

Burning reduced the numbers of *Bromus tectorum* plants plants by about 80 percent, but the reduction was apparently not enough to establish satisfactory grass stands. The greatest reduction of *B. tectorum* occurred from burns made from July 11 to 24.

The number of *B. tectorum* seedlings can be reduced by burning the parent crop at about any time after it is mature and dry enough to carry a good fire and before most of the seed has shattered. However, it is still likely that enough seed will be left to produce a good stand the following year, and without further seedbed preparation *B. tectorum* will reduce seeding success.

Study.—Antrim rate of seeding and row spacing.

Date planted.—October 18, 1946.

Procedures.—The area was plowed and harrowed in 1945 and was replowed, disked, and harrowed before planting in 1946. Plantings were made with a one-horse drill set to seed at 3/4 inch deep. Two species, *Agropyron cristatum* and *A. intermedium*, were each planted at two seeding rates, *A. cristatum* at 4 and 8 pounds per acre and *A. intermedium* at 6 and 12 pounds per acre. Plots were 6 by 80 feet. Treatments were randomly located in two replicated blocks.

Summary of results.—Stands obtained were not very satisfactory. *A. intermedium* was very poor under all treatments. Its best stand of three plants per square yard was produced from a 12-pound-per-acre seeding rate with a 14-inch row spacing.

A. cristatum, however, established fair stands, and variations among treatments were highly significant for both rate of seeding and spacing. The best stand of 21 plants per square yard was established from 7-inch spacings seeded at 8-pounds per acre. The poorest stand of 6 plants per square yard was established from the 14-inch spacing and 4-pound seeding rate.

Study.—Antrim depth of seeding and competition study.

Date planted.—October 11, 1944.

Procedures.—Before seeding, the area was plowed in the fall of 1943, cultivated once during the summer of 1944, and cultivated and seeded in October 1944. Weeds and debris were raked off to leave a clean seedbed. Two 4 by 4 wooden beams were dragged over the area to smooth the soil. Two species, *Festuca ovina* and *Agropyron cristatum*, were drilled at each of three depths, shallow (1/4 to 1/2 in), medium (1/2 to 3/4 in), and deep, (3/4 to 1 in), with a Planet Junior hand seeder. The grasses were drilled in alternate rows 8 inches apart, and treatments were replicated in two blocks. At the time of seeding the seedbed was clean and fairly smooth, but the soil was dry and rather loose.

Summary of results.—By November 1944, *A. cristatum* emerged from the medium and deep seedings but not from the shallow. Undoubtedly, lack of moisture in the surface soil was the reason for this although moisture was apparently adequate for germination a little deeper. *F. ovina* did not germinate until the next spring.

Stands of *A. cristatum* were fairly good in 1945 with the better stands from the shallow and medium seeding depths (table 26).

TABLE 26.—*Establishment of 2 grasses as affected by depth of seeding and competition with each other in cheatgrass-infested cropland, abandoned, near Florence, Mont.*

Species and planting depth[1]	Stand	
	1945	1948
	Pct.	*Pct.*
Agropyron cristatum:		
Shallow	82	80
Medium	78	80
Deep	62	,80
Festuca ovina duriuscula:		
Shallow	25	30
Medium	3	5
Deep	0	1

[1] Planting depth as follows: Shallow, 1/4 to 1/2 inch; medium, 1/2 to 3/4 inch; and deep, 3/4 to 1 inch.

By the fourth growing season (1948), however, stands were equal for all depth treatments.

Festuca ovina failed to become established from the deep seeding treatment. Stands were better on the shallow seeding treatment but at best were relatively poor. By 1948, no *A. cristatum* plants or seedlings were found outside the original rows. However, seedlings of *F. ovina* were common between rows and plants within the rows, especially in the shallow-seeded plots where more *F. ovina* plants had established.

The relative competition between these species could not be evaluated since the stand was open. With the presence of many *F. ovina* seedlings in 1948, probably better stands of this species would have become established in the succeeding years.

Study.—Antrim depth of seeding and soil firming.

Date planted.—April 11, 1946, and October 15, 1946.

Procedures.—Six species of grass were seeded in a randomized block, split-plot design. Plots of species and seeding depths (3 each) were randomly located within each of three replicated blocks. After planting, half of each plot was packed with a cultipacker to firm the soil.

Seeding was with a Planet Junior hand seeder in rows 8 inches apart in plots 2 by 20 feet with three rows per plot. Seeding depths were shallow (1/4 to 1/2 in), medium (3/4 to 1 in), and deep (1 1/4 to 1 1/2 in.) for each species. Rate of seeding was as follows: *Poa ampla*, 3 pounds; *Agropyron cristatum* and *Elymus junceus*, 6 pounds; and *Agropyron intermedium* and *Bromus erectus*, 8 pounds per acre. For the spring-seeding treatment the seedbed was burned, plowed, and harrowed during the fall of 1945. In the spring of 1946 it was spring-tooth cultivated and spike-tooth harrowed, then dragged with three 4-by 4-inch timbers to smooth the surface. For the fall treatment, the seedbed was plowed from sorghum stubble, which was relatively free from cheatgrass, and then it was spring-tooth harrowed. Loose sorghum roots were raked from the soil. The area was dragged with the 4-by-4 drag to smooth and firm the seedbed. During planting the soil was left loose without walking or packing the seeded rows. After planting, half of each plot was packed by converting the Planet Junior seeder into a packing unit.

Summary of results.—With the possible exception of *F. ovina*, spring seeding produced better stands than fall seeding on both the packed and nonpacked seedings (table 27). The spring seeding produced better results even though precipitation and temperatures were unusually low during April, May, and June. Through the summer months, precipitation was unusually high, but temperatures continued below normal. *Elymus junceus*, in particular, established better with spring seeding.

Differences between the packed and nonpacked treatments were not consistent between years for the same species and seeding depth but packing appeared to improve initial establishment slightly. Depth of seeding significantly affected the establishment and vigor of the different species. *Agropyron cristatum*, *A. intermedium*, *Bromus erectus*, and *Elymus junceus* established their best stands generally at the medium depth (3/4 to 1 in.). Establishment, however, was about the same from the deeper seeding. The two wheatgrasses also established well at the shallow depth, but *B. erectus* and *E. junceus* were definitely reduced by the shallow seeding. *F. ovina*, on the other hand, established its best stands at the shallow (1/4 to 1/2 in.) seeding depth. *Poa ampla* also appeared to establish somewhat better from the shallower seeding than at the deeper depth. In general, however, plants from the deeper depths appeared to be more vigorous.

Study.—Antrim date of seeding—seedbed treatments.

Date planted.—September 19, 1941, October 20, 1941, April 8, 1942, September 18, 1942, October 29, 1942, and April 13, 1943.

Procedures.—Three seedbed treatments were randomly pre-

TABLE 27.—*Seedling establishment as affected by seeding depth,*[1] *soil firmness, and planting date*

Species	Percent stand with soil					
	Packed			Nonpacked		
	Shallow	Medium	Deep	Shallow	Medium	Deep
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Spring planted:						
Agropyron cristatum	84	98	76	77	78	80
A. intermedium	89	77	91	74	90	94
Bromus erectus	67	92	93	63	88	78
Elymus junceus	56	78	75	50	62	68
Festuca ovina duriuscula	77	38	31	62	32	30
Poa ampla	41	42	31	53	35	24
Average	69	71	66	63	64	62
Fall planted:						
Agropyron cristatum	51	50	31	47	39	24
A. intermedium	29	39	22	25	36	25
Bromus erectus	31	49	20	32	22	12
Elymus junceus	1	2	4	2	1	4
Festuca ovina duriuscula	76	28	22	100	26	23
Poa ampla	11	3	1	21	0	1
Average	33	28	17	38	21	15

[1] Seeding depth as follows: Shallow, 1/4 to 1/2 inch; medium, 3/4 to 1 inch; deep, 1-1/4 to 1-1/2 inches.

pared in nine blocks. They were (1) light preparation, plot disked once over with a heavy cut-out disk harrow; (2) heavy preparation, plot disked twice; and (3) plot untreated.

Agropyron cristatum was planted at three different dates across the three treatments with three replicated blocks per date of seeding. The individual plots were 20 by 50 feet. Approximately 6 pounds of seed per acre were planted with a one-horse drill. *Agropyron intermedium* was also seeded at the early and late fall dates in single plots of the three seedbed treatments, but it failed with less than one plant per square yard. It was drilled at 5 pounds per acre. The treatments were applied in 1941-42 and again in 1942-43.

Summary of results.—In the 1941-42 seeding, none of the *A. cristatum* treatments were satisfactory. By 1945, the fourth growing season, no plants were left on the nontreated seedbed, and numbers of plants had decreased on all other treatments. In the 1942-43 seeding, stands were substantially better than the 1941-42 seeding; however, by 1945, stands on all treatments were reduced. The heavy stand of *Bromus tectorum* and the failure of disking treatments to control this weed were attributed to the poor stands of seeded grass.

Differences between seasons of seeding were conflicting for the two seeding years. In the 1941-42 seedings, more plants established from the fall seedings than from the spring seedings. In 1942-43, however, spring seeding was far superior to the fall seedings. The superiority of the spring seeding continued to persist through 1945, the third growing season, with fair stands persisting on the disked treatments.

Differences between disked and nondisked treatments were significant. Although double disking consistently gave better stands of grass than single disking, differences were not significant. Based on these results neither single nor double disking is considered a dependable method for preparing *B. tectorum* infested fields for planting to *A. cristatum*.

In the 1941-42 seeding, disking once or twice reduced the cheatgrass by about 45 percent in 1942, with little difference between the disking treatments. The following year for undetermined reasons the *B. tectorum* was markedly reduced on the areas not disked. On the disked areas, *B. tectorum* increased over that in 1942 but still continued slightly lower than that on the non-disked.

Spring seeding was more effective than fall seeding in reducing the *B. tectorum* cover during the seedling year but generally late fall was better than early fall seeding. In the second growing season little difference between seasons of seeding on the *B. tectorum* cover was apparent.

Study.—Antrim fertilizer study.

Date applied.—April 27, 1948.

Procedures.—Ammonium sulfate (20 percent N) was applied at four rates, 0, 24, 38, and 64 pounds N per acre to an *Agropyron cristatum* planting that had been planted in April 1943 and April 1944. Each treatment was replicated four times in plots 15 by 82 feet in a randomized block design. The fertilizer was applied through a fertilizer attachment of a one-horse grain drill. Herbage was harvested in 1948 and again in 1949 to determine the residual effects.

Summary of results.—The fertilizer at all rates increased yields of herbage (table 28). Application of 24 pounds per acre increased production 135 percent of the nonfertilized treatment, while the 38- and 64-pound rates increased yields 167 and 178 percent, respectively, over the 2-year period. Residual effects in the second year increased production significantly by 300 to 950 pounds of herbage per acre.

Study.—Antrim competition study.

Date planted.—November 23, 1943.

Procedures.—Four species were planted in pure stands and as mixtures with *Agropyron cristatum.* In the mixtures the different species were seeded in alternate rows spaced 8 inches apart. Later, in 1944, *A. cristatum* was seeded across all the plots.

Summary of results. — In 1946 *Elymus junceus* was eliminating all *Bromus tectorum,* and *Agropyron cristatum* that had been seeded over the *E. junceus* never became established. Only an occasional plant of the other species seeded was found.

Study.—Antrim alternate row mixtures.

Date planted.—April 7, 1945.

Procedures.—Seven species were planted in alternate row mixtures with *Agropyron cristatum.* Rows were 8 inches apart with 12 rows per plot. Seeding was with a Planet Junior hand seeder. All species were planted 3/4-inch deep at a rate equal to about 30 seeds per foot of row. Before seeding, the area was plowed and spiketooth harrowed. The soil at time of seeding was moist and friable, yet firm. The surface was relatively smooth.

Summary of results.—The initial stands of grasses planted with *A. cristatum* were relatively poor. Whether this was due to competition or to weather conditions is not known; however,

TABLE 28.—*Yield of a 6-year-old crested wheatgrass stand as affected by different rates of fertilizers*

Nitrogen fertilizer per acre	Yields per acre			Increase per acre due to fertilizer
	1948	1949	Total	
	Lb.	*Lb.*	*Lb.*	*Lb.*
None	1,760	1,310	3,070	---
24 pounds	3,535	1,600	4,135	1,065
38 pounds	3,257	1,880	5,137	2,067
64 pounds	3,180	2,270	5,450	2,380

during the 4-year period of this study, no further indication of competition between *A. cristatum* and any of the species was evident. Stands of *A. cristatum* were approximately the same in each of the mixtures within the same year, and stands of all species fluctuated from year to year with a general increase in stand over the 4-year period. Species included in this study were *Agropyron intermedium*, *A. trachycaulum*, *Bromus erectus*, *Elymus junceus*, *Festuca ovina duriuscula*, *Poa ampla*, and *Medicago falcata*.

Study.—Antrim bluegrass strains test.

Date planted.—March 21, 1946.

Procedures.—Thirty-three strains of *Poa* were planted in plots 5 by 16 feet with three rows spaced 18 inches apart leaving a 6-inch border between plots. Seeds were hand planted in rows made with a hoe. They were covered with a half inch of soil packed by tamping with a garden rake. The seedbed was prepared by plowing and then harrowing seven times in the fall of 1945. During the seedling year (1946), the plots were hand weeded on May 8, June 6, and July 30.

Summary of results.—Relatively poor stands established in the seedling year for all strains. The commercial strain and Ppt 5, however, produced the best seedling stand. Of those strains that produced seedlings, only one (C-167) died out in the succeeding years. All the other strains increased their stands. By 1948, the third growing season, the commercial strain and Ppt 5 had increased their stands to 63 and 76 percent. Several other strains also appeared to be spreading rapidly.

Apparently, C-253 was the earliest developing and Ppt 5 the latest. All the other accessions were about equal and intermediate between these two strains.

If more information is desired concerning these strains, see Annual Report of Progress, 1963, Forage and Range Research. Strain numbers refer to Bureau of Plant Industry accessions.

Ft. Missoula

Study location.—Located on part of the old military fort near Missoula, Mont., sec. 31, T. 13N., R. 19 W. (location 24, fig. 10).

Elevation.—3,500 feet.

Average precipitation.—Annual, 12.5 inches; April-September, 58 percent.

Topography.—2 percent slope to the southwest.

Type of vegetation.—Intermountain valley grassland and bottom land.

Dominant and associated species.—*Agropyron smithii, A. spicatum, Festuca idahoensis, Poa* spp., and *Carex. Bromus tectorum* and *Agropyron repens* have invaded the area.

Previous use.—Old military field.

Study.—Ft. Missoula nursery.

Date planted.—April 1950; May 23, 1951; and April 16, 1952.

Procedures.—Methods of seedbed preparation and planting are unknown. In 1950, 62 species were planted. In areas where species failed in the 1950 seeding, the species were either reseeded in May 1951, or other species were planted in the vacant plot. Data were not recorded for the last seedings.

Summary of results.—Stands were either good or failures. Species that initially established good stands were as follows:

Species	*Initial stand (percent)*
Agropyron intermedium	95
A. trichophorum	95
Stipa viridula	95
Agropyron amurense	90
A. cristatum	90
A. sibiridum	90
Bromus inermis (Manchar)	90
Festuca arundinacea (Alta)	90
Lolium remotum	90
Bouteloua gracilis	90
Phleum pratense	90
Arrhenatherum elatius	85
Dactylis glomerata	85
Festuca ovina duriuscula	85
Bromus erectus	80
Agropyron elongatum	70
Bromus inermis (Lincoln)	70

The failure of some species to become established may have been caused from poor seed since some lots of seed were old. Such failures do not necessarily indicate lack of adaptation. Species that established poor stands or failed completely were *Agropyron caninum, A. dasystachyum, A. inerme, A. riparium, A. semicostatum, A. smithii, A. spicatum, A. trachycaulum, Bromus marginatus, B. tomentellus, Dactylis glomerata, Elymus condensatus, E. dahuricus, E. giganteus, E. glaucus, E. junceus, E. sibiricus, E. virginicus, Eragrostis curvula, E.*

trichodes, *Festuca elatior*, *F. idahoensis*, *F. rubra*, *F. scabrella*, *Lolium perenne*, *Phalaris arundinacea*, *Phleum boehmeri*, *P. phleoides*, *Poa ampla*, *P. bulbosa*, *P. compressa*, *P. longifolia*, *P. stenantha*, *Sporobolus cryptandrus*, *Astragalus cicer*, *A. rubyi*, *Carex filifolia*, *Lespedeza stipulacea*, *Lotus corniculatus*, *Medicago falcata*, *M. lupulina*, *Onobrychis vulgaris*, *Sanquisorba minor*, and *Trifolium fragiferum*.

Deer Lodge

Study location.—Near the town of Deer Lodge, Powell County, T. 9W., R. 8N. (location 25, fig. 10).

Elevation.—4,900 feet.

Average precipitation.—Annual, 10 inches; April-September, 71 percent.

Soil.—Silt loam over granitic gravel.

Topography.—2 percent slope to the west.

Type of vegetation.—Intermountain valley grassland.

Dominant species.—*Agropyron spicatum*, *Stipa comata*, *Sitanion hystrix*, *Poa secunda* and *Agropyron smithii*.

Previous use.—Cultivated farmland - abandoned.

Study.—Deer Lodge adaptation nursery.

Date planted.—October 10, 1950.

Procedures.—Forty-two species of grass were seeded in plots 3 by 20 feet with three rows per plot spaced 1 foot apart. Species treatments were replicated three times in a randomized block design. Seeds were drilled through a belt-type hand seeder into a duckfoot cultivated seedbed.

Summary of results.—Stands were poor to fair during the seedling year (table 29). *Agropyron trachycaulum*, *A. inerme*, *A. trichophorum*, *Bromus erectus*, *Elymus glaucus*, and *Dactylis glomerata* established the best initial stands, but by 1954 most of these species had failed or had poor stands. A few species, however, improved in stand establishment and appeared adapted to the site. They included *Agropyron desertorum* (M 24-3), *A. intermedium*, *A. sibiricum*, *Bromus inermis* (Lincoln), *Elymus junceus*, *Arrhenatherum elatius*, and *Festuca arundinacea*.

Although species in group IV generally failed in this study, some of them established fair to good stands in similar areas and, therefore, all species in this group should not be considered as nonadapted.

TABLE 29.—*Grass establishment near Deer Lodge, Mont.*

Species	Stand 1951	Stand 1954
	Pct.	*Pct.*
I. Fair stands established initially:		
Agropyron trachycaulum	55	22
Bromus erectus	40	32
Agropyron inerme	35	23
A. trichophorum	35	17
Dactylis glomerata	35	18
Elymus glaucus	35	0
Agropyron subsecundum	30	25
II. Poor stands established but improved to fair in 4 years:		
Bromus inermis (Lincoln)	30	60
Festuca arundinacea (Alta)	5	35
Agropyron intermedium	25	33
III. Improved stands but did not rate fair in 4 years:		
Agropyron desertorum (M 24-3)	20	28
A. sibiricum	20	28
Arrhenatherum elatius	20	30
Elymus junceus	5	25
Alopecurus pratensis	11	13
IV. Failed to improve or failed completely:		
Agropyron cristatum	10	5
A. elongatum	25	22
A. smithii	20	1
A. spicatum	5	0
Agrostis alba	5	0
A. tenuis	0	0
Bouteloua curtipendula	1	0
B. gracilis	0	0
Bromus marginatus	5	3
Elymus canadensis	15	1
E. triticoides	10	2
Festuca elatior	8	1
F. ovina duriuscula	25	17
F. rubra	10	0
Oryzopsis hymenoides	5	0
Poa ampla	5	1
P. bulbosa	20	0
P. compressa	25	0
P. pratensis	10	0
Stipa viridula	2	1

Hall

Study location.—Located near Hall in Granite County, sec. 24, T. 14W., R. 10N. (location 26, fig. 10).
Elevation.—4,300 feet.
Average precipitation.—Annual, 9 to 10 inches; April-September, 80 percent.
Soil.—Loam.
Topography.—5 percent slope to the north.
Type of vegetation.—Intermountain valley grassland.
Dominant and associated species.—*Agropyron spicatum*, *Stipa comata*, *Poa secunda*, *A. smithii*, and *Sitanion hystrix*.
Previous use.—Cultivated farmland.

Study.—Hall adaptation nursery.
Date planted.—1952.
Procedures.—Forty-two species of grass (the same as listed for Deer Lodge) were seeded in plots 3 by 20 feet with three rows per plot spaced 1 foot apart. Species treatments were replicated in a randomized block design. Seeding was done with a belt-type seeder into a poorly prepared seedbed.
Summary of results.—By September 2, 1953, most stands had failed and all species had been heavily grazed by grasshoppers. Although generally a failure, *Agropyron desertorum* established the best stand.

Tarkio Flat

Study location.—Located halfway between Alberton and Superior; approximately one-half mile northwest of the Tarkio school, Mineral County, NE1/4 sec. 22, T. 15N., R. 25W. (location 27, fig. 10).
Elevation.—2,900 feet.
Average precipitation.—Annual, 17 inches; April-September, 45 percent.
Soil.—A deep soil of light sandy texture.
Topography.—3 percent slope to the west.
Type of vegetation.—Intermountain valley grassland.
Dominant and associated species.—*Agropyron spicatum* and *Festuca idahoensis*
Previous use.—Cropland.

Study.—Tarkio Flat adaptation planting.
Date planted.—April 8, 1946.
Procedures.—The seedbed was prepared by plowing, disking,

and harrowing to form a medium-firm seedbed free from competing vegetation. Twelve species of grass were planted through a grain drill in plots 8 by 675 feet. Depth of seeding was approximately 3/4 inch.

Summary of results.—On June 4, 1946, stands were uneven. Plants occurred mostly in tractor tracks and places where furrows did not close, indicating that the seed was planted too deep.

Ratings made in 1947 showed good to fair stands of most species. Excellent stands were established by *Agropyron cristatum, A. intermedium, A. trachycaulum, Bromus inermis*, and *Elymus junceus. Festuca ovina, Poa compressa*, and *Phleum phleoides* rated good, and *Bromus erectus, Poa ampla*, and *Stipa viridula* had fair stands.

Plains

Study location.—Located at the Plains Ranger Station in the Cabinet National Forest, Sanders County, sec. 26, T. 20N., R. 26W. (location 28, fig. 10).

Elevation.—3,300 feet.

Average precipitation.—Annual, 14 inches; April-September, 40 percent.

Soil.—A deep, light-colored, sandy loam high in organic matter.

Topography.—7-percent slope to the southwest.

Type of vegetation.—Intermountain valley grassland.

Dominant and associated species.—*Agropyron smithii* and *A. spicatum; Bromus tectorum* has invaded the area.

Previous use.—Horse pasture.

Study.—Plains adaptation plantings.

Date planted.—November 1, 1947.

Procedures.—Sixteen species were planted in two differently prepared seedbeds: (1) Plowed and disked once, and (2) disked twice. The seedbeds were not smoothed. Seeding was done by broadcasting. The seed was covered by dragging a harrow behind a tractor. Each species was seeded in randomized blocks with two replications within seedbed treatments. Plots were 10 by 16 feet.

Twelve additional species were planted in single plots 5 by 16 feet. Seeding was done by scattering seed in handmade furrows, which were covered and packed with a hand rake. Three rows per plot were spaced 18 inches apart leaving a 6-inch border between plots.

Summary of results.—All the grasses established good stands with the best established on the plowed-disked seedbed (table 30). Stands were generally maintained the second year except for *Eragrostis curvula* which winterkilled. By 1963 *Agropyron trachycaulum*, *Arrhenatherum elatius*, and *Elymus junceus* had also failed from the plowed-disked treatment. The other grasses continued to produce good stands.

On the disked seedbed, fair to excellent stands were established in the seedling year, but by 1963 most species had failed. Of those that survived, *Agropyron cristatum*, *A. intermedium*, *Festuca ovina*, and *Poa bulbosa* appeared best adapted.

Of the legumes *Medicago falcata* and *Melilotus officinalis* established good stands, but by 1963 had failed. In the row plots (table 31) *Lotus* spp. established a good stand of seedlings the first year but died out from winterkill by the second season. *Trifolium subterraneum* established a poor stand the first year and died out the second, while *Astragalus rubyi* and *Sanguisorba minor* completely failed. With the exception of *A. rubyi*, *S. minor*, and *T. subterraneum*, most species produced good stands in the

TABLE 30.—*Species e-tablishment from broadcast seeding near Plains, Mont.*

Species	Ratings of stand [1]			
	Plowed-disked seedbed		Disked seedbed	
	1948	1963	1948	1963
Festuca ovina duriuscula	10	10	10	10
Poa bulbosa	10	10	10	10
Agropyron cristatum	8	9	5	8
A. intermedium	8	9	5	5
Phleum pratense	10	5	8	1
Poa ampla	8	5	9	1
Agropyron trichophorum	9	1	8	1
A. inerme	5	5	4	1
Bromus erectus	9	9	5	0
B. inermis (Lincoln)	9	9	6	0
B. inermis (Manchar)	10	9	6	0
Agropyron trachycaulum	9	0	7	0
Arrhenatherum elatius	8	0	3	0
Medicago falcata	7	1	5	0
Melilotus officinalis	7	0	6	0
Elymus junceus	6	0	3	0

[1] Rating on scale of 0 to 10 where 0 = failure, 10 = 100 percent stand.

TABLE 31.—*Species establishment in row plots near Plains, Mont.*

Species	Stand 1948	Stand 1963
	Pct.	*Pct.*
Alopecurus arundinacea	95	0
A. pratensis	90	0
Poa stenantha	90	0
Lotus spp.	90	0
Agropyron elongatum	85	0
Stipa viridula	85	0
Eragrostis curvula	80	0
Phleum phleoides	80	0
P. boehmeri	60	0
Trifolium subterraneum	5	0
Sanguisorba minor	0	0
Astragalus rubyi	0	0

first seedling year. By 1963, however, all row-planted species had failed.

Hot Springs

Study location.—Located near Hot Springs, Sanders County, T. 21W., R. 24W. (location 29, fig. 10).

Elevation.—3,000 feet.

Average precipitation.—Annual, 11 inches; April to September, 40 percent.

Soil.—Clay loam.

Topography.—1-percent slope to the south; surrounding areas are hummocky.

Type of vegetation.—Intermountain valley grassland.

Dominant and associated species.—Agropyron smithii, A. spicatum, Bromus tectorum and *Artemesia tridentata.*

Study.—Hot Springs yield study.

Date planted.—1953.

Procedures.—Nine grasses were seeded with three replications per species in a randomized block design. Plots were 3 by 20 feet with three rows spaced 1 foot apart.

Summary of results.—Yields in 1954 were low for all species: *Agropyron desertorum,* however, produced the most herbage with over 600 pounds per acre. In 1955 *A. desertorum* was again the highest yielding species with over 1,000 pounds per acre.

A. trichophorum was second highest with 980 pounds, and *Elymus junceus* third with over 650 pounds per acre (table 32). In the previous year, however, *E. junceus* produced only 34 pounds.

Polson

Study location.—Located 8 miles southwest of Polson, Lake County, at the scenic turnout above Kerr Dam, SW1/4 sec. 22, T. 22N., R. 21W. (location 30, fig. 10).

Elevation.—2,800 feet.

Average precipitation.—Annual, 15 inches; April-September, 59 percent.

Soil.—Gravel silt loam, hilly phase.

Topography.—3 to 5 percent slope to the south-southwest on the canyon rim above Flathead River.

Type of vegetation.—Intermountain valley grassland.

Dominant species.—*Artemesia frigida*, *Agropyron spicatum*, and scattered *Artemesia tridentata;* invaded by *Bromus tectorum*, *Agropyron repens*, and *Poa pratensis*.

Previous use.—Cultivated cropland; good stands of *Medicago sativa* were near the study plot.

Study.—Polson adaptation study.

Date planted.—May 6, 1958.

Procedures.—Seventeen species and varieties were planted in plots 4 by 20 feet with four rows per plot spaced 1 foot apart. Plots were spaced 2 feet apart in four randomized blocks. Seeds

TABLE 32.—*Herbage yield of species near Hot Springs, Mont.*

Species	Herbage yield per acre, oven-dry weight 1954	1955
	Lbs.	*Lbs.*
Agropyron desertorum (Nordan)	639	1,038
A. trichophorum	310	973
A. elongatum	397	726
Elymus junceus	34	653
Bromus inermis	140	559
Medicago sativa	38	534
Agropyron intermedium	253	501
Bromus carinatus	242	284
Festuca arundinacea (Alta)	53	254

were drilled at 30 seeds per foot except for small-seeded species that were seeded at a minimum of 4 pounds per acre. The seedbed was cultivated before seeding, and at time of seeding was dry to 4 inches or more.

Summary of results.—By 1963 most of the species had established stands and were rated as follows:

Species	*Stand percent in 1963*
Agropyron intermedium	99
Bromus inermis (Lincoln)	98
Dactylis glomerata (Potomac)	92
Agropyron desertorum (Nordan)	91
Bromus inermis (Manchar)	91
Agropyron elongatum	90
A. trachycaulum	88
Alopecurus pratensis	86
Agropyron desertorum (Standard)	77
Festuca arundinacea (Alta)	76
Poa ampla (Sherman)	74
Agropyron trichophorum	61
Phleum pratense (Hopkins)	46
Elymus junceus	42
Medicago falcata (Ladak)	20
Arrhenatherum elatius	5
Lotus corniculatus	0

Lotus corniculatus was the only one that failed completely. Stands of *Arrhenatherum elatius* were poor.

Although stands of *Medicago falcata* were also poor, this species appeared adapted since plants were all at one end of the rows where that part of the plot would have been rated at near complete stands. The area seemed to have been sprayed with herbicides. This spraying would account for the appearance of the alfalfa plot and possibly for the complete loss of *L. corniculatus*. This assumption is made also since a good field of alfalfa was growing near the study site.

Grasses that were especially well adapted to the site were *Agropyron desertorum* (Nordan), *A. elongatum*, *A. intermedium*, *A. trachycaulum*, *Alopecurus pratensis*, *Bromus inermis* (Lincoln and Manchar), and *Dactylis glomerata*. Others that established good stands were *Agropyron desertorum* (Standard), *A. trichophorum*, *Festuca arundinacea* (Alta), and *Poa ampla* (Sherman), while stands of *Elymus junceus* and *Phleum pratense* (Hopkins) were fair.

Creston

Study location.—Located at the Northwestern Montana Experiment Station at Creston, Flathead County, sec. 15, T. 28N., R. 20W. (location 31, fig. 10).

Elevation.—2,900 feet.

Average precipitation.—Annual, 18 inches; April-September, 53 percent.

Soil.—Creston, Flathead, Blanchard silt loams.

Topography.—1 percent slope to the south.

Type of vegetation.—Intermountain valley grassland with scattered *Pinus ponderosa* in savannah grassland.

Dominant and associated species.—*Festuca idahoensis, Agropyron spicatum, Poa compressa, Pinus ponderosa; Poa pratensis* is a dominant introduced species.

Previous use.—Cultivated farm crops.

Study.—Creston herbage yield study.

Date planted.—May 1949.

Procedure.—Six grasses and alfalfa were seeded in pure stands and in simple grass-alfalfa mixtures on dryland and under irrigation. Plots were 5 by 24 feet. Rows were 12 inches apart in dryland plantings and 6 inches in irrigated plantings. The hay was harvested from 1950 to 1953. In this study the yearly totals and the 4-year average from the dryland are given. Only the 4-year average from the irrigated study is given for comparison.

Summary of results.—Alfalfa and alfalfa-grass mixtures produced considerably more than the grasses alone (table 33), but differences in yield among the alfalfa-grass mixtures or among the grasses were small. With the exception of *Agropyron desertorum*, the grasses in pure stands produced better under irrigation over the 4 years than they did on dryland. Alfalfa, however, and the alfalfa-grass mixtures produced much better yields on dryland. Two cuttings of hay were made on the alfalfa and alfalfa-grass plots, while the grasses alone produced only one cutting.

All the grasses produced their highest in 1950 (second growing season), while alfalfa alone and the alfalfa-grass mixtures continued to increase their yields each year of the study. This yearly decline in production of the grasses indicates the possibility of soil-nitrogen deficiencies.

Study.—Creston grass seed yields.

Date planted.—May 1949.

TABLE 33.—*Herbage yields of forage species from dryland and irrigated plots at Creston, Mont., 1950-53*

Species	Yield per acre				Average	
	1950	1951	1952	1953	Dryland	Irrigated
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Single species:						
Medicago falcata	7,354	7,467	8,412	9,132	8,029	3,720
Festuca arundinacea (Alta)	3,100	2,654	3,054	2,949	2,939	4,460
Agropyron desertorum (Standard)	3,457	2,365	2,568	3,131	2,880	2,640
Bromus inermis (Manchar)	2,592	1,679	1,633	1,962	1,966	3,960
Phalaris arundinacea	2,538	1,645	1,470	1,815	1,867	2,280
Dactylis glomerata	3,346	1,373	1,543	1,112	1,843	3,500
Phleum pratense (Hopkins)	3,015	1,202	1,584	1,554	1,838	3,600
Mixtures:						
Mefa and Phpr	7,115	7,153	9,043	9,506	8,204	4,940
Mefa and Agde	6,962	7,929	8,644	9,166	8,175	4,620
Mefa and Brin	6,974	7,180	8,440	9,597	8,048	5,580
Mefa and Fear	6,432	7,492	8,685	9,302	7,978	5,160
Mefa and Phar	7,189	7,430	8,399	8,555	7,893	5,600
Mefa and Dagl	6,367	6,853	8,281	8,440	7,485	5,540

Procedures.—Fifteen grasses were seeded on dryland and irrigated land. Plots were 9 by 20 feet with three rows per plot spaced 3 feet apart. Plots were replicated four times in a randomized block design.

Seed was harvested from 1950 to 1953 by sampling the center row of each plot. In this study the yearly yields and the 4-year average from the dryland area are given and only the 4-year average from the irrigated land for comparison.

Nitrogen fertilizer at 50 pounds N per acre was applied to both the dryland and irrigated plots on April 30, 1952.

Summary of results.—Seed yields, generally, were highest in the second growing season for all species; they declined in the succeeding years (table 34). For most grasses their dryland yields were about equal to their irrigated yields. The nitrogen fertilizer applied in 1952 appeared to only slightly increase seed yields for a few species.

TABLE 34.—*Grass seed yields at Creston, Mont.*

Species	Yield per acre				Average	
	1950	1951	1952	1953	Dryland	Irrigated
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Agropyron desertorum	1,134	486	735	628	746	682
Festuca arundinacea (Alta)	499	643	1,098	479	680	578
Bromus inermis (Manchar)	762	450	590	241	511	347
B. marginatus	420	257	699	588	491	306
B. erectus	712	383	308	68	368	572
Arrhenatherum elatius (Tualatin)	411	370	299	330	352	430
Agropyron intermedium	468	399	200	305	343	320
Festuca rubra	198	230	172	234	208	442
Dactylis glomerata	232	121	247	74	168	276
Agropyron spicatum	200	113	141	14	117	154
Phalaris arundinacea	40	93	91	25	62	137
Elymus junceus	136	131	20	38	81	58
Poa ampla	---	---	---	---	[1]	266
Agrostis tenuis	---	---	---	---	[1]	207
Poa pratensis (Troy)	---	---	---	---	[1]	42

Eureka

Study location.—Located 1 mile north of Eureka, Lincoln County, Mont., T. 36N., R. 27W. (location 32, fig. 10).

Elevation.—2,600 feet.

Average precipitation.—Annual, 17 inches; April-September, 50 percent.

Soil.—Gravelly loam.

Topography.—Benchland with 2 percent slope to the south.

Type of vegetation.—Intermountain valley grassland.

Dominant species.—Agropyron spicatum, Festuca idahoensis, and *Poa compressa; Bromus tectorum* is an invading species.

Previous use.—Cropland.

Study.—Eureka herbage yield study.

Date planted.—1950.

Procedures.—Forty-two grasses were planted in plots 3 by 20 feet with three rows per plot spaced one foot apart. The seeding treatments were replicated three times in a randomized block design. Species planted were: *Agropyron cristatum, A. desertorum* (Standard, Nordan, and M 24-3), *A. elongatum, A. inerme, A. intermedium, A. sibiricum, A. smithii, A. spicatum, A. subsecundum, A. trachycaulum, A. trichophorum, Agrostis alba,* *Alopecurus pratensis, Arrhenatherum elatius, Bouteloua curtipendula* (Commercial and El Reno), *B. gracilis, Bromus erectus, B. inermis* (Lincoln), *B. marginatus, Dactylis glomerata, Elymus canadensis, E. glaucus, E. junceus, E. triticoides, Festuca arundinacea, F. elatior, F. ovina, F. rubra, Oryzopsis hymenoides, Panicum virgatum, Phalaris arundinacea, Phleum pratense* (Commercial and Hopkins), *Poa ampla* (Sherman and Robust), *P. bulbosa, P. compressa, P. pratensis,* and *Stipa viridula.*

Summary of results.—Only eight species produced stands and yields sufficient to harvest. In 1954, *A. intermedium* was the highest yielding species with over 2,800 pounds per acre. Second highest was *A. trichophorum* with 1,990 pounds per acre. Other species that appeared adapted were *A. desertorum, A. trachycaulum, A. pratensis, A. elatius, B. erectus,* and *B. inermis.*

Study.—Eureka adaptation planting.

Date planted.—May 5, 1955.

Procedures.—Fourteen grasses and three legumes were seeded with a grain drill in plots 10 by 150 feet. At time of planting the seedbed was loose but moist.

Summary of results.—By 1958 most grasses had established fair to good stands. Those that had established good to excellent stands were *Agropyron desertorum* (Standard and Nordan), *A. inerme, A. sibiricum, A. trachycaulum, A. trichophorum,* and *Bromus inermis.* Stands of *Lotus corniculatus, Medicago sative, Agropyron intermedium, A. smithii, Dactylis glomerata, Elymus junceus, Poa ampla,* and *Stipa viridula* were fair, while those of *Astragalus falcata* and *Agropyron elongatum* were poor.

Palatability ratings, based on estimated utilization by cattle, showed *Bromus inermis* and *Agropyron desertorum* (Standard) to be the most preferred, while *Astragalus falcata, Agropyron smithii, Poa ampla,* and *Stipa viridula* were the least preferred. Significant difference in preference was observed between the two varieties of *A. desertorum* with Standard being one of the more preferred plants, but Nordan was one of the less preferred.

Rexford

Study location.—Located near Rexford, Lincoln County, SW1/4 sec. 17, T. 37N., R. 27W. (location 33, fig. 10).

Elevation.—2,500 feet.

Average precipitation.—Annual, 18 inches; April-September, 45 percent.

Soil.—Gravelly loam.

Type of vegetation.—Intermountain valley bottom land.

Dominant and associated species.—*Agropyron spicatum*, *Bromus tectorum*, and species of *Stipa* and *Poa*.

Previous use.—Abandoned cropland.

Study.—Rexford adaptation planting.

Date planted.—September 19, 1944, and April 5, 1945.

Procedures.—The seedbed was prepared by plowing in the fall of 1944. The spring seeding was also harrowed before seeding. Twelve grasses were planted in plots with 12 inches between rows.

Summary of results.—Six years after planting most species had established good stands. Those that appeared well adapted were *Agropyron desertorum*, *A. inerme*, *A. smithii*, *A. trachycaulum*, *Bromus inermis*, *Elymus junceus*, *Festuca arundinacea*, *Poa bulbosa*, and *Dactylis glomerata*. Species that did not establish good stands were *Agropyron sibiricum*, *Arrhenatherum elatius*, and *Festuca elatior*. Since data on initial establishment are not known, these three species may or may not be adapted. Nevertheless they also failed in plantings at Eureka, a short distance away.

Establishment was better from spring seeding than from fall seeding, although good stands of most species were obtained from the fall seeding.

Foothill Sagebrush Rangeland

This type of vegetation is often associated with or adjacent to valley bottom lands located primarily in southwestern Montana. It often forms a distinct zone of vegetation between the foothill grasslands and the forest types with which it may be intermixed. It comprises approximately 2,832,000 acres in Montana.

Elevation ranges from 4,000 to 7,000 feet where the growing seasons vary from 30 to 135 days, and precipitation varies from 12 to 20 inches per year.

The soils are moderately dark to black loams varying in depth from shallow and rocky to deep.

Artemesia tridentata is the dominant shrubby species, with *Agropyron spicatum* and *Poa secunda* dominant grasses. Species of *Chrysothamnus*, *Phlox*, *Eriogonium*, and *Mertensia* are often found in associations. On the more moist clayey sites, *Agropyron smithii* and *Festuca scabrella* are important species; at the higher elevations *Festuca idahoensis* is dominant. Much of the drier sandy sites that have been overgrazed or cultivated and abandoned have been invaded by *Bromus tectorum.*

Where water is available and soils are not too rocky, the sagebrush rangelands are being cultivated. Heavy grazing, particularly in the spring, has deteriorated much of the remaining area, and remnant grasses are found only where they are protected by sagebrush or rock. Areas that remain in sagebrush are generally nonirrigable. These nonirrigable areas have good production potential and are relatively easy to seed. Thousands of acres of this type have already been treated either by being sprayed for brush control or being plowed and seeded.

Although much of the revegetation work has involved seeding, other methods of range improvement should be considered before plowing. Artificial seeding requires plowing first to remove competition from sagebrush and other native species. This plowing, however, leaves the site unprotected and open for wind and water erosion and invasion from weedy species.

Where stands of native grasses are sufficient to recover and revegetate the site, deferred grazing, change in season of grazing, or control of brush by herbicides or fire combined with controlled grazing may improve the range and increase forage production.

Studies at Dry Fawn Bench indicate that burning in the fall and rotobeating each gave 95 percent kill of mature sagebrush. These two methods and fall burning followed by planting to *Agropyron desertorum* were also slower to be reinvaded by sagebrush. Although disking gave good initial sagebrush kill, reinvasion by sagebrush was rapid. Six years following the disk and seed treatments, the area that was covered by sagebrush was similar to the nontreated plots. At Coyote Flat, burning, rotocutting, rototilling, disking three times, and repeat spray treatments all gave sagebrush control of over 90 percent. Reinvasion by sagebrush was greater after rototilling or disking than after treatments that did not disturb the soil surface. Seeding *Elymus junceus* after rototilling or disking appeared to reduce sagebrush invasion.

Where artificial seeding appears advisable, thorough preparation of the seedbed is essential. At Dry Fawn the success of seedling establishment was directly related to the percentage of sagebrush killed and competition removed. Establishment following a single disking treatment averaged 28 percent stand. Double disking increased establishment to 49 percent, and triple disking, to 64 percent.

Planting by drilling has been more successful than by broadcasting, particularly on the drier sites.

Species that have appeared well adapted to the sagebrush rangeland type include *Agropyron desertorum*, *A. intermedium*, *A. trichophorum*, *Bromus erectus*, *B. inermis*, *Festuca ovina duriuscula*, *Poa ampla*, and *Elymus junceus*. At the more moist sites *Lotus corniculatus*, *Medicago falcata* (Ladak), *Dactylis glomerata*, *Phleum pratense*, *Poa pratensis*, *Arrhenatherum elatius*, and *Poa compressa* also appear well adapted. *Melilotus officinalis* produces good initial stands but is often lost unless allowed to reseed.

Following brush removal or artificial seeding, the area must be protected. This has been repeatedly demonstrated and is essential for successful seeding or for the reestablishment of desirable native grasses.

Dry Fawn Creek

Study location.—Located on a bench between Dry Fawn Creek and south fork of Fawn Creek, of the Ruby River drainage, Madison County, SW1/4, sec. 20, T. 10S., R. 3W. (location 34, fig. 10).

Elevation.—7,200 feet.

Average precipitation.—Annual, 15 to 16 inches; April-September, 75 percent.

Soil.—Well-developed sandy loam interspersed with sandstone fragments.

Topography.—8 to 10 percent slope to east-northeast.

Type of vegetation.—Foothill sagebrush rangeland.

Dominant and associated species.—*Artemesia tridentata*, *Festuca idahoensis*, *Poa ampla*, *P. secunda*, *Agropyron dasystachyum*, *Stipa columbiana*, *Koeleria cristata*, *Geum trifolium*, and species of *Achillea*, *Ranunculus*, *Carex* and *Geranium*.

Previous use.—Rangeland, summer grazed by cattle and game.

Study.—Dry Fawn seedbed preparation and adaptation plantings.

Date planted. — May 16-17 and June 14, 1951.

Procedures.—Treatments included planting 13 grasses at two rates on seedbeds prepared by disking at three intensities. Treatments were randomly located within two blocks. Individual plots were 15 by 58 feet.

The seedbed was plowed with a 1,400-pound 6-foot offset disk loaded with 700 pounds of ballast. The single-disk treatment was plowed to a depth of 3 to 4 inches, which killed 50 to 75 percent of the sagebrush. Double or triple disking was in the same direction.

The quantity of seed planted varied among species depending on the size and quality of the seed. Seeds were broadcast with a cyclone hand seeder and left uncovered except for a brush-dragged strip 28 feet wide running across the center of one block.

Summary of results.—Herbage yields were taken on September 15, 1952, and in October 1954. Differences in yields among species were highly significant in 1952 but were not significant in 1954.

Differences in yields as affected by treatments were highly significant (table 35). In 1952, yields were similar from the double-disked, double-seeded and triple-disked, single-seeded plots; however, variation in species was considerable. Double-disking, double-seeding favored production of some species, while triple-disking, single-seeding favored others. Yields from

TABLE 35.—*Herbage yields of grasses as affected by methods of treatment on sagebrush rangeland at Dry Fawn, 1952 and 1954*

Species	Yield per acre from 3 seeding treatments [1]				
	Single-disked, single-seeded		Double-disked, double-seeded	Triple-disked, single-seeded	
	1952	1954	1952	1952	1954
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Bromus inermis (Lincoln)	168	1,237	1,743	1,767	2,804
Arrhenatherum elatius	283	1,592	1,148	980	2,449
Agropyron trachycaulum	672	1,102	1,556	2,795	2,322
Bromus erectus	302	1,037	816	1,061	2,295
Agropyron trichophorum	398	2,144	1,902	941	2,292
Festuca ovina duriuscula	274	1,736	1,575	1,594	2,245
Agropyron intermedium	1,220	2,144	3,088	2,521	2,183
Dactylis glomerata	855	797	2,218	2,113	2,082
Elymus junceus	38	1,289	134	485	1,960
Agropyron desertorum	130	886	898	1,320	1,719
Stipa viridula	86	1,078	336	418	1,606
Agropyron smithii	106	1,083	1,354	749	1,587
Poa ampla	38	800	192	1,263	1,107
Average	352	1,302	1,304	1,384	2,050

[1] Least significant difference at 5 percent level among seeding treatments in 1952 = 282 pounds per acres and in 1954 = 579 pounds per acre.

single-disked, single-seeded plots were considerably below those of the more intensively prepared plots.

In 1956, average differences among seeding treatments favored establishment following the more intensive disking operations (table 36). *Bromus inermis* (Lincoln), *B. erectus*, *Agropyron intermedium*, *A. trichophorum*, and *Festuca ovina* appeared well adapted for seeding under the soil and climatic conditions of this study, and the importance of brush control to eliminate competition from native vegetation was clearly indicated.

Study.—Dry Fawn Creek sagebrush control planting.

Date planted.—July 17 and October 1, 1951.

Procedures.—In 1951 10 control treatments were applied on a mature stand of *Artemesia tridentata*. Plots, 30 by 80 feet, were replicated twice. On July 17, 1951, plots were sprayed with 2,4-D at 3 pounds of acid equivalent per acre. All seeded plots were broadcast with *Agropyron cristatum* at 18 pounds per acre.

TABLE 36.—*Establishment of grass species on sagebrush rangeland as affected by seedbed preparation and seeding rates at Dry Fawn, 1956*

Species	Stand of grasses from 3 seeding treatments		
	Single-disked, single-seeded [1]	Double-disked, double-seeded [2]	Triple-disked, single-seeded [3]
	Pct.	*Pct.*	*Pct.*
Agropyron intermedium	50	90	93
Bromus inermis (Lincoln)	63	90	93
Agropyron trichophorum	30	70	80
Festuca ovina duriuscula	63	88	80
Bromus erectus	25	70	78
Poa ampla	18	10	65
Agropyron trachycaulum	10	10	63
Arrhenatherum elatius	10	83	63
Agropyron desertorum	28	48	60
A. smithii	30	50	53
Dactylis glomerata	23	13	40
Stipa viridula	5	15	33
Elymus junceus	5	3	30
All species	28	49	64

[1] 35 percent stand of live sagebrush.

[2] 25 percent stand of live sagebrush.

[3] 15 percent stand of live sagebrush.

Summary of results.—In 1955 the percent kill and percent cover of *A. tridentata* and herbage utilized by cattle was estimated (table 37). The herbage utilized correlated directly with the percent *A. tridentata* cover and decreased as brush cover increased. The percentage of utilization recorded for the sprayed-seeded treatment appears to be extremely low and out of line with the other values.

A. tridentata reinvasion was estimated in 1956. Brush plants were counted in 1957, and the area covered by *A. tridentata* was measured for total brush density. The 1957 measurements compare closely with the estimated values for 1956.

Differences among treatments on the total brush density were highly significant, but reinvasion of *A. tridentata* seedlings was not significant. Fall-burning combinations, however, apparently gave better control and reduced reinvasion. Spring-burning and spring-disking treatments apparently favored reinvasion or did less to reduce it.

Gopher activity was extensive in open areas and under mature plants, especially on burned plots, and reinvasion by *A. tridentata* was correlated to the extent of gopher activity. Brush seed-

TABLE 37.—*Brush kill, cover, and reinvasion of sagebrush from control treatments made in 1951 and their effect on subsequent herbage production and utilization by cattle*

Treatment	Brush kill	Plants per 100 sq. ft.	Area covered	Utilized by cattle 1955	Yield per acre, 1952
	Pct.	*No.*	*Pct.*	*Pct.*	*Lb.*
Spring-burned, disked-seeded	83	[1] 38	18	60	2,601
Sprayed-seeded	80	7	15	18	1,362
Sprayed	50	[1] 26	20	35	1,311
Spring-disked, seeded	65	[1] 23	35	50	1,191
Fall-burned	95	[1] 12	7	40	867
Fall-burned, seeded	95	6	3	18	612
Rotobeat	95	7	5	[2]	444
Untreated	0	9	36	5	430
Untreated, seeded	0	9	34	8	317
Summer-burned	30	9	29	23	[2]
Summer-burned, seeded	40	[1] 14	25	20	[2]

[1] Primarily seedlings under 6 inches tall.
[2] Not determined.

lings were few and small on unbroken sod, while on gopher mounds the seedlings were numerous and thrifty. The percentage of grass cover was also more directly affected by gopher mounds and burrows than by brush cover.

In 1957 the entire area was grazed by cattle. Although the grass cover was about the same for all plots, the forage was utilized inversely proportionate to the density of sagebrush.

Diamond

Study location.—Located along the Ruby River road about 4 miles below the Vigilante Experimental Range Headquarters, Beaverhead National Forest, Madison County, sec. 17, T. 9S., R. 3W. (location 35, fig. 10).

Elevation.—6,200 feet.

Average precipitation.—Annual, 13 inches; April-September, 77 percent.

Soil.—Loam.

Topography.—3 percent slope to the northwest; alluvial fan close to the foothills.

Type of vegetation.—Foothill sagebrush rangeland.

Dominant and associated species.—*Agropyron smithii*, *Stipa comata*, *Salsola kali*, and species of *Chrysothamnus*, *Poa*, and *Phlox*.

Previous use.—Road right-of-way used for livestock drive trail in spring and fall.

Study.—Diamond demonstration planting.

Date planted.—September 28, 1939.

Procedures.—Before seeding, one-half of the area was double-disked with a heavy cut-out disk. Four species of grass were broadcast with a cyclone seeder in strips across the seedbeds, (both nonprepared). An exclosure was established to protect part of the area while part of each treatment was left unprotected.

Summary of results.—During the first year of establishment, stands were not evaluated. In the second year all species had poor stands, and *Agropyron cristatum* had failed completely. In 1943, the fourth year, *Arrhenatherum elatius*, *Bromus carinatus*, and *B. inermis* maintained fair stands inside the exclosure with only a few plants on the grazed area. Fair stands of *A. elatius* under protection continued through 1946.

Although none of the treatments were considered very successful, the study demonstrated the necessity of preparing an adequate seedbed and controlling grazing.

Timber Creek

Study location.—Located along a secondary road on Timber Creek several hundred feet north of the main road of the Ruby River, Beaverhead National Forest, Madison County, sec. 17, T. 9S., R. 3W. (location 35, fig. 10).

Elevation.—6,100 feet.

Average precipitation.—Annual, 13 inches; April-September, 77 percent.

Soil.—Clay loam, stoney phase.

Topography.—30 to 45 percent slope to the east.

Type of vegetation.—Foothill sagebrush rangeland.

Dominant and associated species.—*Artemesia tridentata*, *Agropyron smithii*, *Oryzopsis hymenoides*, and species of *Chrysothamnus*, *Phlox*, and *Juniperus*.

Previous use.—Overgrazed rangeland heavily trampled by cattle.

Study.—Timber Creek adaptation planting.

Date planted.—September 29, 1939.

Procedures.—Seven grasses and two mixtures were planted by broadcasting with a cyclone seeder in plots 15 by 200 feet. The seed was not covered. Before seeding, part of each plot was double disked with a cut-out disk.

Summary of results.—The area was heavily grazed and trampled by cattle before and after planting. Nevertheless, several species became established and competed successfully with the natives (table 38). In the second year *Agropyron pungens*, *Dactylis glomerata*, and *Melilotus officinalis* established the best stands. The next year *M. officinalis* and *Bromus carinatus* were present only as traces. By 1946, the seventh year, *A. pungens* and *Poa compressa* had developed relatively good stands, and *Bromus inermis* and *Dactylis glomerata* had also increased to fair stands.

Lewis Creek

Study location.—Located on the west side of the Ruby River road about 0.3 miles northwest of Vigilante Experimental Range Headquarters, Beaverhead National Forest, Madison County, between the benchlands and the river bottom, sec. 28, T. 9S., R. 3W. (location 35, fig. 10).

Elevation.—6,200 feet.

Average precipitation.—Annual, 13 inches; April-September, 77 percent.

TABLE 38.—*Establishment of seeded species on deteriorated foothill sagebrush rangeland at Timber Creek*

Species	Stand ratings[1]		
	1941	1943	1946
Fair to good stands established or maintained for 7 years:			
Agropyron pungens	3	7	10
Poa compressa	0	4	10
Bromus inermis (Parkland)	1	6	7
Dactylis glomerata	4	6	6
Poor to fair stands established:			
Agropyron trichophorum	1	6	3
Medicago falcata	1	5	2
Arrhenatherum elatius	1	3	1
Melilotus officinalis	3	2	1
Agropyron cristatum	1	1	1

[1] Relative ratings where 1 = poor; 10 = excellent.

Soil.—Clay loam with pebble erosion pavement.

Topography.—8 to 35 percent slopes to the east and southeast.

Type of vegetation.—Foothill sagebrush rangeland.

Dominant and associated species.—*Koeleria cristata, Poa secunda, Agropyron smithii, A. spicatum, Artemesia tridentata,* and species of *Phlox*, *Selaginella* and *Chrysothamnus.*

Previous use.—Heavily grazed by cattle trailing to and from the Upper Ruby.

Study.—Lewis Creek gully control plantings.

Date planted.—May 1937 and October 1937.

Procedures.—Strips 66 feet wide were established through a fenced exclosure to about 30 feet outside the fence. The strips were treated at different dates as follows. Three gullies were also variously treated.

Strip 1 - May 25, 1937: Seven contour furrows were plowed with a hand plow and team. Furrows were 6 to 18 feet apart. *Agropyron desertorum* (Standard) was seeded by broadcasting then brush dragged to cover the seed.

Strip 2 - October 15, 1937: Five contour furrows were prepared as in strip 1. Four grass species, *A. cristatum, A. desertorum, Bromus carinatus,* and *Arrhenatherum elatius,* were broadcast along the furrows. The seed was not covered.

Strip 3 - May 25, 1937: *A. desertorum* was broadcast on unprepared seedbed. Following seeding, one-half of the area was single disked with a light 6-foot horse-drawn disk. The other half was double disked.

Strip 4 - October 12, 1937: One-half of the area was left untreated while the other half was seeded to *A. desertorum* and double disked as in strip 3.

Strip 5 - October 12, 1937: One-half of the area was left untreated, one-fourth was broadcast to *A. desertorum* and double disked. The other one-fourth was broadcast to *A. desertorum* but was not disked following seeding.

Strip 6 - October 15, 1937: Four contour furrows were plowed as in strip 1. Two furrows were seeded to *A. desertorum* (Standard), one to *A. cristatum* (Fairway), and one to *A. elatius*.

Strip 7 - May 25, 1937: Six contour furrows plowed as in strip 1. Two furrows were seeded to *A. elatius;* the rest were seeded to *A. desertorum.*

Strip 8 - October 12, 1937: *A. desertorum* was broadcast on unprepared seedbed. Following seeding part of the strip was double disked.

Strip 9 - May 25, 1937: *A. desertorum* was broadcast on unprepared seedbed. Following seeding part of the strip was double disked.

Strip 10 - Left untreated.

Gully 1 - October 14, 1937: Aspen and juniper were skidded into the gully bottom. Contour furrows were made by hand on the gully sides and seeded to seven species. Each species was seeded separately over four furrows. After seeding, the furrows were lightly raked to cover the seed.

Gully 2 - June 2, 1937: Treatment was the same as for Gully 1 except species were seeded over six furrows.

Gully 3 - Untreated.

Summary of results.—Seeding dates had little effect on seeding success. Although a few scattered plants became established, broadcasting on unprepared seedbeds without further treatment resulted in almost complete failure. Single disking after seeding gave some coverage of the seed and eliminated some competition from native species. This treatment resulted in fair stands of *A. desertorum* with about five plants per square yard. Double disking after seeding increased the success of the stand to about 15 plants per square yard.

Agropyron desertorum (Standard), *A. cristatum* (Fairway), *Arrhenatherum elatius*, *Bromus inermis*, and *Melilotus officinalis* were successful when seeded in contour furrows and maintained good stands through the next 12 years. *Oryzopsis hymenoides* and *Bromus carinatus* also established good stands, initially, but died out, and *Poa bulbosa* failed almost completely.

Clipping yields of *A. desertorum* on the double-disked areas indicate that forage production could be increased 65 percent, from 660 to 1,065 pounds per acre over that on untreated range after one growing season. Gullies were fairly well controlled by 1944. From 1937 to 1944 the gully area (cross section) increased slightly. However, the treated gullies had filled in at the bottom and sloughed off at the sides and appeared to be stabilizing.

Bear Gulch

Study location.—Located on the Horse Prairie drainage, Beaverhead National Forest, Beaverhead County, sec. 1, T. 11S., R. 14W. (location 36, fig. 10).

Site No. 1 = NE1/4SW 1/4 sec. 1
Site No. 2 = SE1/4NW1/4 sec. 1
Site No. 3 = W1/2SE1/4SE1/4 sec. 1

Elevation.—Approximately 7,500 feet.

Average precipitation.—Annual, 13 inches; April-September, 74 percent.

Soil.—Loamy with the "A" horizon 12 to 15 inches deep but rocky in places.

Topography.—Variable depending on site: (1) 20 percent slope to the southwest; (b) 10 percent slope to the northwest; (2) 20 percent slope to the east; (3) 5 to 8 percent slope to the northwest.

Type of vegetation.—Foothill sagebrush rangeland.

Dominant and associated species.–*Agropyron spicatum, Artemesia tridentata, Festuca idahoensis, Poa secunda,* and species of *Taraxacum* and *Ranunculus.*

Study.—Bear Gulch adaptation plantings.

Date planted.—September 27, 1949, and June 28, 1950.

Procedures.—Site No. 1: Two blocks of six plots of species, 8 by 25 feet, were seeded in September 1949. Block one (northwest slope) was previously in annual weeds. The seedbed was well prepared with an offset-disk harrow. Block two (southwest slope) was in sagebrush. The disk harrow removed an estimated 60 to 75 percent of the sagebrush. The six species were broadcast with a cyclone seeder. The seed was not covered after planting.

Sites No. 2 and 3: Before seeding in June 1950, the area was plowed with an offset disk to kill the sagebrush. Kill estimates varied from 50 to 95 percent. Nine species of grass and one mixture of all nine grasses were planted in 18- by 100-foot plots with plots running up and down the slope. The area was seeded using a cyclone seeder set at 12 to 15 pounds seed per acre. After broadcasting, a 10- by 10-foot area in the upper righthand corner of each plot was hand raked to cover the seed.

Summary of results.—By June 27, 1950, good stands of all seeded species were established in the northwest exposure plots of site No. 1. In the southwest exposure plots, establishment was less successful. *Festuca ovina* established a good stand, but other species were rated poor to fair. The poorer stands of the southwest exposure plots were attributed to the lower moisture content of the soil due to slope and exposure and to the difference in seedbed conditions at time of seeding. Live sagebrush plants and soddy clumps were left on the southwest plots, while the northwest plots were relatively free from perennial competition.

By September 1951, the plots had all been grazed destructively by cattle to the extent that many seedlings especially those in sites 2 and 3 had been trampled or pulled. Plots that had many seedlings in 1950 were comparatively bare in 1951. Despite the heavy use, *F. ovina* maintained nearly a full stand. *Dactylis glomerata* ranked second but was inferior to *F. ovina*. Only occasional plants of *Agropyron trichophorum*, *Poa ampla*, *Agropyron intermedium*, and *Arrhenatherum elatius* were also found.

Horse Prairie

Study location.—Located 9 miles west-northwest of Grant, Mont., on Coyote Flat, Beaverhead County, SW1/4 sec. 18, T. 9S., R. 13W. (location 37, fig. 10).

Elevation.—6,500 feet.

Average precipitation.—Annual, 8 to 9 inches; April-September, 82 percent.

Soil.—Gravelly loam with outcrops of rock.

Topography.—5 percent slope to the southeast.

Type of vegetation.—Foothill sagebrush rangeland.

Dominant and associated species.–*Artemesia tridentata*, *Agropyron spicatum*, *A. smithii*, *Poa secunda*, *Sitanion hystrix*, *Phlox hoodii*, *Phlox longifolia*, and species of *Chrysothamnus* and *Eriogonium*.

Previous use.—Overgrazed sagebrush rangeland.

Study.—Horse Prairie adaptation planting.

Date planted.—October 4, 1956, and June 6, 1957.

Procedures.—The seedbed was prepared by disking, piling and burning the sagebrush, and cultivating with a Planet Junior garden tractor. Twenty-six species were planted in 3- by 20-foot plots with three rows per plot spaced 1 foot apart. Fall and spring seedings for each species were made adjacent to each other. The study was in a randomized block-split-plot design with three replications.

Summary of results.—The species established better from the spring than from the fall planting.

Over a 6-year period, most of the grasses were able to maintain themselves or improve slightly (table 39). A few grasses decreased slightly, but *Agropyron trichophorum* and *A. elongatum* decreased sharply in 1961 and 1962. *Melilotus officinalis* died out completely following the second year of growth. *Dactylis glomerata* and *Festuca arundinacea* were also reduced markedly in 1960 and were completely lost by 1961. *Alopecurus arundinacea* and *Poa pratensis* also died out in 1961. *Medicago falcata* was sharply reduced in 1961 and completely died out in 1962. The heavy grazing by rabbits, particularly on the legumes, was a major cause for loss of stand. Of the grasses, *Festuca rubra*, *F. ovina*, and *D. glomerata* were the most heavily grazed by the rabbits. The *Agropyrons* were only moderately utilized.

Yields of herbage varied considerably among species and years. In 1959 and 1961 *Elymus junceus* was the highest yielding species, but in 1960 and 1962 it was surpassed by *Agropyron desertorum* and *A. intermedium*. Nevertheless, *E. junceus* continued to be one of the highest yielding species in all years.

Although ratings would indicate good stands, the herbage harvested from several of the species was extremely low. The low yields were attributed partly to grazing by rabbits. Low yields in 1961 were also attributed to an extremely dry season.

Yields of native grasses from adjoining areas were harvested for comparison.

Study.—Horse Prairie fertilization at time of seeding.

Date planted.—October 3, 1956.

Procedures.—The seedbed was prepared with a heavy disk that completely killed the mature sagebrush and destroyed most of the other native vegetation. Thirteen seeding treatments consisting of three grasses (*Agropyron desertorum, A. intermedium,* and *A. trichophorum*) and two legumes (*Medicago falcata* and *Melilotus officinalis*) alone and in mixtures were drilled through a rangeland drill to a 1-inch depth. Seeding depth was controlled by depth-band regulators.

TABLE 39.—*Establishment and herbage yield of forage species on foothill sagebrush rangeland at Horse Prairie*

Groups of species	Stand 1957	Stand 1962	Yields per acre, oven-dry weight, 1959-62
	Pct.	*Pct.*	*Lb.*
Good to excellent stands established and maintained for 6 years:			
Agropyron desertorum (Standard)	92	97	1,157
A. desertorum (Nordan)	92	95	1,357
A. intermedium	87	95	1,092
Elymus junceus	82	93	1,150
Bromus inermis (Lincoln)	70	90	926
B. inermis (Manchar)	80	90	768
Stipa viridula	43	70	619
Bromus erectus	65	60	370
Poa ampla	15	50	514
Native grasses	--	--	223
Fair stands maintained for 6 years:			
Alopecurus pratensis	46	40	531
Elymus triticoides	5	30	268
Festuca ovina duriuscula	30	30	231
Agropyron trichophorum	63	20	501
Fair to good stands maintained for 4 years failed by the 6th year:			
Agropyron elongatum	53	5	354
Festuca rubra	55	1	213
Phleum pratense	82	10	121
Medicago falcata (Ladak)	85	0	[1]
Dactylis glomerata	83	0	[1]
Festuca arundinacea	82	0	[1]
Poorly established or failed completely:			
Agropyron smithii	1	5	[1]
A. spicatum	1	1	[1]
Alopecurus arundinacea	30	0	[1]
Arrhenatherum elatius	15	1	[1]
Poa bulbosa	1	1	[1]
P. pratensis	33	10	[1]
Melilotus officinalis	82	0	[1]

[1] Data not available.

The study area was split with a fence for controlled grazing and further split with fertilizer applications so that one-half of each fertilized and nonfertilized plot could be grazed and the other half protected. Subplots 20 by 30 feet were replicated three times. Fertilizer was applied on October 4, 1956, by broadcasting after seeding using 50 pounds available N with 40 pounds P_2O_5 per acre. The unprotected plots were lightly grazed in the fall of 1958 and were grazed in a management program during June and July each year thereafter. The nonutilized herbage of both protected and grazed plots was mowed in the early spring to a 3-inch stubble.

Summary of results.—Generally, more grass but fewer legume seedlings established on the fertilized plots. Plant counts in 1959 and 1962, however, showed no significant response to fertilizers on the establishment of species or reinvasion of native grasses, forbs, or brush.

In 1959, yield responses to fertilizers were variable. Fertilizer apparently lowered the yield of *Agropyron desertorum* while increasing yields of *A. intermedium*. At the same time fertilizer seemed to increase the yield of grass and grass-legume mixtures except for the *A. trichophorum*-legume mixtures and the complete mixture. *A. trichophorum* returned the highest nonfertilized yield, while *A. intermedium* responded most favorably to fertilizers and gave the highest treatment yield.

In 1960, differences among species were highly significant with A. desertorum yielding the highest. Residual effects from fertilization gave significant increases in yields for all seeding treatments except simple grass-legume mixtures of *A. intermedium* and *A. trichophorum*.

The 1961 yields were low, and none of the seeding or fertilization treatments were significantly different. However, the nonfertilized treatments averaged slightly higher than the fertilized.

In 1962, yields were good with *A. desertorum* again the highest yielding species. Production on fertilized plots was higher than that on plots not fertilized except for the *A. trichophorum*-*Melilotus officinalis* mixture and the complete mixture, which averaged slightly higher on the nonfertilized plots.

Over the 4 years (1959-62), fertilizer increased average grass production from 100 to 175 pounds per acre per year (table 40). In mixtures with legumes, however, *A. intermedium*, *A. trichophorum*, and the complete mixture showed little or no increase from fertilizers.

TABLE 40.—*Herbage from fertilized and nonfertilized stands of seeded species on foothill sagebrush rangeland at Horse Prairie*

Item [1]	1959-62 yields per acre, oven-dry weight		Average herbage utilized
	Not grazed	After grazing	
	Lb.	*Lb.*	*Pct.*
Grasses			
Agropyron desertorum:			
Fertilized	944	399	58
Not fertilized	844	435	48
A. intermedium:			
Fertilized	778	186	76
Not fertilized	596	234	61
A. trichophorum:			
Fertilized	658	173	74
Not fertilized	547	179	67
Mixtures [2]			
A:			
Fertilized	897	375	58
Not fertilized	726	357	50
B:			
Fertilized	866	338	61
Not fertilized	748	394	47
C:			
Fertilized	861	401	53
Not fertilized	665	386	42
D:			
Fertilized	588	175	70
Not fertilized	597	157	74
E:			
Fertilized	740	174	76
Not fertilized	534	132	75
F:			
Fertilized	432	148	66
Not fertilized	396	207	48
G:			
Fertilized	380	126	67
Not fertilized	460	128	72
H:			
Fertilized	744	362	51
Not fertilized	758	450	41

[1] Fertilizer = 50 lb. N with 40 lb. P_2O_5 per acre.

[2] Mixtures were as follows: A = all 3 grasses; B = *Agropyron desertorum* + *Medicago falcata*; C = *A. desertorum* + *Melilotus officinalis*; D = *Agropyron intermedium* + *M. falcata*; E = *A. intermedium* + *M. officinalis*; F = *Agropyron trichophorum* + *M. falcata*; G = *A. trichophorum* + *M. officinalis*; H = all 3 grasses and 2 legumes.

The amount of forage consumed by livestock and the percent utilized, as affected by fertilizing, were determined from the differences in yield on the nongrazed and grazed plots. In general, on pure grass plots, more forage was utilized from the fertilized plots than from the nonfertilized ones. Exceptions to this occurred in 1959 with *A. desertorum* and in 1961 when cattle utilized more from the nonfertilized plot. In 1962, however, they grazed more forage from the fertilized treatments, and, on an average, grazed 150 to 250 pounds more forage each year from the fertilized than from the nonfertilized treatments.

The percentage of forage utilized varied considerably throughout the study period. In 1960, use of fertilizers appeared to increase the percentage of forage utilized. In 1961 and 1962 the percentage of forage utilized was nearly the same for both treatments. Over the 4 years, however, cattle utilized about 10 percent more of the fertilized than the nonfertilized herbage.

Study.—Horse Prairie plant succession following sagebrush control.

Procedure and results.—This study was incorporated into the sagebrush control study and into exclosures and pastures under grazing management to determine changes in vegetal composition of sagebrush rangeland following control treatments, seeding, and grazing management.

In the grazing management area, line transects were established in 1956 to determine the composition of the plant cover in the native state before treatment. The area was then disked and seeded through a rangeland drill to a mixture of five species; *Agropyron desertorum*, *A. intermedium*, *A. trichophorum*, *Medicago falcata*, and *Melilotus officinalis*. Permanent transects were established on the treated areas in 1958. Additional transects were established in 1960 on an area of adjacent seeding and spraying treatments. Readings were made with a 3/4-inch loop.

After 6 years of grazing deferment, plant composition showed increases in *Poa secunda*, *Sitanion hystrix*, *Agropyron spicatum*, *Carex* spp, *Phlox* spp, and litter with a decrease in gravel-sized pebbles. Other changes in composition were negligible (table 41).

In the area that was seeded and grazed, seeding treatments reduced *Artemesia tridentata* from 18.0 percent in 1956 to 4.5 percent in 1959. Most of the other native plants were also reduced. From 1959 to 1962, *A. tridentata* increased slightly. *A. desertorum* seeded in 1956 also increased from 15.2 percent

TABLE 41.—*Changes in vegetational cover as affected by grazing deferment, range seeding, and grazing management on sagebrush rangeland at Horse Prairie*

Component	Frequency of plant occurence				
	Pre-treatment, 1956	Deferred 1958	Deferred 1962	Seeded & grazed 1959	Seeded & grazed 1962
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Artemesia tridentata (alive)	18.0	20.0	18.2	4.5	5.8
A. tridentata (dead)	2.0	5.0	5.6	---	---
Agropyron spicatum	6.3	8.0	12.6	.2	---
Astragalus spp	.9	---	1.0	.1	---
Aster spp	.5	---	.5	.4	.1
Carex spp	.2	1.7	1.0	.1	.1
Chrysothamnus spp	.7	.7	1.2	1.0	.1
Eriogonium spp	.2	---	.2	---	.1
Mertensia spp	.2	---	---	---	---
Phlox hoodii	2.2	2.7	5.0	.2	.1
Phlox longifolia	2.0	2.3	5.0	2.0	3.2
Poa secunda	5.0	11.6	9.2	2.0	1.5
Sitanion hystrix	.1	.7	.6	.6	.2
Misc. natives	---	---	---	.7	.1
Gravel-sized pebbles	35.5	7.6	5.5	.2	.6
Rock	5.0	4.0	4.5	3.9	2.0
Bare ground	20.0	22.0	26.0	34.1	15.7
Litter	---	15.0	13.6	28.4	41.2
Agropyron desertorum	---	---	---	15.2	23.3
Agropyron intermedium	---	---	---	2.8	1.5
Medicago falcata	---	---	---	.3	---
Melilotus officinalis	---	---	---	2.0	.1

in 1959 to 23.2 percent in 1962, but *A. intermedium* decreased slightly. During the same period, litter increased while the percentage of bare ground decreased. Very little change occurred in the frequency of the other components.

The number of plants in 10 feet of row as affected by seeding and fertilizing changed markedly (table 42). From 1957 to 1962, numbers of seeded plants declined while native plants generally maintained themselves or increased in numbers. By 1962, both *M. falcata* and *M. officinalis* completely failed, and the seeded grasses lost up to 60 percent of their original stands. The loss in total numbers of seeded plants did not appear obvious in the stand since the surviving plants increased in size and compensated for the reduced numbers.

The native plants increased least on plots containing *A. deser-*

TABLE 42.—*Effect of seeding and fertilizing treatments on the establishment of seeded plants and on the reinvasion of natives*

(Values are for numbers of plants per 10 feet of row space)

Item [1]	Seeded plants						Native plants					
	Grass			Legume			Grass		Forbs		Sagebrush	
	1957	1959	1962	1957	1959	1962	1959	1962	1959	1962	1959	1962
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
Species												
Agropyron desertorum												
Fertilized	26	20	15	--	--	--	1	1	1	3	2	2
Not fertilized	31	20	14	--	--	--	1	1	1	4	1	2
A. intermedium												
Fertilized	18	14	10	--	--	--	3	4	1	3	3	3
Not fertilized	19	15	11	--	--	--	1	2	2	2	2	3
A. trichophorum												
Fertilized	13	13	9	--	--	--	2	3	1	2	2	3
Not fertilized	13	11	9	--	--	--	2	3	1	3	2	3
Medicago falcata												
Fertilized	--	--	--	12	10	0	3	3	3	5	3	6
Not fertilized	--	--	--	18	15	0	3	3	2	4	4	7
Melilotus officinalis												
Fertilized	--	--	--	11	7	0	3	3	1	4	3	7
Not fertilized	--	--	--	14	10	0	2	3	3	4	2	5

Footnotes at end of table.

TABLE 42. —*Effect of seeding and fertilizing treatments on the establishment of seeded plants and on the reinvasion of natives* — Continued

(Values are for numbers of plants per 10 feet of row space)

Item[1]	Seeded plants						Native plants					
	Grass			Legume			Grass		Forbs		Sagebrush	
	1957	1959	1962	1957	1959	1962	1959	1962	1959	1962	1959	1962
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
Mixtures[2]												
A:												
Fertilized	24	19	14	--	--	--	1	2	2	2	1	2
Not fertilized	20	18	14	--	--	--	1	2	1	3	3	3
B:												
Fertilized	33	18	13	3	2	0	1	1	0	1	2	2
Not fertilized	26	18	14	6	5	0	1	1	1	1	3	3
C:												
Fertilized	35	22	16	8	1	0	2	3	3	2	2	3
Not fertilized	26	18	16	10	1	0	2	3	3	2	2	3
D:												
Fertilized	19	15	14	1	3	0	1	2	2	3	2	3
Not fertilized	18	15	14	6	2	0	1	2	2	3	3	3
E:												
Fertilized	13	11	9	7	4	0	1	2	2	3	3	3
Not fertilized	11	11	8	8	5	0	1	1	2	3	4	4

F:												
Fertilized	12	9	9	4	2	0	2	1	2	3	3	4
Not fertilized	13	9	7	5	2	0	1	1	1	2	2	4
G:												
Fertilized	8	8	8	6	2	0	2	2	2	3	4	4
Not fertilized	6	7	8	4	3	0	2	2	4	3	5	5
H:												
Fertilized	19	15	13	3	2	0	2	2	1	3	2	2
Not fertilized	17	14	13	6	5	0	2	2	2	2	2	3

[1] Fertilizer = 50 lb. N and 40 lb. P_2O_5 per acre.

[2] Mixtures were as follows: A = all 3 grasses; B = *Agropryon desertorum* + *Medicago falcata*; C = *A. desertorum* + *Melilotus officinalis*; D = *Agropyron intermedium* + *Medicago falcata*; E = *Agropyron intermedium* + *Melilotus officinalis*; F = *Agropyron trichophorum* + *Medicago falcata*; G = *Agropyron trichophorum* + *Melilotus officinalis*; H = all 3 grasses and 2 legumes.

torum, and they increased most on plots that had been seeded to pure stands of legumes and where the legumes had died out. *A. tridentata* in particular reinvaded these plots in large numbers. Native forbs, largely *Phlox* and *Aster*, increased considerably from 1959 to 1962.

During early establishment, fertilizer appeared to increase the number of introduced grass seedlings. More legume plants, however, were on the nonfertilized plots. In the years that followed, the number of established seedlings were about the same regardless of fertilizer treatment. Fertilizers did not affect the reestablishment of the native plants.

Study.—Horse Prairie forage production following sagebrush control.

Date planted.—Spring 1958 to spring 1960.

Procedures.—The study consisted of 13 treatments that compared various methods of sagebrush control upon existing and succeeding vegetation and upon forage production. Plots 20 by 50 feet were replicated three times in a randomized block design. The entire area had been deferred from grazing since 1956.

Treatments were as follows:

Treatment	*Date of treatment*
Rotary-cut with horizontal brush cutter	4-17-58
Rototilled with commercial Roto-vator:	
At surface level	10-14-58
To 3-in. depth:	
Only	Do.
On 10-14-58; seeded to *Elymus junceus*	5-11-59
Disked with bush and bog harrow, 24-in notched disk:	
Once	5-7-59
Twice in opposite directions	Do.
Three times in opposite directions	Do.
Three times in opposite directions, 5-7-59: seeded to *Elymus junceus*	5-11-59
Sprayed with 2, 4-D Isopropyl ester 334 E at 2 lb acid per acre:	
Once	5-29-58
Repeat	Do. and 6-2-60
Fertilized at 400 lb available N per acre	4-8-60
Burned with hand-flame thrower	10-24-58
Check (no treatment)	

Elymus junceus seedings were planted in May 1959 through a Planet junior seeder in rows 12 inches apart. During the winters of 1959 and 1960, rabbits grazed the seedling plants to ground level.

Summary of results.—In 1960 the spray-repeat treatment produced the most herbage but was only significantly better than the disked twice, rototilled to 3-inch depth and seeded, and disked 3 times treatments (table 43).

In 1961 the disked three times and seeded treatment produced the most and was significantly better than all other treatments with the exception of the rototilled 3 inches deep and seeded, and the spray-repeat treatments. These three treatments were the only ones significantly better than the check.

In 1962, yields of all treatments averaged higher than the check with the two seeded treatments significantly above all others. The two spray and the burn treatments were also significantly above the check.

TABLE 43.—*The effect of control treatments on sagebrush kill, sagebrush reinvasion, and yield of forage species* [1]

Treatment	Kill of old sagebrush	Sagebrush seedlings per 100 sq. ft., 1962	Yield per acre, oven-dry herbage		
			1960	1961	1962
	Pct.	*No.*	*Lb.*	*Lb.*	*Lb.*
Rototilled, 3-in depth, seeded	99a	1c	209abc	521ab	1,800a
Disked 3 times, seeded	100a	3c	325abc	575a	1,400a
Sprayed 2, 4-D	48c	1c	430a	341cde	983b
Sprayed, repeated	92a	9bc	452a	414abc	967b
Burned	98a	4c	386ab	354bcd	933bc
Rotocut	95a	19b	420a	342cde	583bcd
Disked once	53c	3c	164abc	166ef	567bcd
Fertilized, 400 N per acre	0d	1c	276abc	226def	550bcd
Disked 3 times	93a	14bc	78c	96f	533bcd
Rototilled, 3-in depth	93a	37a	107bc	192def	517cd
Rototilled surface	93a	6bc	268abc	281cde	500cd
Disked twice	73b	8bc	112bc	190def	400d
Check	3d	3c	311abc	205def	300d

[1] Values in columns followed by the same letter are not significantly different.

The percentage of *A. tridentata* plants killed and the number of brush seedlings established after brush control were significantly affected by control methods (table 43). Disking three times with and without seeding, rototilling to the 3-inch depth with and without seeding, rotary cutting, rototilling at the surface level, burning, and spray-repeat treatments all gave good brush kills. All these treatments killed over 90 percent of the mature sagebrush. Disking once and spraying once did not give adequate control.

The greatest reinvasion by *A. tridentata* seedlings occurred on the plots rototilled to 3 inches deep and then left unseeded. Reinvasion was also high on plots rotocut and those disked three times without seeding. The lowest reinvasion was on the seeded plots and those treated by spraying, burning, light disking, and fertilizing.

The amount of bare ground and plant vigor were not statistically different among treatments. Nitrogen fertilizer, however, apparently increased the vigor of both the grasses and sagebrush as shown by their color and growth.

Shultz

Study location. —Located near Jackson, Mont. on benchland along the west side of the Big Hole Valley, Beaverhead County, NW1/4 sec. 23, T. 3S., R. 17W. (location 38, fig. 10).

Elevation.—7,000 feet.

Average precipitation. —Annual, 13 to 14 inches; April to September, 48 percent.

Soil.—Clay loam.

Topography.—Benchland with 5 percent slope to the northeast.

Type of vegetation.—Foothill sagebrush rangeland.

Dominant and associated species.—*Agropyron spicatum*, *Artemesia tridentata*, and *Poa secunda*.

Previous use.—Farmed.

Study.—Shultz adaptation nursery.

Date planted.—May 24, 1951.

Procedures.—Forty-two species of grass and 22 legumes were planted in 3- by 16-foot plots with three rows per plot. Rows were spaced 1 foot apart. Seeds were drilled with a belt-type hand seeder to a depth of approximately 1 inch. Seeding treatments were replicated three times in a randomized block design.

The original plan was to irrigate this study area. However, additional water was never applied. In 1959 this area was grazed extremely heavily by cattle.

Summary of results.—Fair stands of most grasses were established in the seedling year (table 44) with *Dactylis glomerata, Bromus inermis, Agropyron desertorum, Arrhenatherum elatius,* and *Festuca rubra* producing the best initial stands. Stands improved for most species during the next 2 years but generally they declined thereafter.

All species of *Medicago, Lotus,* and *Trifolium* established good initial stands, and except for *T. agrarium* and *T. fragiferm* maintained good stands as evidenced by their yields. Grasses that were able to maintain or improve their stands through the fifth growing season included *Agropyron desertorum, A. trichophorum, Agrostis tenuis, Alopecurus pratensis, Bromus erectus, B. inermis, Elymus junceus, Festuca arundinacea, F. elatior, F. ovina, F. rubra, Phalaris arundinacea, Phleum pratense, Poa ampla, P. compressa,* and *P. pratensis.* These species appeared well adapted.

Two groups of grasses maintained fair to poor stands by the fifth year but because of their relatively high production should not be ignored. Many of these species in other studies have appeared adapted. Groups IV and V include those species that are least likely to be adapted. Some of these, particularly *A. smithii* and *E. triticoides,* improved their stands from scattered plants to 10 percent stands in 5 years. Possibly they would have improved further given more time.

In 1954 several species yielded over 2 tons herbage per acre. These highest yielding grasses were *Agropyron desertorum* (M24-3), *Alopecurus pratensis, Bromus erectus, Elymus canadensis, Agropyron inerme, Phleum pratense, Bromus inermis* and *Agropyron sibiricum.* Highest protein content of the grass herbage was from *Poa pratensis* closely followed by *Festuca elatior, Agrostis tenuis, Dactylis glomerata, Bromus marginatus,* and *Stipa viridula.*

The highest yielding legumes included *Lotus corniculatus, Medicago sativa, Trifolium pratense,* and *T. hybridum.* Although *Melilotus alba* and *M. officinalis* established good stands initially, they died out. *Trifolium agrarium, T. fragiferum, Astragalus cicer, A. falcatus,* and *Oxytropis riparia* also failed. Protein content of all legumes was high with little, if any, difference between species or strains.

TABLE 44.—*Establishment and yield of herbage and protein from grasses and legumes planted on foothill sagebrush rangeland near Jackson, Mont.*

Species	Stand 1951	Stand 1955	Oven-dry herbage per acre yield, Aug. 1, 1954	Protein
	Pct.	*Pct.*	*Lb.*	*Pct.*
Good to excellent stands for 5 years:				
Bromus inermis (Lincoln)	73	100	4,200	6.1
Poa pratensis	60	100	2,680	9.4
Bromus erectus	67	97	5,540	6.7
Phleum pratense (Hopkins)	40	95	4,460	7.3
Agropyron trichophorum	60	93	1,940	5.8
Phleum pratense	43	88	4,960	5.5
Festuca rubra	70	85	2,220	5.0
F. elatior	67	83	1,340	8.6
F. ovina duriuscula	63	83	2,740	5.6
Elymus junceus	60	80	3,260	7.3
Agrostis tenuis	10	80	1,880	7.9
Phalaris arundinacea	23	67	4,160	6.5
Agropyron desertorum (Standard)	73	63	2,680	4.2
Festuca arundinacea	67	60	3,060	5.2
Medicago falcata (Ladak)	100	--	3,360	12.9
M. sativa (Sevelra)	98	--	5,240	14.3
M. sativa (Ranger)	98	--	4,700	13.3
Trifolium hybridum	97	--	4,700	14.0
Medicago sativa (Nomad)	95	--	3,560	13.6
Trifolium pratense	93	--	5,200	14.8
T. repens (White)	93	--	1,180	14.7
Lotus corniculatus (Cascade)	85	--	6,180	12.7
L. corniculatus (Tana)	80	--	4,560	13.9
Trifolium repens (Ladino)	80	--	1,980	15.7
Lotus corniculatus (Empire)	60	--	5,440	12.6
Established and maintained fair stands for 5 years:				
Agropyron intermedium	63	56	2,180	4.5
A. inerme	67	53	4,960	5.7
Poa ampla (Robust)	30	53	3,560	5.5
P. compressa	3	53	--	--
Alopecurus pratensis	40	52	5,800	6.1

TABLE 44. —*Establishment and yield of herbage and protein from grasses and legumes planted on foothill sagebrush rangeland near Jackson, Mont.* — Continued

Species	Stand		Oven-dry herbage per acre yield,	
	1951	1955	Aug. 1, 1954	Protein
	Pct.	*Pct.*	*Lb.*	*Pct.*
Agropyron desertorum (M24-3)	65	50	6,240	7.2
Elymus canadensis (Mandan)	25	49	5,200	5.5
Poa ampla (Sherman)	7	43	3,060	5.2
Agropyron cristatum (Fairway)	40	40	2,780	4.6
A. sibiricum	50	33	4,160	4.5
Dactylis glomerata	80	30	3,160	8.0
Relatively poor stands maintained but produced good yields:				
Stipa viridula	45	23	2,580	7.9
Fair to good stands initially established but failed in 5 years:				
Agropyron subsecundum	63	0	1,980	5.9
Arrhenatherum elatius	73	0	1,980	6.3
Bromus marginatus	57	0	840	7.9
Panicum virgatum	30	0	----	---
Melilotus alba (Huban)	100	0	----	---
M. officinalis	100	0	----	---
Trifolium agrarium	70	0	----	---
T. fragiferum	55	0	----	---
Poorly established or failed completely:				
Agropyron elongatum	17	2	----	---
A. smithii	3	10	----	---
A. spicatum	7	0	----	---
Agrostis alba	17	2	----	---
Bouteloua curtipendula	10	0	----	---
B. gracilis	17	0	----	---
Elymus glaucus	27	0	----	---
E. triticoides	0	10	----	---
Oryzopsis hymenoides	3	0	----	---
Poa bulbosa	17	3	----	---
Astragalus falcatus	23	0	----	---
Oxytropis riparia	0	0	----	---

Silver Bow

Study location.—Located along U.S. Highway 10S approximately 5 miles south of Butte, or 1 mile north of the mouth of Blacktail Creek Canyon, Silver Bow County, SE1/4, sec. 9, T. 2N., R. 7W. (location 39, fig. 10).

Elevation.—6,300 feet.

Average precipitation.—Annual, 12-13 inches; April-September, 68 percent.

Soil.—Sandy loam.

Topography.—2 to 3 percent slope to the southeast.

Type of vegetation.—Foothill sagebrush rangeland.

Dominant and associated species.—*Agropyron spicatum*, *A. smithii*, *Artemesia tridentata*, *A. frigida*, and *Chrysothamnus* spp.

Previous use.—Farmed; previously in rye, 1952; abandoned in 1953 and 1954.

Study.—Silver Bow adaptation nursery.

Date planted.—October 13, 1954, and May 1955.

Procedures.—Twenty-two species and strains were planted in three row plots with a belt-type seeder. Plots, 3 by 20 feet, were replicated three times in a split plot-randomized block design. The plots were split by fall and spring seeding treatments. Before seeding in the fall of 1954 the area was cultivated. Seedbeds received no further treatments before seeding in the spring of 1955.

Summary of results.—Initial stands were generally good for all species with spring seeding superior to the fall. By 1957, the third growing season, stands of *Agropyron smithii*, *Arrhenatherum elatius*, *Festuca arundinacea*, and *Phalaris arundinacea* had declined and appeared not adapted to the site, and by 1963 *Agropyron elongatum* and *Dactylis glomerata* also failed.

Species that improved or generally maintained their stands and appeared adapted included *Agropyron desertorum* (Standard and Nordan), *A. intermedium*, *A. trichophorum*, *Bromus erectus*, *B. inermis*, *Elymus junceus*, *Festuca ovina*, *F. rubra*, *Phleum pratense*, and *Poa compressa*. By 1963 *B. inermis*, *P. compressa*, and *Poa pratensis* had formed solid stands, while *A. desertorum* (Nordan), *Alopecurus pratensis*, *B. erectus*, *E. junceus*, *F. ovina*, and *P. pratense* formed stands of 90 to 95 percent (table 45). *P. compressa* and *F. ovina* appeared particularly well adapted and were found scattered throughout the study area.

The study area was grazed heavily by horses in the spring of 1963. Herbage around manure piles indicated a general nitrogen deficiency in the soil since the plants that received additional nutrients from the manure were vigorous and dark green, while plants in the surrounding area were light green to yellowish and produced relatively little herbage.

TABLE 45.—*Establishment and herbage yield of grasses planted in the spring on foothill sagebrush rangeland near Butte, Mont.*

Species	Stand 1955	Stand 1963	Herbage per acre (1957-58), oven-dry
	Pct.	*Pct.*	*Pounds*
Good stands established and maintained for 9 years:			
Bromus inermis	92	100	1,365
Poa compressa	88	100	1,075
Poa pratensis (Troy)	77	100	375
Agropyron desertorum (Nordan)	88	95	2,115
Festuca ovina duriuscula	91	95	1,020
Alopecurus pratensis	92	95	665
Phleum pratense	84	90	1,000
Bromus erectus	79	90	875
Elymus junceus	87	90	350
Poa ampla (Sherman)	82	75	1,150
P. ampla (Robust)	95	75	1,020
Agropyron intermedium	92	70	1,060
A. trichophorum	83	65	1,170
Festuca rubra	94	60	855
Fair stands established and maintained for 9 years:			
Agropyron desertorum (Standard)	80	50	1,370
A. inerme	92	40	455
Good stands initially established but failed within 9 years:			
Agropyron elongatum	87	1	890
A. smithii	62	0	40
Arrhenatherum elatius	94	0	520
Dactylis glomerata	90	0	640
Festuca arundinacea (Alta)	91	0	250
Phalaris arundinacea	91	10	220

Lennep

Study location.—Located approximately 3 miles southwest of Lennep, Meagher County, on benchland south of the road, sec. 3, T. 7N., R. 9E. (location 40, fig. 10).

Elevation.—5,600 feet.

Average precipitation.—Annual, 13 inches; April-September, 58 percent.

Soil.—Silty loam.

Topography.—Rolling foothill benchland with 2 percent slope to the northeast.

Type of vegetation.—Foothill sagebrush rangeland.

Dominant species.—*Artemesia tridentata*, *Poa secunda*, *Poa ampla*, and *Agropyron spicatum*.

Previous use.—Rangeland.

Study.—Lennep adaptation nursery.

Date planted.—October 12, 1951.

Procedures.—Forty-two species of grass were planted in plots 3 by 20 feet with three rows per plot spaced 1 foot apart. (The grasses planted were the same as those for the Shultz adaptation nursery, table 44). Seeding treatments were replicated three times in a randomized block design. Before seeding, the sagebrush cover was burned. Furrows were dug in the burned but undisturbed seedbed. Seed was scattered in the furrows and covered with a half inch of soil.

Summary of results.—Stands in 1952 were relatively poor. However, species producing the best initial stands were *Poa pratensis*, *Dactylis glomerata*, and *Phleum pratense*. By 1955 most species maintained stands comparable to those produced initially. These were *Agropyron desertorum*, *A. elongatum*, *A. intermedium*, *A. sibiricum*, *A. subsecundum*, *A. trichophorum*, *Agrostis alba*, *Bromus erectus*, *B. inermis*, *Dactylis glomerata*, *Festuca elatior*, *F. arundinacea*, *F. rubra*, *Phleum pratense*, *Poa ampla*, *P. compressa*, and *P. pratensis*. Species that failed completely included: *Bromus marginatus*, *Elymus triticoides*, *Arrhenatherum elatius*, *Bouteloua gracilis*, *B. curtipendula*, *Oryzopsis hymenoides*, and *Panicum virgatum*.

The plots were not protected from grazing. Because of grazing pressure and poor stands, the study was abandoned.

White Sulphur Springs

Study location.—Located along the Fort Logan Road, 3 miles west of White Sulphur Springs, Meagher County, sec. 34, T. 20N., R. 6 E. (location 41, fig. 10).

Elevation.—5,300 feet.

Average precipitation.—Annual, 18 inches; April-September, 59 percent.

Soil.—Loam.

Topography.—2 percent slope to the southwest along the edge of the valley.

Type of vegetation.—Foothill sagebrush rangeland.

Dominant and associated species.—*Agropyron spicatum*, *Poa secunda*, and *Artemesia tridentata*.

Previous use.—Cultivated farmland.

Study.—White Sulphur Springs adaptation nursery.

Date planted.—October 13, 1950.

Procedures.—Forty-two grasses were planted in plots 3 by 20 feet with three rows per plot spaced 1 foot apart. (The species planted were the same as those listed for the Shultz adaptation nursery, table 44). Seeding treatments were replicated three times in a randomized block design. Seeding was done with a belt-type hand seeder into summer fallow.

Summary of results.—Initial stands in 1951 were relatively poor but those that established fair to good stands were *Agropyron desertorum* (Nordan), *Dactylis glomerata*, and *Phleum pratense*. In succeeding years, stands of most species improved. By 1955 those that maintained good stands included *Bromus inermis* (Lincoln), *Elymus junceus*, *Dactylis glomerata*, and *Phleum pratense*. Other species that had improved markedly over the initial stand included *A. desertorum* (M24-3 and Standard), *A. trachycaulum*, *Bromus erectus*, *Festuca rubra*, *F. ovina*, *Poa ampla*, *P. compressa*, and *Alpecurus pratensis*.

Livestock grazed the area so heavy before 1959 that species were difficult to recognize and many plants appeared to be dead. Despite the heavy use, *A. desertorum* and *B. inermis* persisted with relatively good stands.

Hansen

Study location.—Located along the old Fort Logan road next to an irrigation canal 4 miles northwest of White Sulphur Springs, Meagher County, sec. 32, T. 10N., R. 6E. (location 41, fig. 10).

Elevation.—5,300 feet.

Average precipitation.—Annual 18 inches; April-September, 59 percent.

Soil.—Loam

Topography.—2 percent slope to the west in valley bottom.

Dominant and associated species.—*Agropyron spicatum, A. smithii, Stipa comata, Poa secunda,* and scattered *Artemesia tridentata.*

Type of vegetation.—Foothill sagebrush rangeland.

Previous use.—Farmed cropland.

Study.—Hansen adaptation nursery.

Date Planted.—September 26, 1952, and spring 1953.

Procedures.—Twenty-one species of grass were planted in plots 6 by 20 feet in a split-plot design with species split by date of seeding. Each subplot contained three rows per plot spaced 1 foot apart. Treatments were replicated three times. Seeds were planted with a belt-type seeder.

The seedbed was cultivated before the fall seeding, they received no additional treatment before the spring seeding. The study was planned and established so that plots could be irrigated, but they never were.

Summary of results.—Fall plantings for most species established fair to poor stands, but spring plantings were good to excellent. *Agropyron desertorum* (Nordan) was the only species to establish a good stand initially from the fall seeding.

Species that appeared adapted to the site and maintained or improved their stands included *A. desertorum* (Standard and Nordan), *A. intermedium, A. sibiricum, A. trichophorum, Bromus erectus, B. inermis,* and *Elymus junceus* (table 46).

Herbage yields from spring-seeded treatments in 1954 were relatively low due to the young age of the plants. *A. trichophorum, A. desertorum* (Nordan), and *A. intermedium,* however, produced fair amounts of herbage of 760 to 960 pounds per acre. In the following year, yields were measured from only nine of the grasses. Yields from the other species were estimated to be too low to consider the species for herbage production. *A. intermedium, A. desertorum* (Standard and Nordan) *A. trichophorum,* and *A. trachycaulum* were the highest yielding species producing from 1,360 to 1,640 pounds of herbage per acre. Although stands of *Alopecurus pratensis* and *Festuca rubra* were good to fair in 1955, these species failed to produce sufficient growth to be considered suitable for forage production.

Coughlin

Study location.—Located 5 miles northwest of Helmville, Mont., Powell County, NE1/4 sec. 5, T. 13N., R. 11W. (location 42, fig. 10).

TABLE 46.—*Establishment and herbage production of grasses planted in the spring on foothill sagebrush rangeland near White Sulfur Springs, Mont.*

Species	Stand		Yield per acre, oven-dry weight	
	1953	1955	1954	1955
	Pct.	*Pct.*	*Lb.*	*Lb.*
Good stands established and maintained for 3 years:				
Agropyron intermedium	94	94	760	1,640
A. desertorum (Nordan)	87	93	820	1,440
A. trichophorum	88	93	960	1,400
Bromus inermis (Lincoln)	88	93	480	960
Agropyron sibiricum	80	91	460	660
A. desertorum (Standard)	87	88	480	1,440
Elymus junceus	80	87	100	380
Bromus erectus	77	83	---	840
Agropyron trachycaulum (Primar)	96	80	660	1,360
Alopecurus pratensis	80	77	100	----
Festuca rubra	82	63	---	----
Fair to poor stands maintained in 3 years:				
Agropyron elongatum	62	20	200	----
Arrhenatherum elatius	95	3	---	----
Dactylis glomerata	87	5	---	----
Festuca arundinacea	96	10	---	----
F. elatior	88	1	120	----
Phalaris arundinacea	87	1	---	----
Phleum pratense (Hopkins)	93	7	---	----
Poa ampla (Sherman)	60	30	---	----
P. compressa	63	12	---	----
P. pratensis	27	15	---	----

Elevation.—4,300 feet.

Average precipitation.—Annual, 13 inches; April-September, 59 percent.

Soil.—Silt loam overlaying gravel.

Topography.—Uniform 5 percent slope to the south.

Type of vegetation.—Foothill sagebrush rangeland.

Dominant and associated species.—*Agropyron spicatum, Poa secunda, Artemesia tridentata.*

Previous use.—Cultivated cropland; dryland barley that was reverting back to sagebrush.

Study.—Coughlin adaptation nursery.

Date planted.—October 9, 1950 (grass); April 1951 (legume).

Planting procedures.—Forty-two grasses and 20 legumes were seeded in plots 3 by 20 feet with three rows per plot spaced 1 foot apart. (The species planted were the same as those planted in the Shultz adaptation nursery, table 44). Each seeding treatment was replicated three times in a randomized block design. Seeding was made directly into barley stubble with a belt-type hand seeder.

Summary of results.—Stands of grass in 1951 were generally fair to poor, however, species that produced the best initial stands were *Agropyron intermedium*, *A. subsecundum*, *A. trichophorum*, *Bromus erectus*, *B. marginatus*, *Elymus canadensis*, and *Festuca ovina*.

By 1956 *Artemesia tridentata* had reinvaded the plots, and stands of many grasses had improved while others declined. Those species that improved were *Agropyron desertorum* (M24-3), *A. elongatum*, *A. inerme*, *A. intermedium*, *A. trichophorum*, *Alopecurus pratensis*, *Bromus erectus*, *B. inermis* (Lincoln), *Festuca ovina*, *F. rubra*, *Phleum pratense*, *Poa compressa*, and *P. pratensis*.

From 1956 to 1963 the area was grazed heavily by cattle and horses. Despite the heavy grazing, however, several grasses continued to improve or maintained good stands. Species included in this group were *Agropyron cristatum* (Fairway), *A. intermedium*, *Alopecurus pratensis*, *Bromus erectus*, *B. inermis* (Lincoln), *Festuca ovina*, *Phleum pratenses*, and *Poa compressa* (table 47).

Stands of most of the other grasses (groups II and III) declined from 1956 to 1963, and those in groups III and IV died out completely.

Initial stands of *Lotus corniculatus*, *Medicago*, and *Trifolium* spp. were generally good in 1951. *Oxytropis riparia* was the only species that failed to produce seedlings the first year. By 1954, however, all *Melilotus* species, *Trifolium agrarium*, and *T. repens* had failed to reseed themselves and were lost.

In 1963 *L. corniculatus* (Empire) had established an excellent stand and had spread into surrounding plots and sagebrush areas. Herbage production was estimated at about 1,500 to 2,000 pounds per acre. *Astragalus cicer*, *A. falcata*, *Medicago sativa*, and *M. falcata* continued to persist but stands had declined and the vigor of plants was poor. However, some plants of *A. cicer* and *A. falcata* were large and robust.

TABLE 47.—*Establishment of grasses and legumes planted on foothill sagebrush rangeland near Helmville, Mont.*

Species	Stand		
	1951	1956	1963
	Pct.	*Pct.*	*Pct.*
Good stands maintained for 12 years:			
Bromus erectus	67	83	92
B. inermis (Lincoln)	60	95	90
Lotus corniculatus (Empire)	90	75	90
Agropyron intermedium	87	93	87
Poa compressa	10	50	80
Agropyron cristatum (Fairway)	30	40	78
Alopecurus pratensis	63	85	77
Festuca ovina duriuscula	73	75	77
Phleum pratense (Hopkins)	43	57	70
Phleum pratense	60	72	67
Fair to good stands maintained for 6 years but were reduced to fair or poor by 12 years:			
Agropyron trichophorum	67	90	57
Agropyron desertorum (Standard)	60	60	47
Poa pratensis	47	87	37
Agropyron inerme	43	63	33
Elymus junceus	13	33	33
Agropyron desertorum (M24-3)	57	77	17
Poa ampla (Robust)	27	43	15
Agropyron elongatum	53	73	8
Stipa viridula	33	47	7
Dactylis glomerata	47	33	7
Festuca rubra	53	72	3
Agropyron sibiricum	40	33	2
Fair to good stands maintained for 6 years but failed in 12 years:			
Phalaris arundinacea	30	50	0
Elymus canadensis	70	47	0
Arrhenatherum elatius	53	42	0
Agropyron subsecundum	67	40	0
A. trachycaulum	60	40	0
Elymus glaucus	53	33	0
Poor stands maintained or failed within 6 years:			
Agropyron smithii	3	18	47
A. spicatum	24	0	0
Agrostis alba	17	15	0

TABLE 47.—*Establishment of grasses and legumes planted on foothill sagebrush rangeland near Helmville, Mont.*—Continued

Species	Stand		
	1951	1956	1963
	Pct.	*Pct.*	*Pct.*
Poor stands maintained or failed within 6 years—continued			
Agrostis tenuis	3	7	3
Bouteloua curtipendula	3	0	0
B. gracilis	0	0	0
Bromus marginatus	80	0	0
Elymus triticoides	17	13	22
Festuca arundinacea (Alta)	35	27	0
F. elatior	60	20	0
Oryzopsis hymenoides	0	0	0
Panicum virgatum	2	0	0
Poa ampla	17	27	7
P. bulbosa	47	1	1
Melilotus alba	70	0	0
M. officinalis	80	0	0
Oxytropis riparia	0	0	0
Trifolium agrarium	20	0	0
T. fragiferum	67	1	0
T. repens	57	1	0

Foothill Grassland

This type of vegetation extends from Canada to Wyoming through the central mountains and is found in adjacent mountainous areas. It occurs mostly at 4,000- to 5,000-foot elevations where precipitation ranges from 12 to 20 inches, and the growing season varies from 60 to 140 days. The soils are mostly moderately deep dark to black loamy types. Some, however, are thin overlaying bedrock. Approximately 8,128,000 acres of this type are located in Montana.

Dominant grasses include *Agropyron spicatum* and *Festuca idahoensis* with *Poa secunda* and *Koeleria cristata* as associated species. Occasionally, *Artemesia tridentata* and *Chrysothamnus* spp. are found in areas adjacent to the sagebrush foothill type, and *Bouteloua gracilis* is common in transition zones with the plains grasslands. *Poa pratensis* and *Bromus inermis* have become well established and appear naturalized to the more moist sites.

Most of the area has been plowed and is presently under cultivation. In the drier sites where cropping is marginal, some land has been abandoned or has already been seeded to grasses.

Generally, conditions have been favorable for seeding grasses, but where failures have occurred, the cause of failure has most often been a result of poor preparation of seedbed or lack of grazing control after seeding.

Besides *Poa pratensis*, *Bromus inermis*, and *B. Tectorum* that often invade seeded areas, other adapted species include *Agropyron cristatum*, *A. desertorum*, *A. inerme*, *A. intermedium*, *A. trichophorum*, *A. sibiricum*, *Bromus erectus*, *Elymus junceus*, *E. triticoides*, *Festuca arundinacea*, *F. rubra*, *Phleum pratense*, *Phalaris arundinacea*, *Dactylis glomerata*, *Poa ampla*, and *P. compressa*.

Grazing studies on a few important species have shown that sheep make satisfactory gains on seeded grasses when limited to a single species during the early part of the growing season. As the season progresses, however, gains decline. Where pastures were grazed continuously through the season, sheep regrazed spot areas until some plants, particularly *P. ampla*, were killed out.

Herbage yields are generally good with production as high as 1-1/2 tons per acre from *E. triticoides* and *Agropyron elongatum*.

Alfalfa produces good yields, but the precipitation is too low in the late summer for more than one crop. Sweetclover has also produced well. Where it is capable of seeding itself, sweetclover has become an important plant in the rangelands.

Studies at Fort Ellis showed that herbage yields declined after the third growing season to about 1,000 pounds of herbage per acre. The decline in production was attributed in part to nitrogen deficiencies in the soil. Yields were more than double in plots fertilized with 67 pounds of nitrogen per acre compared with yields in nontreated plots.

Waterloo

Study location.—Located east of Waterloo, Mont., SE1/4 sec. 1, T. 2S., R. 5W. (location 43, fig. 10).

Elevation.—5,000 feet.

Average precipitation.—Annual, 10 inches; April-September, 78 percent.

Soil.—Gravelly loam.

Topography.—5 percent slope to the northwest.

Vegetational Type.—Foothill grassland.

Dominant and associated species.—*Stipa Comata, Agropyron spicatum, Koeleria cristata, Poa secunda, Aristida longiseta,* and *Carex filifolia.*

Previous use.—Cultivated cropland.

Study.—Waterloo adaptation nursery.

Date planted.—October 12, 1950.

Procedures.—Forty-two species of grass were planted in 3- by 20-foot plots with three rows per plot spaced 1 foot apart. Planting was done with a belt-type hand seeder. The species planted were the same as for the Shultz adaptation nursery (table 44).

Summary of results.—Initial stands in 1951 were only fair to poor with the best established by *Agropyron desertorum* (Standard and M24-3), *A. trachycaulum, A. subsecundum, Bromus erectus, B. marginatus, Elymus junceus, Dactylis glomerata, Bouteloua curtipendula* (El Reno), and *Panicum virgatum.* Generally, stands were improved in 1952, but in 1953 they were mostly poorer than they were initially. Species that rated the highest and those that generally maintained or improved their stands were *A. desertorum* (Standard and M24-3), *A. trichophorum, Bromus inermis* (Lincoln), *B. erectus, Elymus canadensis, Poa ampla* (Sherman and Robust), *Arrhenatherum elatius, Alopecurus pratensis, Phleum pratense,* and *Festuca arundinacea.*

By 1957 most species had either failed or had poor stand. However, a few, *Agropyron cristatum, A. desertorum* (M 2403), *A. intermedium, A. sibiricum, B. inermis, B. erectus,* and *E. junceus,* were good.

Bozeman

Study location.—Located at the Montana Agricultural Experiment Station at Bozeman, Gallatin County, sec. 12, T. 2S., R. 5 E. (location 44, fig. 10).

Elevation.—4,800 feet.

Average precipitation.—Annual, 17.5 inches; April-September, 55 percent.

Soil.—Huffine silt loam.

Topography.—1 percent slope to the north.

Type of vegetation.—Foothill grassland.

Dominant and associated species.—*Agropyron spicatum, Festuca idahoensis, Koeleria cristata, Agropyron smithii, A. trachycaulum, Artemesia tridentata, A. cana, Balsamorhiza* *sagittata, Geranium viscosissimum,* and species of *Lupinus* and *Potentilla.*

Previous use.—Farmland in alfalfa before 1935. In various crop rotation and experimental plantings after 1935.

Study.—Bozeman adaptation plantings.

Date Planted.—April 1936 to May 1937.

Procedures.—Six individual studies were made to test the adaptability of many species and selections. Many of these species were included in several studies, and planting procedures varied from single rod-row plantings to 16- by 16-foot plots. Generally, most of the species responded similarly regardless of how planted.

Summary of results.—Most grasses established good stands and maintained them through 3 years(table 48). Based on establishment and herbage yields, the following species appeared best suited for forage production: *Agropyron cristatum, A. elongatum, A. pungens* (intermedium), *A. repens, Bromus erectus, B. inermis, Elymus canadensis, E. dahuricus, E. macounii, E. virginicus, Festuca arundinacea, Stipa robusta, S. vaseyi,* and *Astragalus rubyi.*

Species that initially established good stands but failed within 3 years or completely failed to establish included *Agrostis racemosa, A. saccharoides, Bouteloua hirsuta, B. trifida, Calamagrostis viriflavescens, Carex filifolia, Chloris virgata, Cynodon dactylon, Elymus condensatus, Eragrostis ferruginea, Muhlenbergia porteri, Oryzopsis miliacea, Panicum antidotale, Poa macrantha, Sorgastrum nutans, Stipa pulchra, and S. speciosa.* Reduced yields or failure of these species was attributed to natural short life, lack of adaptation, or poor seed.

Several species established relatively poor stands initially, but improved during the next 2 years. Most notable among this group were *Agropyron elongatum, A. tenerum, Buchloe dactyloides, Calamovilfa longifolia, Oryzopsis hymenoides, Stipa comata,* and *Atriplex canescens.* Part of the improvement in stand of some of these species was attributed to delayed germination of dormant seed.

Study.—Bozeman date of seeding-adaptation study.

Date planted.—September 18, 1937; October 22, 1937; May 17, 1938.

Procedures.—Thirty-five grasses were planted in single rows 16 feet long spaced 12 inches apart on each of three dates. Dates of seeding treatments were made adjacent to each other.

TABLE 48.—*Establishment and herbage and seed yields of forage species planted at Bozeman, Mont.*

Species	Stand 1936	Stand 1938	Average yields per acre (1937-38) Herbage, oven-dry	Average yields per acre (1937-38) Seed
	Pct.	*Pct.*	*Lb.*	*Lb.*
Good stands maintained for 2 to 3 years:				
Elymus macounii	[1]	100	5,238	676
Agropyron elongatum	20	95	4,733	350
Elymus canadensis	97	100	4,604	589
Bromus inermis	89	100	4,034	391
Agropyron pungens	[1]	100	3,795	321
Astragalus rubyi	70	73	3,365	214
Agropyron repens	[1]	100	3,314	220
A. cristatum	100	100	3,298	416
Stipa vaseyi	100	100	3,278	431
S. robusta	[1]	95	3,201	472
Festuca arundinacea	[1]	100	3,169	354
Elymus sibiricus	[1]	100	3,072	286
E. virginicus	[1]	98	2,847	517
Agropyron tenerum	40	95	2,836	303
Bromus erectus	100	100	2,752	443
Agropyron pauciflorum	[1]	100	2,662	564
Elymus dahuricus	[1]	100	2,616	236
Agropyron caninum	[1]	100	2,599	208
Panicum virgatum	80	77	2,401	84
Festuca elatior	[1]	100	2,396	334
Bromus polyanthus	100	98	2,389	546
Phalaris arundinacea	63	81	2,227	81
Agropyron smithii	70	96	2,185	142
A. inerme	100	99	2,146	187
Agrostis palustris	83	100	1,908	173
Elymus junceus	100	85	1,902	128
Bromus marginatus	82	94	1,825	467
Elymus triticoides	80	75	1,795	23
E. glaucus	100	100	1,783	182
Agropyron semicostatum	[1]	100	1,763	261
A. ciliare	[1]	100	1,759	371
Stipa viridula	95	100	1,703	271
Agrostis alba	90	100	1,671	195
Calamovilfa longifolia	32	82	1,640	28
Agropyron desertorum	[1]	95	1,588	437
A. violaceum	[1]	95	1,526	331
A. sibiricum	[1]	98	1,492	249

Footnotes at end of table.

TABLE 48. — *Establishment and herbage and seed yields of forage species planted at Bozeman, Mont.* — Continued

Species	Stand 1936	Stand 1938	Average yields per acre (1937-38) Herbage, oven-dry	Average yields per acre (1937-38) Seed
	Pct.	*Pct.*	*Lb.*	*Lb.*
Good stands maintained for 2 to 3 years — Continued				
Bromus lanatipes	95	95	1,377	329
Hordeum nodosum	[1]	100	1,326	259
Agropyron ugamicum	[1]	100	1,293	285
Dactylis glomerata	[1]	100	1,151	13
Agropyron spicatum	90	98	1,144	167
Bromus porteri	[1]	90	1,030	160
Poa compressa	[1]	90	1,002	136
P. ampla	100	100	1,000	136
Alopecurus pratensis	[1]	100	918	12
Bromus racemosus	20	76	873	291
Poa nevadensis	65	96	777	88
Bouteloua curtipendula	89	96	761	56
Puccinellia nuttalliana	55	91	651	95
Stipa columbiana	[1]	90	647	50
Festuca rubra	95	97	641	105
Sporobolus cryptandrus	62	80	633	53
Stipa comata	30	91	602	98
Hilaria jamesii	95	98	559	57
Poa bulbosa	93	86	520	178
Bouteloua gracilis	95	96	514	48
Sporobolus airoides	85	85	459	65
Oryzopsis hymenoides	15	95	432	147
Beckmannia syzigachne	50	67	380	102
Festuca ovina duriuscula	[1]	60	378	82
Phalaris tuberosa	[1]	70	291	9
Poa canbyi	100	77	223	36
Deschampsia caespitosa	[1]	75	129	10
Poa epilis	[1]	80	78	1
Buchloe dactyloides	10	90	---	---
Sporobolus asper	90	90	---	---
Atriplex canescens	23	72	---	---
Festuca scabrella	[1]	70	---	---
Poor to fair stands established for 3 years:				
Elymus cinereus	75	55	1,685	94
Stipa spartea	95	58	966	143
Andropogon furcatus	29	48	670	26
Poa palustris	85	55	598	73
Spartinea pectinata	5	5	582	17
Sporobolus flexuosus	75	5	336	21

Footnotes at end of table.

TABLE 48. —*Establishment and herbage and seed yields of forage species planted at Bozeman, Mont.* —Continued

Species	Stand 1936	Stand 1938	Average yields per acre (1937-38) Herbage, oven-dry	Seed
	Pct.	*Pct.*	*Lb.*	*Lb.*
Poor to fair stands established for 3 years -- Continued				
Bromus machrostachys	[1]	10	323	150
Danthonia californica	25	26	259	99
Andropogon scoparius	28	21	251	24
Bromus catharticus	100	48	245	83
Stipa lettermani	[1]	40	236	34
Koeleria cristata	72	39	224	21
Andropogon hallii	10	10	181	5
Aristada longifolia	10	15	149	---
Festuca idahoensis	70	41	107	13
F. brachyphylla	[1]	40	90	6
Poa secunda	60	42	80	9
Atriplex nuttallii	18	42	---	---
Panicum obtusum	25	15	---	---
Ammophila arenaria	[1]	10	---	---
Atriplex confertifolia	1	3	---	---
Failed to establish in 3 years:				
Agrostis racemosa	1	0	---	---
Andropogon saccharoides	50	0	---	---
Bou- eloua hirsuta	90	0	---	---
B. trifida	[1]	0	---	---
Calamagrostis viriflavescens	1	0	---	---
Chloris virgata	90	2	1,578	342
Cynodon dactylon	0	8	---	---
Elymus condensatus	95	0	---	---
Eragrostis ferruginea	50	1	---	---
Muhlenbergia porteri	1	0	---	---
Oryzopsis miliacea	100	2	---	---
Panicum antidotale	100	0	---	---
Poa macrantha	[1]	0	---	---
Sorghastrum nutans	10	1	16	---
Stipa pulchra	70	0	---	---
S. speciosa	95	0	---	---
Carex filifolia	1	1	---	---

[1] Less than 1 percent stand.

Summary of results.—The time of seeding best suited for any species varied (table 49). *Andropogon furcatus, A. scoparius, Bouteloua curtipendula, B. gracilis, Calamovilfa longifolia,* and *Panicum antidotale* failed completely in the early fall seeding, but most of these grasses and *Eragrostis curvula, Panicum virgatum,* and *Sorghastrum nutans* established better in the spring than in the fall. *Elymus canadensis, Festuca idahoensis, Poa ampla, P. canbyi, P. nevadensis, P. secunda,* and *Sporobolus cryptandrus,* however, became better established from fall seedings. Most of the other species established about equally well at all three seeding dates.

Study.—Bozeman palatability test.

Date planted.—1936 to 1938.

Procedure.—Twelve beef cows were allowed to graze free choice the species previously planted in adaptation nurseries. Grazing was continuous for 8 days from July 5 to July 13, 1940.

Amounts of each species grazed were estimated after various periods of time for utilization values.

Summary of results.—The results of this and other palatability studies were published (Gomm, 1969).

Stage of maturity appeared to be the most significant factor affecting cattle preference for the different selections. All but seven species were utilized equal to or more than that of *Agropyron cristatum,* after 192 hours of continuous grazing. These seven included *Bromus machrostachys, B. polyanthus, B. purgans, Calamagrostis canadensis, C. inexpansa, Elymus triticoides,* and *Poa ampla.*

Some species were rejected early in the grazing period but heavily utilized after the forage of more palatable species was removed. This group of secondarily palatable plants included *Agropyron inerme, A. spicatum, Agrostis alba, A. palustris, Aristida longiseta, Bromus catharticus, B. tectorum, Cynodon dactylon, Elymus sibiricus, Hilaria jamesii, Muhlenbergia squarrosa, Oryzopsis hymenoides, Phalaris arundinacea, Phleum alpinum, Poa juncifolia, P. nevadensis, P. secunda, Stipa columbiana, S. comata, S. occidentalis, S. viridula, and Trisetum spicatum.*

Fort Ellis

Study location.—Located at the Fort Ellis experimental farm 3 miles east of Bozeman, Gallatin County, Mont., sec. 15, T. 2S., R. 6 E. (location 45, fig. 10).

TABLE 49.—*Establishment of grasses planted at Bozeman, Mont. as affected by planting date*

Species	Stand on October 6, 1938, seeded on		
	9/18/37	10/22/37	5/17/38
	Pct.	*Pct.*	*Pct.*
Established equally well at all three dates:			
Bromus inermis	100	100	100
Arrhenatherum elatius	95	80	100
Agropyron cristatum	90	95	95
Bromus marginatus	95	85	95
Elymus junceus	90	95	90
Stipa viridula	65	75	75
Buchloe dactyloides	25	30	25
Best established when fall planted:			
Agropyron pungens	100	100	85
Phleum pratense	90	95	85
Dactylis glomerata	90	90	80
Koeleria cristata	90	95	60
Elymus canadensis	80	80	40
Best established when planted in early fall:			
Agropyron smithii	100	95	90
Stipa comata	80	60	50
Sporobolus cryptandrus	60	45	15
Oryzopsis hymenoides	30	12	12
Best established from late fall planting:			
Poa secunda	80	100	35
P. canbyi	90	100	25
Agropyron spicatum	0	100	0
A. pauciflorum	0	100	0
Poa pratensis	80	98	60
P. nevadensis	90	98	52
Puccinellia nuttalliana	75	95	60
Poa bulbosa	60	95	50
P. ampla	80	95	40
Festuca idahoensis	65	85	10

TABLE 49. —*Establishment of grasses planted at Bozeman, Mont. as affected by planting date* — Continued

Species	Stand on October 6, 1938, seeded on --		
	9/18/37	10/22/37	5/17/38
	Pct.	*Pct.*	*Pct.*
Best established when spring planted:			
Eragrostis curvula	5	50	95
Panicum antidotale	0	0	90
Bouteloua gracilis	0	5	80
Panicum virgatum	40	50	75
Bouteloua curtipendula	0	10	70
Sorghastrum nutans	10	20	35
Andropogon scoparius	0	3	20
Calamovilfa longifolia	0	10	10
Andropogon furcatus	0	0	5

Elevation.—4,800 feet.

Average precipitation.—Annual, 17.5 inches; April-September, 68 percent.

Soil.—Bozeman silt loam.

Topography.—2 percent slope to the northwest.

Type of vegetation.—Foothill grassland.

Dominant and associated species.—*Agropyron spicatum, Festuca idahoensis, Koeleria cristata, Agropyron trachycaulum, Artemesia tridentata, A. cana, Balsamorhiza sagitata, Geranium viscossisimum,* and *Lupinus* spp.

Previous use.—Farmed.

Study.—Fort Ellis dryland hay planting.

Date planted.—May 1945.

Procedures.—Seven grasses were planted in pure stands and in mixtures with *Medicago falcata* and with *Melilotus officinalis.* In addition, pure stands of *M. falcata* and *M. officinalis* were seeded. In pure stands *M. falcata* and each grass were seeded at 10 pounds and *M. officinalis* was seeded at 15 pounds per acre. In mixtures, the grasses were seeded at 7 pounds and the legumes at 5 pounds per acre. Seeding rates were adjusted for germination. Each plot consisted of six rows, 1 foot apart, and 40 feet long. In mixtures the species were mixed before planting. Each treatment was replicated four times. *M. officinalis* was replanted in 1947.

Summary of results.—Herbage yields were considered high for dryland conditions (table 50). Generally, they increased until the third harvest year when maximum production was obtained.

A. desertorum was the highest yielding grass, except in the third year of harvest.

TABLE 50.—*Herbage yield and protein content of grasses and grass-legume mixtures at Fort Ellis, Mont., 1946-50*

Species or mixture	Yield, oven-dry weight (1946-50)	Crude protein content (1946)
	Lb.	*Pct.*
Pure stands:		
Agropyron desertorum	5,280	9.4
Bromus inermis (Parkland)	4,600	8.8
Melilotus officinalis	[1] 4,200	13.0
Agropyron trachycaulum	[2] 3,867	8.0
Festuca arundinacea	3,560	8.3
Medicago falcata (Ladak)	[2] 3,200	14.3
Elymus junceus	3,080	11.1
Dactylis glomerata	[3] 2,750	5.8
Mixtures with M. falcata:		
Bromus inermis	4,320	10.6
Agropyron trachycaulum	[2] 4,133	12.7
Festuca arundinacea	3,840	9.1
Agropyron desertorum	3,720	11.7
Dactylis glomerata	[3] 3,650	10.1
Elymus junceus	3,280	14.8
Mixtures with M. officinalis:		
Agropyron desertorum	5,040	13.9
Bromus inermis	4,480	13.2
Agropyron trachycaulum	[2] 4,067	14.8
Festuca arundinacea	3,280	11.4
Elymus junceus	3,200	15.7
Dactylis glomerata	[3] 3,150	11.1

[1] 2-year average.
[2] 3-year average.
[3] 4-year average.

Elymus junceus was generally a low producer. However, yields were about 1.5 tons per acre with little yearly variation despite the dry year, 1949, when production of the other grasses was decreased considerably.

Agropyron trachycaulum had failed by 1949 and *Dactylis glomerata*, by 1950.

M. officinalis died out by 1949 and so had *M. falcata* in pure seedings. Since the herbage was cut for hay, *M. officinalis* had no chance to reseed itself. *M. falcata* was killed out because of rodent activity, except in mixtures with grasses where the grass apparently afforded some protection.

Variable yield response was obtained from legumes in mixtures with the grasses. With the exception of *D. glomerata*, *M. falcata* in the mixture, apparently, did not increase yields. Mixtures with *M. officinalis* appeared to yield higher than mixtures with *M. falcata*, particularly in the first harvest year.

Protein content of the herbage was increased with a legume in the mixture, and generally, mixtures with *M. officinalis* had higher protein content than mixtures with *M. falcata*.

Study.—Fort Ellis study of hay yields.

Date planted.—October 1950.

Procedures.—Eight grasses were planted in 5- by 20-foot plots with five rows per plot spaced 1 foot apart. The plots were replicated six times in a randomized block design. In April 1957, fertilizer was applied at 33.5 and 67 pounds N per acre with two replications for each rate and compared with a zero check.

Results.—All grasses produced their highest yields in the second harvest year and declined each year for the next 4 years. Average yields for the 6-year period and yields for the 1957 fertilizer treatments are given in table 51.

Differences among species were highly significant. *Bromus inermis* (Lincoln) produced the most forage over the 6-year period. It declined in yield rapidly, however, and by 1956, it was producing less than many of the other grasses. In 1955 *Poa ampla* and *Agropyron intermedium* were about equal and yields were above *B. inermis*. In 1956, yield of *P. ampla* declined while that of *Agropyron desertorum* (Standard) and *A. intermedium* were high. Although *A. intermedium*, *B. inermis*, and *A. desertorum* (Nordan) had the highest yields in 1957, all species on the unfertilized plots continued to decline.

Except for 1956, *A. desertorum* (Nordan) returned greater yields than *A. desertorum* (Standard). Over the 6-year period,

TABLE 51.—*Establishment and yield of grasses at Fort Ellis, Mont., 1952-57*

Species	Stand, 1951	Yields per acre, oven-dry weight			
		Average 1952-57	N per acre, 1957		
			None	33.5	67
	Pct.	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Bromus inermis (Lincoln)	79	4,964	1,240	2,000	3,020
Agropyron intermedium	69	4,496	1,340	2,840	3,600
A. desertorum (Nordan)	84	4,420	1,320	2,400	2,980
Poa ampla	67	3,868	920	1,680	2,400
Agropyron desertorum (Standard)	68	3,548	1,140	2,140	2,460
A. trichophorum	72	3,320	1,300	2,280	2,980
A. elongatum	55	2,748	640	2,460	2,340
Elymus junceus	71	2,044	560	720	1,260

Nordan produced 22 percent more forage than the Standard variety.

Elymus junceus was the lowest producer with yields less than half that of *B. inermis* and several other species. In 1957 its yield was less than that of other species, and it responded the least to fertilizers.

Response to fertilizer was highly significant in 1957. Yields were increased 116 to 266 percent with applications of 67 lb. of N per acre. Although fertilizers increased herbage yields in 1957, the herbage produced was never as high as it was in 1953 or 1954 when the stands were young.

The optimum and economical rates of applications under the conditions of this experiment are unknown. More intensive studies are needed to determine combinations of rates and fertilizer needed under dryland conditions. Other methods of renovation and rejuvenation of old stands are important also, and they should be determined and compared.

Poa pratensis invaded most of the plots and may be responsible for some decline in yield, especially in most of the wheatgrass plots. Bluegrass only slightly invaded plots of *Bromus inermis, Elymus junceus,* and *Agropyron desertorum* (Nordan).

Samples of herbage analyzed for protein content showed no significant difference among species or among fertilizer rates.

Study.—Fort Ellis adaptation nursery.
Date planted.—October 24, 1950.

Procedures.—Forty-two species of grass were planted in plots 3 by 20 feet with three rows per plot spaced 1 foot apart. Seeding treatments were replicated three times in a randomized block design. The seedbed was plowed and harrowed before seeding. The seed was planted by drilling with a belt-type hand seeder.

Results.—Fair to good stands of most species were established in 1951, and they improved until 1955, after which many of them declined (table 52). The reduction in stand was attributed to

TABLE 52.—*Establishment of grasses seeded at Fort Ellis, Mont.*

Species	Stand 1951	Stand 1955	Stand 1959
	Pct.	*Pct.*	*Pct.*
Good stands maintained through 9 years:			
Bromus inermis	90	100	100
Agropyron trichophorum	72	100	100
A. intermedium	57	93	100
Phleum pratense (Hopkins)	95	97	98
Festuca ovina duriuscula	85	97	98
Bromus erectus	83	100	93
Festuca rubra	87	97	93
Phleum pratense	80	87	93
Dactylis glomerata	92	95	92
Alopecurus pratensis	70	85	88
Agropyron inerme	73	85	75
Poa ampla (Robust)	73	83	75
Festuca arundinacea (Alta)	88	95	70
Poa compressa	44	87	68
Agropyron cristatum (Fairway)	20	33	60
Fair stands maintained through 9 years:			
Phalaris arundinacea	57	92	45
Stipa viridula	43	43	43
Agropyron desertorum (Nordan)	78	85	37
A. desertorum (M24-3)	63	92	35
A. desertorum (Standard)	65	93	28
Poa ampla (Sherman)	60	92	28
Good to fair stands maintained through 5 years but generally failed by the 9th year:			
Elymus triticoides	33	80	0
Arrhenatherum elatius	65	63	17
Agropyron sibiricum	57	60	10
Elymus junceus	60	57	10
Festuca elatior	93	53	1
Poa bulbosa	12	53	0

TABLE 52.—*Establishment of grasses seeded at Fort Ellis, Mont.* Continued

Species	Stand 1951	Stand 1955	Stand 1959
	Pct.	*Pct.*	*Pct.*
Poorly established, poorly maintained or failed in 5 years:			
Agropyron elongatum	33	27	3
A. smithii	10	15	10
A. spicatum	3	0	0
A. subsecundum	50	0	0
A. trachycaulum	63	0	1
Agrostis alba	62	28	17
Bouteloua curtipendula	5	0	0
B. gracilis	2	0	0
Bromus marginatus	93	0	1
Elymus canadensis	47	5	0
E glaucus	37	27	1
Oryzopsis hymenoides	1	0	0
Panicum virgatum	4	0	0

competition from *Bromus inermis* and *Poa pratensis* that invaded the area. As a result, stands of several species otherwise adapted to the site degenerated.

Species that appeared adapted in 1955 before competition became severe were *Agropyron desertorum* (Standard, M24-3, and Nordan), *A. intermedium*, *A. trichophorum*, *A. inerme*, *A. sibiricum*, *Bromus erectus*, *B. inermis*, *Elymus junceus*, *E. triticoides*, *Festuca rubra*, *F. ovina*, *Poa ampla* (Sherman and Robust), *P. pratensis*, *P. compressa*, *Arrhenatherum elatius*, *Alopecurus pratensis*, *Phalaris arundinacea*, *Dactylis glomerata*, *Phleum pratense*, and *Festuca arundinacea*.

Species that appeared most capable of competing with *B. inermis* and *P. pratensis* included *Agropyron cristatum*, *A. intermedium*, *A. trichophorum*, *A. inerme*, *Bromus erectus*, *Festuca rubra*, *F. ovina*, *Poa ampla* (Robust), *P. compressa*, *Alopecurus pratensis*, *Dactylis glomerata*, *Phleum pratense*, and *Festuca arundinacea*.

Grasses that appeared the least adapted and those that generally failed to become established are listed in table 52.

Study.—Fort Ellis pasture plantings.
Dates planted.—August 1938 to May 1941.

Procedures.—Fifteen grasses were seeded in 2- and 3-acre blocks with a grain drill.

Results.—Except for *Andropogon scoparius*, all species produced fair to good stands in 1941.

The highest yielding species were *Agropyron cristatum*, *Agropyron desertorum*, *Bromus inermis*, and *Festuca arundinacea;* the earliest growing were *A. cristatum*, *A. desertorum*, and *F. arundinacea;* and the most palatable were *Dactylis glomerata* and *B. inermis* (table 53).

Study.—Fort Ellis dryland pastures (1943-50).

Date planted.—*Agropyron cristatum* (Fairway), June 1939 and May 8, 1944; *A. desertorum*, June 1939 and May 8, 1944; *Bromus inermis* (Parkland), June 1941 and May 10, 1944; *Elymus junceus*, May 10, 1940, and May 8, 1944.

Procedures.—Two 2-acre pastures were seeded for each of four species at different times in different years. Good stands were obtained on each pasture. *A. cristatum* and *A. desertorum* were grazed by sheep in 1943, 1948, 1949, and 1950; but *B. inermis*

TABLE 53.—*Establishment, development, utilization, and yield of grass planted 1938-40 at Fort Ellis, Mont.*

Species	Ratings made in 1941			Yield per acre, oven-dry weight (1941)
	Stand	Earliness [1]	Spring utilization	
	Pct.	*Rating*	*Rating*	*Lb.*
Festuca arundinacea	100	1	4	7,825
Agropyron cristatum	100	1	8	7,582
A. desertorum	98	1	6	6,595
Bromus inermis	100	2	2	6,326
Dactylis glomerata	100	2	1	4,960
Agropyron trachycaulum	99	2	3	4,128
Bromus marginatus	99	2	4	3,742
Arrhenatherum elatius	70	2	3	2,290
Elymus junceus	100	2	9	1,739
Phalaris arundinacea	100	3	7	---
Bromus inermis (Parkland)	90	2	2	---
Agropyron smithii	75	4	6	---
Bouteloua gracilis	75	9	9	---
Stipa viridula	50	3	9	14
Andropogon scoparius	0	0	0	0

[1] Earliness ratings from 1 to 9 with No. 1 being earliest and 9, latest.

[2] Utilization ratings from 1 to 9 with 1 being most utilized and 9, the least.

and *E. junceus* were grazed only in 1949 and 1950. All pastures were grazed for an equal period in any 1 year. In 1948 they were grazed 71 days; in 1949, 57 days; and in 1943 and 1950, 85 days.

Results.—Sheep consumed more and gained more per day and per acre from *B. inermis* than from any other grass (table 54). *A. desertorum* and *E. junceus* were similar in production, while *A. cristatum* produced the least forage and animal gains.

Study.—Fort Ellis dryland pastures (1952-1957).

Previous use.—Farmed.

Date planted.—October 1950.

Procedures.—Five grasses were planted by drilling in triplicate 1-acre pastures. Each pasture was fenced and grazed by sheep. Management procedures varied from year to year depending on the conditions of the pastures and animals.

In 1952 the pastures were grazed continuously from May 28 to October 29 by yearling ewes. The sheep on *Agropyron deser-*

TABLE 54.—*Average production of dryland pastures at Fort Ellis, Mont. 1943-50 and 1952-56*

Pasture species	Length of season	Animals per acre per day	Herbage consumed per acre, oven-dry weight	Individual daily gains per animal	Animal gains per acre
	Days	*No.*	*Lb.*	*Lb.*	*Lb.*
1943-50 pastures:					
Bromus inermis (Parkland) [1]	74.5	6.2	2,106	0.34	144
Agropyron desertorum (Standard)	74.5	6.5	1,764	.28	132
Elymus junceus [1]	74.5	6.4	1,758	.30	129
Agropyron cristatum (Fairway)	74.5	6.3	1,661	.24	109
1952-56 pastures:					
Agropyron trichophorum	121.0	4.4	1,330	.22	116
Poa ampla	139.0	5.3	1,64	.16	112
Agropyron elongatum	137.0	5.3	1,620	.16	112
A. desertorum	135.0	5.0	1,500	.15	102
A. intermedium	132.0	5.2	1,470	.13	95

[1] Averaged values for 1949 and 1950 only.

torum and *A. intermedium* were below maximum seasonal weight on October 29, but sheep on the other grasses were at their maximum weight. In 1953, the pastures received continuous grazing from May 18 to October 20, except for those in *A. trichophorum* that were grazed to September 8.

In 1954 each pasture was divided with an electric fence into two lots. One pasture was to be grazed continuously and the other, in rotation. The sheep, however, could not be held with the electric fence and after the first rotational period the electric fence was removed, and all lots were grazed continuously for the rest of the season. The pastures were grazed from May 13 to October 5.

In 1955 permanent net-wire fences were used to divide the pastures into two similar half-acre lots. One was continuously grazed; the other was grazed in rotation with lots from replications of the same species. Grazing extended from May 13 through October 12.

In 1956 grazing extended from May 23 through August 29 except for the pastures in *Poa ampla*, which were grazed from May 16. The numbers of sheep on pasture varied throughout the season and were adjusted to the carrying capacity of the pastures.

Palatability and preference ratings were determined in 1957 when fences were removed and the plots grazed by male sheep (table 55). The pastures were grazed from May 15 through May 30. *A. intermedium* was the most preferred and *P. ampla* the least. After 2 weeks of grazing, *A. intermedium* and *A. trichophorum* were heavily utilized, and *A. desertorum* was becoming mature and stemmy. At that time *A. elongatum* was only moderately grazed. Even under these conditions, only light use was made of *P. ampla*.

Poa ampla was generally ready to graze before the other species, being as much as a week ahead of *A. desertorum*. It matured early in the growing season if not closely grazed. When grazing was close enough to prevent heading, green forage was available throughout the season. In the fall, *P. ampla* started regrowth sooner than the other grass and went into the winter green. Pastures were green late in December 1956 after intermittent freezing and snowstorms.

Over the 5-year period, *P. ampla* compared closely with *A. elongatum* in carrying capacity, animal gains, and total digestible nutrients (TDN). These two species were generally the highest producers (table 54).

TABLE 55.—*Estimated use of grasses by sheep at Fort Ellis, Mont. after different periods of grazing*

Species	Herbage utilized at different dates [1]		
	May 17	May 22	May 29
	Pct.	*Pct.*	*Pct.*
Agropyron intermedium	5	40	85
A. trichophorum	4	30	75
A. desertorum	2	10	15
A. elongatum	1	3	10
Poa ampla (Sherman)	0	0	1

[1] Grazing began May 15.

Results.—Continuous grazing was better than rotational grazing in pounds of animal gains and TDN. The difference was attributed to the quality of forage available for grazing. The rotational grazing cycle, which was 14 days on and 28 days off pasture, gave the plants 28 days to grow before being grazed again. When the sheep were turned in, the grass was mature and coarse. The stocking rates of the continuously grazed pastures were such that animals were not forced to graze the pastures uniformly. As a result, large areas of grass were allowed to mature and were grazed only lightly at the expense of small heavily grazed patches where the sheep grazed tender green leaves throughout the season; hence, they were getting higher quality forage from the continuously grazed pastures.

In the spring of 1957, extensive heaving of dead and weakened plants occurred in areas previously spot grazed, primarily in pastures that were continuously grazed. Species most affected were *P. ampla* and *A. intermedium.*

A. elongatum produced an abundance of coarse forage and was ready to graze approximately 2 to 3 weeks after *P. ampla.* Regardless of its coarse appearance, however, this grass was taken fairly well by sheep when grazed in pure stand. *A. elongatum* stayed green late into the season and its protein content remained higher later than the other grasses.

A. desertorum was ready to graze early in the spring but not as early as *P. ampla.* Although it matured early in the summer, sheep continued to gain until late August. Generally, sheep lost weight after that date, although they appeared full. The pastures of *A. desertorum* were the first to be fully utilized.

A. intermedium and *A. trichophorum* were ready for grazing 1 to 2 weeks after *A. desertorum*. *A. intermedium* surpassed *A. trichophorum* in average number of sheep days and TDN but fell below in pounds of daily animal gains and pounds of gain per acre. For most years, sheep on *A. intermedium* were below their maximum seasonal weight at the end of the grazing season, while sheep on other grasses were at or near their maximum seasonal weight.

Apparently forage species must be managed and grazed in various ways. The following factors appear to be particularly important and should be considered in grazing management.

1. Date at which the grass is ready for grazing.
2. Rate at which growth and development take place.
3. Rate of stocking.
4. Class of animals.
5. Stage of growth.
6. Percent of utilization at which animals should be removed from grazing.

Maximum herbage and animal gains will not be obtained if these factors are not considered in determining the management practices. Apparently, maximum yields were not obtained in this study because the effects of certain factors were not known.

Herbage samples were taken at intervals throughout the grazing season and analyzed for protein content.

A curvilinear decline in protein was expressed for all grasses as the season advanced.

The protein content of the collected herbage was higher from rotationally grazed pastures than from those continuously grazed (table 56). However, the herbage collected may not represent true samples of the forage actually ingested and the sheep were actually ingesting forage of higher quality. This is indicated since sheep gains were higher on the continuously grazed pastures than on the rotationally grazed. The spot grazing of the continuously grazed pastures also indicates that the sheep were getting the new regrowth as soon as it could be grazed.

A 4-year summary of the different grasses under continuous grazing showed *P. ampla* to average lower in protein content during June and July than any of the other species, but late in the season, *A. desertorum*, *A. intermedium*, and *A. trichophorum* dropped below *P. ampla*. In September and October difference among the species was slight, but *A. elongatum* averaged slightly higher (table 57).

Livingston

Study location.—Located 8 miles west of Livingston, Park County, along the roadway to Bozeman, sec. 3, T. 2S., R. 8E. (location 46, fig. 10).

Elevation.—4,900 feet.

Average precipitation.—Annual, 14 inches; April-September, 68 percent.

Soil.—Loam.

Topography.—4 percent slope to the south on the edge of the shallow canyon of Quinn Creek.

Type of vegetation.—Foothill grassland.

Dominant species.—*Agropyron spicatum*, *Festuca idahoensis*, *Koeleria cristata*, *Balsamorhiza sagitata*, and *Lupine* spp.; *Poa pratensis* and *Bromus inermis* have invaded.

Previous use.—Farmed.

TABLE 56.—*Protein content of grasses grown under dryland conditions at Fort Ellis, Mont., 1956*

Species and system of grazing	Protein content on date of sampling			
	6/14	7/11	8/8	8/31
	Pct.	*Pct.*	*Pct.*	*Pct.*
Agropyron desertorum:				
Continuous	8.5	7.3	4.8	3.3
Rotation	10.7	8.6	6.0	4.5
A. elongatum:				
Continuous	7.5	9.1	7.2	4.5
Rotation	10.5	9.6	6.8	4.4
A. intermedium:				
Continuous	8.6	6.6	3.6	2.8
Rotation	10.8	7.2	4.2	2.9
A. trichophorum:				
Continuous	10.6	9.2	5.1	4.2
Rotation	15.1	8.4	5.2	4.6
Poa ampla:				
Continuous	7.5	5.6	4.1	3.2
Rotation	7.9	5.6	4.7	3.5

TABLE 57.—*Average protein content in grasses grown under dryland conditions at Fort Ellis, Mont., 1952-55*

Species	Crude protein on date of sampling						
	6/17	6/27	7/25	8/10	8/22	9/19	10/14
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Agropyron desertorum	14.8	10.1	6.6	5.4	5.0	3.5	2.9
A. elongatum	14.9	10.4	7.8	7.3	5.9	4.7	4.0
A. intermedium	13.9	9.3	6.2	4.8	4.3	3.2	2.4
A. trichophorum	14.7	11.4	7.4	7.0	4.9	3.8	2.8
Poa ampla	11.8	8.5	5.6	5.6	4.3	4.0	3.2

Study.—Livingston adaptation nursery.

Date planted.—October 18, 1950.

Procedures.—Forty-two grasses were planted in plots 3 by 20 feet with three rows spaced 1 foot apart. Treatments were replicated three times in a randomized block design.

Summary of results.—Stands were mostly fair to poor in 1951 (table 58). Species that appeared adapted to the site increased in stand establishment during the next few years. However, competition from invading *Bromus inermis* and *Poa pratensis* reduced many stands by 1959.

Species that appeared adapted to the site before competition decreased stands included *Agropyron desertorum* (Standard, Nordan, and M24-3), *A. cristatum*, *A. trachycaulum*, *A. intermedium*, *A. trichophorum*, *A. inerme*, *A. sibiricum*, *A. elongatum*, *Bromus inermis*, *B. erectus*, *Elymus junceus*, *Festuca rubra*, *F. ovina*, *Arrenatherum elatius*, *Alopecurus pratensis*, *Stipa viridula*, *Phalaris arundinacea*, *Dactylis glomerata*, *Phleum pratense*, and *Festuca arundinacea*. Of these species those that appeared capable of competing with *B. inermis* and *P. pratensis* included *A. cristatum*, *A. intermedium*, *A. trichophorum*, *B. erectus*, *F. ovina*, *A. elatius*, *A. pratensis*, *P. arundinacea*, and *P. pratense*.

Species that were established and maintained poor stands or failed completely were listed in table 58. Some of these and some of those listed as having failed or having poor stands by the 9th year, notably *A. desertorum* and *P. ampla*, have been shown to be adapted at similar sites. Most likely, the competition from *B. inermis* and *P. pratensis* caused many of these species to die out.

TABLE 58.—*Establishment and yield of grasses planted near Livingston, Mont.*

Species	Stand			Yield per acre, oven-dry weight
	1951	1955	1959	(1959)
	Pct.	*Pct.*	*Pct.*	*Pct.*
Good to fair stands maintained for 9 years:				
Bromus inermis (Lincoln)	50	100	100	1,700
Agropyron trichophorum	38	95	100	1,533
A. intermedium	60	83	100	1,433
Bromus erectus	77	90	96	900
Phalaris arundinacea	33	73	69	933
Phleum pratense (Hopkins)	20	50	69	900
Poa pratensis	0	0	69	[1]
P. compressa	0	0	68	[1]
Alopecurus pratensis	27	63	62	533
Phleum pratense	60	70	58	600
Agropyron cristatum (Fairway)	5	50	55	1,433
Festuca ovina duriuscula	37	87	54	867
Arrhenatherum elatius	50	73	50	533
Agrostis alba	47	67	41	[1]
Festuca arundinacea (Alta)	47	67	41	[1]
Fair stands maintained for 5 years but failed or were reduced to poor stands by the 9th year:				
Agropyron desertorum (Standard)	38	60	26	[1]
Festuca rubra	33	60	23	[1]
Agropyron sibiricum	20	60	8	[1]
Elymus junceus	18	60	8	[1]
Dactylis glomerata	33	57	27	[1]
Agropyron desertorum (*M24-8*)	20	57	27	[1]
A. desertorum (Nordan)	50	53	24	[1]
Festuca elatior	60	37	1	[1]
Agropyron inerme	27	37	0	[1]
Stipa viridula	18	37	15	[1]
Elymus glaucus	7	37	15	[1]
Agropyron trachycaulum	67	33	1	[1]
Bromus marginatus	43	30	0	[1]
Agropyron elongatum	25	30	1	[1]

Footnotes at end of table.

TABLE 58.—*Establishment and yield of grasses planted near Livingston, Mont.* —Continued

Species	Stand 1951	Stand 1955	Stand 1959	Yield per acre, oven-dry weight (1959)
	Pct.	*Pct.*	*Pct.*	*Pct.*
Poorly established or failed completely:				
Agropyron smithii	2	0	2	[1]
A. spicatum	0	0	0	[1]
A. subsecundum	20	0	0	[1]
Bouteloua curtipendula	2	0	0	[1]
Poorly established or failed completely -- continued				
Bouteloua gracilis	1	0	0	[1]
Elymus canadensis	0	20	1	[1]
E. triticoides	2	0	0	[1]
Oryzopsis hymenoides	2	0	0	[1]
Panicum virgatum	0	0	0	[1]
Poa ampla	0	0	0	[1]
P. bulbosa	2	3	0	[1]

[1] Data not available.

Herbage harvested in 1959 showed 11 species producing sufficient to be considered for forage production. *B. inermis* was the highest yielding species followed by *A. trichophorum*, *A. intermedium*, and *A. cristatum.*

East Helena

Study location.—Located 3 miles east of East Helena, Lewis and Clark County, sec. 33, T. 10N., R. 2W. (location 47, fig. 10).

Elevation.—4,000 feet.

Average precipitation.—Annual, 11 inches; April-September, 76 percent.

Soil.—Loam.

Topography.—2 percent slope to the northwest on benchland soils.

Type of vegetation.—Foothill grassland.

Dominant and associated species.—*Agropyron spicatum, A. trachycaulum, Koeleria cristata,* and *Lupine* spp.; *Bouteloua gracilis* was originally part of vegetation on the more silty sites.

Previous use.—Cultivated dry farmland.

Study.—East Helena adaptation nursery.

Date planted.—October 20, 1950.

Procedures.—Forty-two grasses were seeded in plots 3 by 20 feet with three rows spaced 1 foot apart.

Results.—Fair to good stands of most species were established in 1951. The study, however, was plowed out in 1952 without further data on stands.

Species that established best were *Agropyron desertorum*, *A. intermedium*, *A. sibiricum*, *A. trachycaulum*, *A. trichophorum*, *Bromus erectus*, *B. inermis*, *Elymus junceus*, *Festuca arundinacea*, and *Phleum pratense*. Those that established poor stands or failed completely were *Agropyron elongatum*, *Agrostis alba*, *Bouteloua curtipendula*, *B. gracilis*, *Festuca rubra*, *Oryzopsis hymenoides*, *Panicum virgatum*, *Poa bulbosa*, *P. compressa*, and *P. pratensis*.

Other species planted were the same as those planted near Livingston and listed in table 58.

Augusta

Study location.—Located 12 miles west of Augusta, Lewis and Clark County, sec. 22, T. 19N., R. 6 W. (location 48, fig. 10).

Elevation.—4,900 feet.

Average precipitation.—Annual, 13 inches; April-September, 73 percent.

Soil.—Regent clay loam.

Topography.—5 percent slope to the northeast on gently rolling land.

Type of vegetation.—Foothill grassland.

Dominant and associated species.—*Agropyron spicatum*, *Poa secunda*, and *Koeleria cristata*; *Bouteloua gracilis* occurs in transitional areas bordering the Teton-Judith Basin grasslands type.

Previous use.—Abandoned cropland.

Study.—Augusta species planting.

Date Planted.—1938.

Procedures.—Sixteen grasses were planted in plots 9 by 32 feet with three rows per plot spaced 3 feet apart. Seeds were scattered in handmade furrows and covered with 1/4 to 1/2 inch of soil. The soil was packed by tamping with a hoe.

Summary of results.—The seeding was generally very good, and by 1945 all but five species rated good or better. The best stands were established by *Agropyron cristatum*, *A. deser-*

torum, A. inerme, Arrhenatherum elatius, Bromus inermis, Elymus junceus, Phleum pratense, Stipa viridula, Agropyron smithii, A. spicatum, and *A. trachycaulum.* Fair to poor stands were established by *Bouteloua gracilis, Bromus erectus, Elymus canadensis,* and *Festuca idahoensis. Bromus marginatus* failed completely.

Bear Creek

Study Location.—Located 20 miles south of Chinook near Lloyd on Bear Creek, Blaine County, sec. 4, T. 29N., R. 18E. (location 64, fig. 10).

Elevation.—4,000 feet.

Average precipitation.—Annual, 14 inches; April-September, 74 percent.

Soil.—Shallow stony loam.

Topography.—2 percent slope to the northeast.

Type of vegetation.—Foothill grassland.

Dominant and associated species.—*Agropyron smithii, Stipa comata, Koeleria cristata, Artemesia tridentata,* and *Bouteloua gracilis.*

Previous use.—Cultivated cropland.

Study.—Bear Creek adaptation nursery.

Date planted.—May 1952.

Procedures.—Forty-two species of grass were planted in plots 3 by 20 feet with three rows per plot spaced 1 foot apart. Seeding treatments were replicated three times in a randomized block design.

Summary of results.—By 1954 only a few species had established fair to good stands. Most species rated poor. Those that appeared best adapted included *Agropyron cristatum, A. desertorum, A. trachycaulum, Bromus marginstus, Elymus canadensis, E. junceus,* and *Stipa viridula.*

Because of relatively poor stands the study was abandoned.

Teton River-Judith Basin Grassland

These grasslands are found mostly in the west-central part of Montana. An arm also extends up the Missouri, Jefferson, and Beaverhead Rivers from Winston to Dillon forming a zone between intermountain valley bottom lands and foothill sagebrush rangelands.

The area encompasses more than 6,409,000 acres at elevations from 3,000 to 5,000 feet. Annual precipitation varies from 8 to

16 inches, most of which falls during the April to July period. The growing season varies from 80 to 140 days.

Bouteloua gracilis, Carex filifolia, Stipa comata, Poa secunda, and *Agropyron smithii* are characteristic species. *A. smithii* is more abundant on the clay loam soils and moist sites. On the lighter-textured soils *S. comata* is the dominant grass, and *B. gracilis* and *A. smithii* are less abundant. *B. gracilis* is most abundant on dry and overgrazed sites and is often found in association with scattered sagebrush and phlox.

The soils are generally moderately dark loams. In the 12- to 16-inch precipitation zones they are Mollisols, while in areas with less than 12 inches they are Aridisols.

The topography, which is generally level to rolling, has encouraged cultivation. Consequently, much of the area has been farmed. Because the precipitation is low and sometimes undependable, large areas were abandoned. *Bromus tectorum* found ideal seedbed conditions in the abandoned fields and generally invaded these sites. During the late 1930's and through the 1940's, much of the abandoned land was seeded to *Agropyron cristatum* and *A. desertorum.* Federal programs have also encouraged seeding large areas to grass. Although production of grain is still uncertain in dry years, farmers are able to produce economical crops through use of improved technology and improved cereal varieties.

Although precipitation is low, 70 to 85 percent falls during the growing season with most of it during the April to June period when the cool-weather grasses make most of their growth.

The productive soils and generally favorable climate make this type suitable for planting the more drought-tolerant grasses.

Seedbed preparation is essential to eliminate competition from native species and *B. tectorum.* Unless relatively free from *B. tectorum,* disked seedbeds did not produce grass stands as successful as those that were plowed. The most effective method of seedbed preparation was moldboard plowing followed immediately by packing and seeding. Harrowing, following plowing, lowered the seeding success since it raised blue grama sod, cactus pads, and cheatgrass seed near to the surface where these species could become reestablished and compete with the seeded grasses.

The preparatory cropping method of seedbed preparation gave variable results depending on the infestation of *B. tectorum* at the time the grasses were planted. Those treatments that eliminated most *B. tectorum* plants increased the success of the

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seeded stand, and cultivation immediately preceding planting was essential for success.

Although fall planting produced fair to good stands that often developed into good stands within 3 to 5 years, spring seeding generally gave the best results. Stands of *B. gracilis* and other warm-season species were significantly improved by planting in the spring. For spring seeding to be effective, however, it had to be done before the spring rainfall to insure establishment before the late summer dry period.

Broadcast planting generally resulted in failure, but correct drilling depths improved the seeding success. The large-seeded species were best established when drilled at 3/4- to 1-1/4-inch depths, while the small-seeded species established best from planting at 1/4- to 1/2-inch depths.

Studies near Norris, Mont., with *Melilotus officinalis* showed that seedlings of the Madrid strain established best when planted 1 inch deep, while strain PL-187985-L57, with seeds twice as large as Madrid, established seedlings best at the 2-inch depth and also produced successful stands when planted 3 inches deep.

Yields varied considerably among strains within species. In studies near Norris, Mont., the following strains appeared to be the highest forage producers of those tested: *Agropyron cristatum* (Nebraska), *A. desertorum* (Standard and Nordan), *A. elongatum* (S-64, Alkan, Mandan, and Nebraska), *A. intermedium* (Ree and Idaho 3). *A. trichophorum* (Utah 109), *Bromus inermis* (Lincoln and Montana 1), *Dactylis glomerata* (Iowa 6), and *Festuca arundinacea* (Kentucky 31 and Alta). In new stands of *A. intermedium* (South Dakota 20 and Nebraska 50) were high producers but yields declined in older stands.

Mixtures of grasses with alfalfa generally yielded higher than the component species in pure stand. The highest yielding mixture consisted of *Medicago falcata, Agropyron cristatum,* and *Poa compressa.*

At Three Forks, Mont., row spacings affected the size and vigor of bunch-type plants more than it did herbage production, where wide-spaced rows increased basal diameter and numbers of seed stalks. At Moccasin, wide-spaced rows also increased seed production of *Elymus junceus*. There, the optimum row spacing appeared to be about 7 feet.

At sites with less than 12 inches precipitation, *E. junceus* was able to maintain some of the best stands through droughty years; however, *A. cristatum* and *A. desertorum,* although reduced in stand by the drought, were the highest yielding species.

In areas receiving more than 12 inches of precipitation, species that appeared well adapted included *Agropyron cristatum*, *A. desertorum*, *A. intermedium*, *A. riparium*, *A. sibiricum*, *A. smithii*, *A. trichophorum*, *Bromus erectus*, *B. inermis*, *B. marginatus*, *Elymus junceus*, *E. canadensis*, *Stipa viridula*, *Medicago falcata*, and *Melilotus officinalis*. In the Judith Basin area, *Festuca ovina duriuscula*, *Poa ampla*, *P. compressa*, and *Agropyron trachycaulum* were also outstanding species. *A. trachycaulum*, *B. marginatus*, *E. canadensis*, and other short-lived grasses decreased in stand after 5 to 7 years.

Astragalus cicer, *A. falcatus*, *Coronilla varia*, *Lotus corniculatus*, and *Onobrychis viciaefolia* also appeared promising. However, these legumes were not consistently good producers in consecutive years.

Kalsta

Study location.—Located 3 miles north of Glenn, Madison County, at the base of McCarney Mountain, NE1/4 sec. 3, T. 4S., R. 9W. (location 49, fig. 10).

Elevation.—5,000 feet.

Average precipitation.—Annual, 8 inches; April-September, 86 percent.

Soil.—Sandy loam.

Topography.—2 to 5 percent slope to the northwest.

Type of vegetation.—Teton River-Judith Basin grasslands.

Dominant and associated species.—*Bouteloua gracilis*, *Opuntia polyacantha*, *Sporobolus cryptandrus*, *Artemesia tridentata*, and *Stipa comata*.

Previous use.—Depleted rangeland.

Study.—Kalsta species adaptation.

Date planted.—March 28 and October 22, 1958.

Procedures.—The seedbed was prepared by moldboard plowing, then packed immediately after plowing by dragging a float made from railroad ties. Eighteen species and strains were seeded in a split-plot randomized block design with three replications. Species plots were split by spring and fall seeding. Seeding was at a 1-inch depth through a cone-type hand seeder. Plots 5 by 20 feet consisted of five rows spaced 1 foot apart.

Summary of results.—Initial stands of the spring seeding were good for all species except *Stipa viridula*, *Stipa* x *Oryzopsis*, *Poa ampla*, and *Sanguisorba minor*, which were fair (table 59). Rodents ate many seeds of *S. minor* and *Stipa* x *Oryzopsis*, which undoubtedly contributed to the low rating of these two species.

TABLE 59.—*Establishment and herbage production of grasses and legumes near Glenn, Mont.*

Species	Stand 1958	Stand 1960	Stand 1962	Yield per acre (1959-62, average)
	Pct.	*Pct.*	*Pct.*	*Lb.*
Good stands maintained for 5 years:				
Agropyron desertorum (Nordan)	92	91	72	1,197
A. desertorum (Standard)	95	81	60	1,268
A. cristatum (Fairway)	85	77	60	887
Elymus junceus	78	77	84	780
E. junceus (Vinall)	82	77	83	762
Fair stands maintained for 5 years:				
Agropyron intermedium (Greenar)	87	71	46	828
Bromus inermis (Lincoln)	87	79	45	608
B. inermus (Manchar)	87	75	30	536
Fair stands maintained for 3 years but failed or maintained poor stands by the 5th year:				
Stipa viridula	57	36	5	632
Agropyron trichophorum	73	23	1	278
Medicago falcata (Ladak)	88	69	0	[1] 173
M. sativa (Rambler)	90	72	0	[1] 275
Poa ampla (Sherman)	68	37	1	[1] 534
Stipa x Oryzopsis	48	29	1	294
Sanguisorba minor	57	1	1	---

[1] 2-year average, 1959-60, only.

The fall-seeded plots were cultivated and seeded in the fall of 1958. The next year, 1959, most species were complete failures. Fair stands of *Agropyron intermedium* and *A. desertorum* (Standard) were established, however.

Stand ratings of the spring seeding in 1959 were similar to those in 1958. However, stands of *Agropyron trichophorum* and *Melilotus officinalis* were significantly reduced, and all plants of *S. minor* were dead. Stands continued to decline for all species in 1960 except for *Bromus inermis* (Lincoln), *A. cristatum*, *A. desertorum*, and *A. intermedium*. Drought in 1961 caused major reductions in 1961 and 1962 for all species except *Elymus junceus*. Both varieties of *E. junceus* were able to withstand the drought, and by 1962 they had maintained the best stands of all the species.

Herbage yields were fair to good for the grasses in 1959 and 1960 but were relatively poor for the legumes. Because of the drought in 1961, no species produced enough herbage to be harvested. By 1962 a few grasses had recovered from the drought, however, and *A. cristatum* and *A. desertorum* produced good yields, while *A. intermedium* and *E. junceus* produced fair yields. *Sporobolus cryptandrus*, a native to the area, had reinvaded the fall-seeded plots and produced 550 pounds per acre.

Red Bluff

Study location.—Located on the Red Bluff Ranch 2 miles east of Norris, Mont., NW1/4 sec. 7, T. 3S., R. 1E. (location 50, fig. 10).

Elevation.—4,900 feet.

Average precipitation.—Annual, 13 inches; April-September, 67 percent.

Soil.—Sandy loam of decomposed metamorphic material.

Topography.—5 percent slope to the southeast.

Type of vegetation.—Teton River-Judith Basin grassland.

Dominant and associated species.—*Bouteloua gracilis, Agropyron smithii, Stipa comata, Calamovilfa longifolia* and species of *Chrysothamnus, Carex* and *Poa; Bromus tectorum* had invaded the abandoned croplands.

Previous use.—Abandoned croplands grazed by sheep.

Study.—Red Bluff grass adaptation planting.

Date planted.—May 2, 1958.

Procedures.—The seedbed was prepared by moldboard plowing followed by harrowing and cultipacking. Forty-two species and strains of grass were planted in a randomized block design with four replications. Plots, 5 by 20 feet, consisted of five rows spaced 1 foot apart. The seeding was made at a 1-inch depth through a cone-type hand seeder. All old growth was mowed and removed from the plots in September 1959, and grazed by sheep in the fall of 1960.

Summary of results.—Stands were similar among the years for most species. A few species, however, particularly *Agropyron trachycaulum, Agropyron* x *Hordeum, Dactylis glomerata, Festuca arundinacea, F. ovina duriuscula, F. rubra,* and *Poa bulbosa* were reduced as stands matured. Differences among varieties within species were also negligible except for *Agropyron cristatum, A. elongatum,* and *B. inermis.* Within these species the Nebraska variety of *A. cristatum* established better than the commercial; the Utah variety of *A. elongatum* was superior to the others tested; and Lincoln spread faster than the Manchar variety of *B. inermis.* Only stands for the years of 1958 and 1963 are given in table 60 along with average yields from 1959 through 1963.

Herbage yields varied considerably among species and among varieties within species. *Agropyron intermedium* was the highest yielding species, and S.Dak. 20, Ree, and Nebr. 50 were the highest yielding varieties. Good yields were also received from most of the wheatgrass varieties with the exceptions of *Agropyron inerme, A. riparium, A. smithii,* and *A. pungens.*

Yields of most varieties were lower in 1960 than in 1959, and they continued to decline in 1961. The greatest reductions occurred with *Agropyron elongatum, A. trichophorum, A. trachycaulum, Agropyron* x *Hordeum, D. glomerata, P. ampla* and *Stipa* x *Oryzopsis.* The low yields of these species in 1961 were attributed to loss of stand and to extreme droughty conditions. The highest yielding strain that year was *A. desertorum* (Standard); it was closely followed by *A. intermedium* (Ree).

In 1962 Ree became the highest yielding variety, but it was closely followed by *A. intermedium* (Idaho 3) and *A. desertorum* (Nordan). With the exception of *A. trachycaulum* and *Stipa* x *Oryzopsis,* all other varieties had larger yields than they did in 1961.

In 1963 *Poa ampla* (Sherman) was the highest yielding species, although the *A. intermedium* strains also returned good yields.

Yield differed considerably among varieties within species. Nebraska *A. cristatum* consistently had higher yields than the commercial strain, while with the *A. desertorum* strains, S.Dak. 15 produced less in young stands than other varieties but was equal to the standard strain in the fourth year. Nordan and Mandan were similar to Standard, and yields appeared slightly higher during moist years. Standard, on the other hand, had lower yields than Nordan and Mandan during the drier years.

Yields of Nebraska were higher than the other varieties of *A. elongatum* for the first 3 years but were about equal to Mandan in the 4th and 5th years. The Utah variety dropped considerably below the others as the stands matured.

Over the 5-year period, Ree *A. intermedium* gave consistently high yields. During 1959 and 1960 it was outproduced by S. Dak.

TABLE 60.—*Establishment and herbage production of grass species and varieties near Norris, Mont.*

Species and variety	Stand 1958	Stand 1963	Herbage yield per acre (1959-63)
	Pct.	*Pct.*	*Lb.*
Agropyron intermedium:			
S. Dak. 20	80	80	2,205
Ree	83	85	2,162
Nebraska 50	85	85	1,982
Amur	80	85	1,941
Idaho 3	78	80	1,915
Greenar	80	85	1,811
A. desertorum:			
Nordan	90	90	1,868
Mandan	87	90	1,810
Standard	92	90	1,798
S. Dak. 15	98	75	1,473
A. trichophorum:			
Mandan	87	85	1,812
Utah	87	80	1,585
Topar	80	80	1,310
A. cristatum:			
Nebraska	95	85	1,752
Commercial	70	75	1,580
A. sibiricum, (P-27)	98	85	1,661
A. elongatum:			
Nebraska	80	55	1,490
Mandan	83	55	1,217
Utah	85	75	1,089
Bromus inermis:			
Lincoln	87	100	1,405
Manchar	78	85	1,225
Agropyron inerme (Whitmar)	90	60	1,233
Poa ampla (Sherman)	55	30	1,185
Bromus erectus	90	80	1,143
Agropyron trachycaulum	75	25	1,124

TABLE 60.—*Establishment and herbage production of grass species and varieties near Norris, Mont.* — Continued

Species and variety	Stand 1958	Stand 1963	Herbage yield per acre (1959-63)
	Pct.	*Pct.*	*Lb.*
Elymus junceus:			
Commercial	97	80	1,003
Vinall	78	80	808
Agropyron riparium (Sodar)	93	100	979
Stipa viridula	78	50	890
Festuca ovina duriuscula	60	35	833
Agropyron x Hordeum (X-agrohordeum)	95	5	625
Festuca rubra	83	20	519
Stipa x Oryzopsis	40	20	511
Alopecurus pratensis	45	5	452
Agropyron smithii	60	45	449
Dactylis glomerata (Potomac)	75	1	445
Elymus triticoides	55	25	344
Oryzopsis hymenoides	30	5	312
Agropyron pungens	10	5	267
Arrhenatherum elatius	5	0	212
Festuca arundinacea (Alta)	87	0	126
Poa bulbosa	45	1	125

20 and in 1959 by Nebraska 50 but was the highest producing intermediate wheatgrass in 1961, 1962, and 1963. Amur, Greenar, and Idaho 3 were medium producers. Nebraska 50, which produced high yields in 1959, became the lowest producing intermediate wheatgrass in 1960, 1962, and 1963.

Generally, the strains of *A. trichophorum* produced less than *A. intermedium*. Mandan 759 and Utah 109, however, produced good yields.

A. sibiricum generally produced yields lower than strains of *A. desertorum* but equal to the *A. cristatum* strains.

The strains of *B. inermis* were similar throughout the 5-year period. Lincoln, however, consistently produced slightly more than Manchar, and *B. erectus* generally produced less than either strain of *B. inermis*.

Yields of the commercial strain of *E. junceus* consistently were slightly higher than Vinall.

Herbage harvested in 1961 at different dates was analyzed for protein content. Generally, protein content of the grasses decreased as the season advanced (table 61). It decreased rapidly during May and early June and then at a more gradual rate after mid-June. Many strains of grass appeared to reach a low point about June 27. They recovered slightly during July then dropped off again about mid-August with another slight recovery toward the end of August. The low point of late June appeared to coincide with the flowering stage of the grass. Plants that flower later reached their low points later in the season in July. The slight recovery following flowering occurred while the seed was in the dough stage. The second low point occurred when plants were mature and seed had shattered. A slight increase in late August coincided with fall regrowth following heavy rainstorms.

Generally, differences between varieties were insignificant; however, varieties of *A. elongatum* and *A. intermedium* were noticeably different. *A. elongatum* (Mandan) was low in protein, while the Nebraska variety was consistently high in protein throughout the season. Similar differences were also noted between Greenar and Nebraska 50, two varieties of *A. intermedium.*

Study.—Red Bluff smooth bromegrass intrastate test.

Date planted.—May 1, 1958.

Procedures.—The seedbed was prepared by moldboard plowing and cultipacking. Ten varieties of *Bromus inermis* were then planted in a randomized block design with four replications. Plots 5 by 20 feet consisted of five rows spaced 1 foot apart. Similar plantings were made by each branch experimental station in Montana also.

Summary of results.—Only two varieties, Lancaster and Canadian Common, were similar to Lincoln in number of established seedlings (table 62). Lancaster exceeded Lincoln but differences were not significant. Wisconsin 63 failed to establish because of poor seed and was dropped from the analysis.

From 1959 through 1962, no significant differences occurred among stands of the *B. inermis* varieties except in 1959 when Achenback and Montana I were significantly lower than Lincoln.

Differences in yields among varieties were significant in 2 years only, 1960 and 1961. In 1960 Achenback and Manchar produced less than Lincoln, and in 1961 Montana II produced less.

Average yields over the 4 year period showed Lincoln to be the highest producer (table 62).

Ratings of spreading and sodding habits showed Lincoln, Lancaster, Southland, and Achenback to be the most vigorous spreaders, while Manchar, Saratoga, and Montana I were the weakest.

Study.—Red Bluff tall fescue intrastate test.

Date planted.—May 1, 1958.

Procedures.—The soil was plowed with a moldboard plow and smoothed with a float to prepare a clean, firm seedbed. Five

TABLE 61.—*Crude protein of grass herbage through a growing season near Norris, Mont., 1961*

Species	Crude protein in herbage on sampling dates				
	5/8	6/16	7/12	8/10	8/30
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Agropyron cristatum [1]	14.4	10.6	8.5	7.7	7.9
A. desertorum [2]	13.9	10.5	7.6	6.1	6.9
A. elongatum [3]	15.4	10.3	7.9	7.0	6.7
A. elongatum (Nebraska)	16.5	11.5	8.0	6.7	6.6
A. elongatum (Mandan)	12.6	9.1	7.1	7.2	6.3
A. intermedium [4]	13.9	10.4	8.6	7.1	8.3
A. intermedium (Greenar)	13.7	12.1	10.0	7.5	9.7
A. intermedium (Nebraska 50)	14.9	9.4	7.2	6.8	7.0
A. trichophorum [3]	15.2	9.2	7.6	7.3	7.3
A. inerme (Whitmar)	18.9	9.9	6.6	5.5	8.4
A. riparium (Sodar)	16.1	9.2	8.3	7.9	7.3
A. sibiricum (P-27)	14.0	9.8	9.5	7.1	8.9
A. trachycaulum	13.8	8.6	8.7	8.1	8.4
Alopecurus pratensis	15.4	8.9	[5]	6.4	[5]
Bromus erectus	17.6	9.3	[5]	9.9	11.4
Bromus inermis [1]	15.7	10.8	8.3	7.5	7.5
Elymus junceus [1]	17.7	11.0	9.1	7.8	9.4
Festuca ovina duriuscula	13.7	7.0	6.6	7.9	8.8
Poa ampla (Sherman)	10.3	7.9	6.8	6.4	6.1
Stipa viridula	20.0	9.1	9.1	6.8	8.3
Stipa x Oryzopsis	17.9	9.1	8.7	6.6	[5]

[1] 2-variety average.
[2] 4-variety average.
[3] 3-variety average.
[4] 6-variety average.
[5] Data not available.

strains of *Festuca arundinacea* were then planted in plots 5 by 20 feet with rows spaced 1 foot apart. The plots were replicated four times in a randomized block design.

Results.—Kentucky 31 emerged later than other varieties tested. Using Alta as the standard variety, Goar rated significantly lower, while all other varieties were similar to Alta in establishment (table 63).

The varieties maintained their stands from 1958 through 1960, but in 1961 they were seriously reduced. This reduction was attributed to the 1961 drought. Obviously, no variety was able

TABLE 62. —*Establishment and herbage yield of smooth bromegrass varieties near Norris, Mont.*

Variety [1]	Plants per foot in 1958	Stand 1959	Stand 1962	Weight per acre, oven-dry herbage (1958-62)
	No.	*Pct.*	*Pct.*	*Lb.*
Achenback	3.2	40	57	1,237
Canadian Common	4.6	65	61	1,175
Lancaster	6.1	72	72	1,459
Lincoln	5.2	68	80	1,379
Manchar	3.7	57	36	1,149
Montana I	2.9	40	49	1,642
Montana II	2.1	43	42	1,173
Saratoga	4.4	57	48	1,451
Southland	2.3	58	59	1,551

[1] Wisconsin 63 was also included but failed because of poor seed.

TABLE 63. —*Establishment and herbage yield of tall fescue varieties near Norris, Mont.*

Variety	Plants per foot, 1958	Stand 1959	Stand 1960	Stand 1961	Yield per acre, oven-dry weight (1959-61, average)
	No.	*Pct.*	*Pct.*	*Pct.*	*Lb.*
Alta	6.8	50	50	24	620
Kentucky 31	11.6	56	48	20	623
Goar	3.4	20	35	10	266
Kentucky GI-32	12.3	54	52	10	477
Oregon 4-36	6.9	43	45	5	255

to tolerate severe dry conditions. Yields of the two Kentucky varieties in 1959 and 1960 were equal to Alta, while Goar and Oregon 4-36 produced significantly less herbage than Alta. In 1961 stands and yields were poor for all varieties with no difference among varieties.

Study.—Red Bluff orchard grass intrastate test.

Date planted.—April 21, 1959.

Procedures.—The soil was plowed with a moldboard plow and floated to form a clean, firm, smooth seedbed. Nineteen strains of *Dactylis glomerata* were planted by drilling in 5-row plots with rows spaced 1 foot apart. The 5- by 20-foot plots were replicated four times in a randomized block design.

Summary of results.—In 1959 good stands of all varieties but Danish and Trogdon were established. By 1960 stands of these two strains continued to be poor (table 64), and by 1961 all varieties showed signs of winter killing. The 1961 drought further reduced stands and herbage production.

Yield differences among varieties were highly significant in 1960. That year Iowa 6 and Kentucky Syn produced more than the commercial strain, but seven other strains produced less. The next year Iowa 6 continued to be the highest yielding, but herbage production of all varieties was low.

Study.—Red Bluff alfalfa-grass mixtures.

Date planted.—May 2, 1958.

Procedures.—The soil was prepared by plowing and cultipacking to form a clean, firm seedbed. *Agropyron desertorum* (Nordan) and two varieties of *Medicago* were seeded alone and in legume-grass mixtures. The mixtures consisted of drilling the legume and the grass in alternate rows that were space 6 inches apart. The 5- by 20-foot plots were replicated four times in a randomized block design.

Results.—In 1958 more seedlings of *M. falcata* (Ladak) than of *M. sativa* (Rambler) established in both straight seedings and in mixtures with *A. desertorum.* After 1958, however, differences between stands of alfalfa varieties were insignificant although Rambler averaged slightly higher (table 65).

Differences in yield among the treatments were not significant in 1959 and 1960, but they were in 1961. All treatments decreased in yield each year, but mixtures decreased the least. Legumes in mixtures with *A. desertorum* apparently increased the total yield above either species seeded in pure stand.

TABLE 64. — *Establishment and herbage yields of orchard grass varieties near Norris, Mont.*

Variety	Stand			Yields per acre, oven-dry weight	
	1959	1960	1961	1960	1961
	Pct.	*Pct.*	*Pct.*	*Lb.*	*Lb.*
Iowa 6	82	90	34	979	247
Kentucky Syn	86	90	28	880	54
Potomac	78	91	27	769	37
Pennsylvania early	86	88	10	737	128
Iowa I	87	87	35	722	122
Aurora	84	92	26	688	26
Utah Syn 2	91	84	12	650	63
Latar	90	95	22	632	37
Avon	78	68	21	609	98
Commercial	81	86	6	592	8
Pennsylvania late	89	76	10	535	66
Wisconsin 52	78	84	32	526	123
Pennsylvania medium	70	68	11	421	72
S-37	83	72	2	359	28
Trogdon	53	50	18	322	115
Akaroa	90	76	5	260	13
Danish	56	48	7	215	36
S-26	68	56	4	147	0
S-143	72	27	1	43	0
Average	79	75	16	531	67
Least significant difference at 5 percent level	11	24	[1]	196	92

[1] Not significantly different.

Study.—Red Bluff wheatgrass intrastate test.

Date planted.—May 4, 1960.

Procedures.—The seedbed was prepared by moldboard plowing and smoothing with a float. Eighteen species and strains of *Agropyron* were drilled to a 1-inch depth through a cone-type hand seeder. Plots 5 by 20 feet were replicated four times in a randomized block design. Each plot consisted of five rows spaced 1 foot apart.

Results.—Plant counts made in 1960 and stand evaluations made in succeeding years showed good establishment of all but *A. desertorum*, *A. inerme*, and *A. elongatum* (Nebraska) (table 66). The poor stands of these species were attributed to poor seed rather than lack of adaptation since all improved their stands.

Herbage yields in 1961 were low because of the drought. That year S.Dak. 20 was the highest yielding variety with 1,167 pounds per acre.

S. Dak. 20 continued to be the highest yielding strain, and all strains improved their stands except *A. elongatum* (Mandan) in 1962. Although stands of *A. desertorum, A. inerme,* and *A. elongatum* (Nebraska) continued low, their yields were comparatively good.

In 1963 stands remained almost the same as they were in 1962, but yields of all species were lower. *A. intermedium* continued to be the highest yielding species. S.Dak. 20, Nebraska 50, and Ree were the highest yielding strains with little difference among these three.

Study.—Red Bluff sweet clover, alfalfa, and grass studies.

Date planted.—April 22, 1958, and April 22, 1959.

Procedures.—Two strains of *Melilotus officinalis,* Madrid, a widely adapted strain and an unnamed large-seeded strain, PI-18785-L57, hereafter referred to as PI-L57 for simplicity were compared under dryland conditions. Ladak alfalfa (*Medicago falcata*) and Nordan variety of *Agropyron desertorum* were included in some studies.

Plots 5 by 20 feet were replicated four times in a randomized block design. Four plantings were established. The first, seeded

TABLE 65. — *Establishment and yield of 2 alfalfa strains planted alone and in mixtures with crested wheatgrass*

Variety or mixture	Plants per foot, 1958	Stand 1959	Stand 1960	Stand 1961	Yield per acre, oven-dry weight 1959	1960	1961
	No.	*Pct.*	*Pct.*	*Pct.*	*Lb.*	*Lb.*	*Lb.*
Medicago sativa (Rambler)	2.7	57	45	20	3,825	1,925	736
M. falcata (Ladak)	4.7	42	44	14	4,250	1,645	464
Agropyron desertorum (Nordan)	4.3	70	65	67	2,100	2,022	1,368
Rambler-Nordan mixture	3.3	62	58	34	4,725	2,662	[1] 1,985
Ladak-Nordan mixture	4.0	56	51	32	4,150	1,800	[2] 1,776

[1] Nordan, 1,274 pounds per acre; Rambler, 711 pounds per acre.
[2] Nordan, 1,134 pounds per acre; Ladak 642 pounds per acre.

TABLE 66.—*Establishment and yield of* Agropyron *strains planted near Norris, Mont.*

Species and variety	Plants per foot, 1960	Stand 1961	Stand 1963	Yield per acre, oven-dry weight 1961	Yield per acre, oven-dry weight 1962	Yield per acre, oven-dry weight 1963
	No.	*Pct.*	*Pct.*	*Lb.*	*Lb.*	*Lb.*
Agropyron intermedium:						
S. Dakota 20	8.0	90	90	1,167	3,662	1,760
Nebraska 50	4.2	75	85	807	3,050	1,745
Ree	6.4	85	90	1,013	2,900	1,715
Greenar	9.5	91	90	883	3,038	1,620
Idaho 3	6.0	81	90	722	2,612	1,450
Amur	7.0	86	90	926	3,038	1,385
A. elongatum:						
Alkar	6.4	77	80	589	2,325	1,410
S-64	10.2	84	90	567	2,425	1,245
A-12365	5.4	80	80	460	1,962	1,200
Mandan	6.0	76	75	533	1,825	1,020
Nebraska	1.7	28	30	240	962	835
A. trichophorum:						
Utah	6.2	83	90	725	2,462	1,400
Mandan	4.8	78	85	915	2,538	1,385
Topar	7.1	82	90	676	2,188	1,065
A. riparium (Sodar)	7.6	79	95	502	2,150	1,135
A. sibiricum	10.5	87	90	839	2,938	1,090
A. inerme (Whitmar)	1.2	12	25	74	862	855
A. desertorum (Standard)	.3	13	20	361	1,775	395
Least significant difference at 5 percent-level		32	10	153	520	600

in April 1958, compared the two *M. officinalis* to each other, to *M. falcata*, and to *A. desertorum* in pure stands and in simple legume-grass mixtures. Rows were spaced 1 foot apart. In mixtures the legume and grass were seeded in alternate rows. The second study, also seeded in April 1958, compared the two *M. officinalis* strains seeded at varying depths ranging from broadcasting on the soil surface to drilling to a 2-inch depth. A third study was initiated in April 1959 as a repetition of the 1958 seeding depth study but with two treatments added, seeding at depths of 2 1/2 inches and at 3 inches. In both depth-of-seeding studies, rows were spaced 1 foot apart. The fourth study, also seeded in April 1959, compared the two strains of *M. officinalis* and *A. desertorum* in pure stands and in simple grass-legume mixtures. Mixtures of legume and grass seed mixed before planting and planting legume and grass in alternate rows were compared. Rows were spaced 6 inches apart.

Results.—A comprehensive report of these studies has been published (Gomm, 1964).

In summary, the report showed that PI-L57 emerged successfully from 2- and 3-inch depths with only slight reduction in number of seedlings established while seedling numbers of Madrid declined rapidly when planted at depths greater than 1 inch. The seedling plants of PI-L57 were also larger and developed faster than Madrid during the first growing season.

In the second year PI-L57 reached full bloom 2 weeks before Madrid but was about 8 inches shorter. Except under extreme seeding treatments (broadcasting and drilling to 3-inch depth), Madrid produced considerably more herbage than PI-L57. Madrid also produced more than Ladak alfalfa.

Mixtures of the *M. officinalis* strains with *A. desertorum* produced more forage than either the grass or legume alone. Averages indicated that grass in plots that contained *M. officinalis* continued to yield more than pure stands of grass.

The crude protein content in herbage from the two *M. officinalis* strains was equal to each other and higher than *M. falcata*. Protein content from grass grown with the legumes was higher than when grown in pure stand. It was also higher in grass grown with *M. officinalis* than with *M. falcata*.

Mixing legume and grass seed before seeding or seeding legume and grass in alternate rows did not affect yields.

Study.—Red Bluff sudan-sorghum adaptation test.

Date planted.—June 7, 1960.

Procedures.—The seedbed was prepared by moldboard plowing and floating. Six strains of *Sorghum sudanense*, *Sorghum almum*, and *Sorghum halepense* x *S. vulgare* were planted in rows spaced 30 inches apart. The 5- by 20-foot plots were replicated four times in a randomized block design.

Results.—Stage of development of height of plant during the growing season varied considerably among the varieties. Generally, Greenleaf and Piper developed earlier, were taller, and yielded more herbage than the other varieties. All varieties except Perennial Sweet Sorghum produced good stands.

The growing season was too short to mature seed, and Lahoma failed to produce any seed stalks. In 1961 all varieties were dead.

Obviously, these varieties are not perennial under Montana conditions.

Study.—Red Bluff legume adaptation study.

Date planted.—May 4, 1960.

Procedures.—Fourteen species and varieties of legumes were drilled to a 3/4-inch depth through a cone-type seeder. Plots 5 by 20 feet were replicated four times in a randomized block design. Each plot consisted of five rows spaced 1 foot apart.

Results.—Plant counts in 1960 showed good initial establishment for all but four treatments. Those that established poor stands were *Trifolium pratense* (Montgomery), *Astragalus cicer, A. falcatus,* and *A. semibilocularis.*

In 1961, except for *Medicago sative* (Vernal), *M. falcata* (Orenberg), and *Onobrychis viciaefolia* that produced good stands, all the other legumes nearly died out. *O. viciaefolia* bloomed early in June and set seed before the summer drought. The *Medicago* species showed effects of drought and produced little forage.

In 1962 four varieties produced sufficient forage to harvest. They were *M. sativa* (Vernal) 1,625 pounds, *M. falcata* (Orenberg) 4,150 pounds, *A. cicer* 1,300 pounds, and *O. viciaefolia* 4,062 pounds per acre.

In 1963 *A. cicer* with 1,795 pounds and *A. falcatus* with 3,720 pounds per acre were the only species that yielded enough forage to harvest. Only small, weak, scattered plants of *Medicago* and *O. viciaefolia* were found.

Study.—Red Bluff alfalfa variety and miscellaneous legumes study.

Date planted.—April 21, 1961.

Procedures.—The seedbed was prepared by moldboard plowing and floating. Fifteen species and varieties of legumes were planted by drilling 3/4 inches deep through a cone-type hand seeder. Plots were arranged in a randomized block design with four replications. Rows were space 1 foot apart in plots 5 by 20 feet. All the legumes were inoculated at time of seeding with their appropriate inoculum.

Results.—All strains of *Medicago, Onobrychis,* and *Lotus* established excellent initial stands (table 67), but those of *Coronilla varia* and *Oxytropis riparia* were poor while stands of *Trifolium ambiguum* and *Astragalus cicer* were fair. Although most plants showed drying effects from the droughty summer, they all turned green following fall rainstorms.

TABLE 67.—*Establishment of alfalfa and miscellaneous legumes near Norris, Mont.*

Species and variety	Plants per foot, 1961	Stand 1962	Yield per acre, oven-dry weight 1962	1963
	No.	*Pct.*	*Lb.*	*Lb.*
Medicago falcata:				
Orenberg	7.2	80	1,800	--
Ladak	8.2	80	712	--
M. sativa:				
Nomad	9.4	70	1,788	--
Sevelra	9.4	69	1,488	--
Teton	6.6	63	1,488	--
Vernal	7.5	58	1,412	--
Rambler	8.5	82	1,150	--
Grimm	9.6	52	788	--
Stafford	7.8	30	775	--
Onobrychis viciaefolia	5.6	20	738	--
Lotus corniculatus	6.0	79	700	2,705
Coronilla varia	.2	11	562	1,615
Trifolium ambiguum	2.4	43	300	--
Astragalus cicer	3.1	14	50	1,795
Oxytropis riparia	.3	0	---	--

In 1962 all the *Medicago* strains, except *M. sativa* (Stafford), maintained fair to good stands. *L. corniculatus* also maintained a good stand. *M. falcata* (Orenberg) was the best variety in 1962, yielding 1,800 pounds per acre. Other alfalfa varieties that compared closely with Orenberg included Nomad, Sevelra, Teton, Vernal, and Rambler. Stafford, Grimm, and Ladak produced less per acre and were similar to *L. corniculatus* and *O. viciaefolia*. *C. varia*, *T. ambiguum*, and *A. cicer* had very low yields, and *O. riparia* died out completely.

In 1963 only three species produced sufficient herbage to harvest. Stands of *L. corniculatus* were especially good while *A. cicer* and *C. varia* were only fair but produced comparatively well. Only a few scattered plants of *Medicago* were found and they were small and weak.

Study.—Red Bluff sainfoin variety tests.

Date planted.—April 17, 1961.

Procedures.—The soil was moldboard plowed and floated to form a clean, smooth, firm seedbed. Five strains of *Onobrychis* *viciaefolia* were planted by drilling 1 inch deep through a cone-type hand seeder. Plots 5 by 20 feet were in a randomized block design with four replications. Five rows per plot were spaced 1 foot apart. Where seed supplies were not large enough for five rows per plot, grass was seeded in the border rows.

Results.—Only one strain appeared well established with 5.6 plants per foot of row. This strain, referred to here as "Moccasin," was from seed grown at the Central Montana Branch Station near Moccasin, Mont. The other four strains, Giant, Turkish, Ree A, and Hampshire common, established poor stands. Seed of these four strains was received in small quantities from Beltsville, Md. Neither the source of seed or the germination was checked. In 1962, Moccasin continued to maintain a 30 percent stand while the other strains had all failed.

Study.—Red Bluff sainfoin-grass mixture study.

Date planted.—April 21, 1961.

Procedures.—The soil was plowed with a moldboard plow and floated to prepare a clean, smooth, firm seedbed. Six grasses and sainfoin *(Onobrychis viciaefolia)* were planted in straight seedings and in simple sainfoin-grass mixtures. In mixture, the sainfoin and grass seeds were mixed before planting. Plots 5 by 20 feet were arranged in a randomized block design with four replications. The seed was drilled to a 1-inch depth through a cone-type hand seeder in rows spaced 1 foot apart. The sainfoin was from seed grown near Moccasin, Mont.

Results.—All seedings except *Bromus inermis* (Lincoln) showed good establishment, but the poor establishment of Lincoln was attributed to poor seed. Again, in 1962 stands were fair to good for all treatments but *B. inermis* (Lincoln), which continued to be poor.

Herbage yields were generally good (table 68). Highest yields were from sainfoin-bromegrass mixtures and from *A. desertorum* (Nordan). *B. inermis* (Lincoln), *Stipa viridula,* and *Elymus junceus* were the lowest producing grasses.

Study.—Red Bluff creeping alfalfa variety test.

Date planted.—April 29, 1961.

Procedures.—The soil was plowed with a moldboard plow and floated to form a firm, smooth, clean seedbed. Ladak and four creeping varieties of *Medicago* (Orenberg, Rambler, Teton, and Vernal) were planted in single-row plots with 2 feet between rows. Plots were replicated four times in a randomized block design.

TABLE 68. —*Establishment of sainfoin-grass mixtures near Norris, Mont.*

Species and mixtures	Plants per foot, 1961	Stand 1962	Yield per acre, oven-dry, 1962
	No.	*Pct.*	*Lb.*
Pure seedings:			
Agropyron desertorum (Nordan)	5.6	45	1,412
A. intermedium (Nebraska 50)	3.9	56	988
Bromus inermis (Manchar)	3.4	49	738
Onobrychis viciaefolia (Sainfoin)	7.7	30	738
Elymus junceus	3.4	49	262
Stipa viridula	4.0	4	138
Mixture seedings:			
Sainfoin and Lincoln	2.4	46	1,450
Sainfoin and Manchar	3.0	66	1,325
Sainfoin and Nordan	4.1	23	1,212
Sainfoin and *Elymus junceus*	2.6	30	1,200
Sainfoin and *Stipa viridula*	6.5	44	862
Least significant difference at 5-percent level	[1]	31	590

[1] No significant difference.

Results.—Good stands of all varieties were established in 1961 with four to six plants per foot of row. By 1962 all appeared to have survived the 1961 drought equally well and showed equal winter hardiness. No variety, however, showed creeping characteristic. In 1963 only a few weak plants of each variety were found.

Whitehall

Study location.—Located 7 miles north of Whitehall, Jefferson County, near Fitz Creek, NE¼SE¼ sec. 28, T. 3N., R. 4W. (location 51, fig. 10).

Elevation.—4,650 feet.

Average precipitation.—Annual, 9 inches; April-September, 79 percent.

Soil.—Gravelly loam.

Topography.—5 percent slope to the west on alluvial outwash.

Type of vegetation.—Teton River-Judith Basin grassland.

Dominant and associated species.—*Poa secunda, Bouteloua gracilis, Stipa comata, Carex filifolia,* and *Oryzopsis hymenoides.*

Previous use.—Abandoned cropland grazed by livestock and game.

Study.—Whitehall adaptation nursery.

Date planted.—October 12, 1950.

Procedures.—Forty-two grasses and 20 legumes were planted in plots 3 by 20 feet with three rows per plot spaced 1 foot apart. The grasses and legumes were the same as those planted near Jackson (table 44). Seeding treatments were replicated three times in a randomized block design.

Results.—Initial stands of grass in 1951 were poor to failures. By the next year most species had failed or had declined in stand percentage. The only species to maintain their stands were *Agropyron sibiricum, Bromus inermis, B. erectus, Elymus junceus, Bouteloua curtipendula,* and *Oryzopsis hymenoides.*

By 1955 *Elymus junceus, Agropyron desertorum* (Standard and M24-3), and *Oryzopsis hymenoides* showed promise of being adapted to the site.

The plots were subsequently heavily grazed by livestock and game; by 1959 no seeded grass could be found.

Initial stands established by the legumes also were rated as poor to failure; by the second growing season all had failed.

Sappington

Study location.—Located 1 mile west of Sappington Junction on the south side of highway U.S. 10, sec. 30, T. 1N., R.1W. (location 52, fig. 10).

Elevation.—4,500 feet.

Average precipitation.—Annual, 13 inches; April-September, 65 percent.

Soil.—Sandy loam.

Topography.—5 percent slope to the south on rolling foothill lands.

Type of vegetation.—Teton River-Judith Basin grassland.

Dominant and associated species.—*Bouteloua gracilis, Carex filifolia, Stipa comata,* and *Agropyron smithii.*

Previous use.—Rangeland.

Study.—Sappington contour furrow planting.

Date planted.—May 1938.

Procedures.—Nine species were planted in contour furrows.

Seed was broadcast in strips 4 by 200 feet along the furrow. Seeding treatments were repeated five times. Furrows were spaced not more than 25 feet apart. They were 4 inches deep and 8 inches wide at the furrow top. Species planted were *Agropyron cristatum, A. desertorum, A. inerme, A. smithii, A. spicatum, A. trachycaulum, Arrhenatherum elatius, Bouteloua gracilis*, and *Astragalus* spp.

Summary of results.—The entire seeding was rated as poor in 1939. In 1945 three species, *A. cristatum, A. desertorum*, and *B. gracilis*, had persisted but continued to rate poor. The poor stands in 1945 may have been attributed to poor initial establishment of seedlings and undoubtedly reflect the influence of seedbed preparation and seeding method.

Tocci

Study location.—Located 2 miles north of the Helena-Butte Junction, 5 miles northwest of Three Forks, Broadwater County, sec. 16, T. 2N., R. 1E. (location 53, fig. 10).

Elevation.—4,500 feet.

Average precipitation.—Annual, 9 inches; April-September, 63 percent.

Soil.—Wheeler silt loam.

Topography.—1 to 2 percent slope to the northeast.

Type of vegetation.—Teton River-Judith Basin grassland.

Dominant and associated species.—Presently *Poa secunda, Agropyron smithii, Stipa comata, Carex filifolia, Phlox hoodii*, and a few scattered *Artemesia tridentata.*

Previous use.—Abandoned cropland - early 1900.

Study.—Tocci demonstration planting.

Date planted.—April 1954.

Procedures.—Six grasses were planted by drilling each species through a standard grain drill at two-row spacings (7- and 14-inch intervals). Plots were one-fourth acre without replication. The seedings were protected from grazing until 1959 when cattle were turned in during November and December. They were also grazed in 1960 and 1961. The old growth, which remained after grazing, was mowed to a 3-inch stubble and left as litter. In 1957, fertilizer was applied in strips across the seeded plots. Treatments included applications of ammonium nitrate at 0, 50, 75, 100, 200 pounds N per acre each with 0 and 40 pounds P_2O_5 per acre applied as treble super phosphate.

Summary of results.—In the first year of establishment *Agropyron desertorum, A. trichophorum*, and *Elymus junceus* rated good; *Agropyron intermedium* and *Stipa viridula* were fair; and *Agropyron elongatum* was poor. The establishment of *A. elongatum* was largely restricted to low places in the bottom of plow furrows. This was also true for *A. intermedium* and *S. viridula* but to a lesser degree.

Differences in yields among species were significant from 1955 to 1958 but not thereafter. Each year, however, each seeded grass produced more than the adjacent native range. Over the 7-year period (1955-61) *A. intermedium* and *A. desertorum* produced the most herbage (table 69). In dry years *E. junceus* was one of the best producers. Differences in yields due to row spacings were not significant in any year.

Low precipitation in 1956, 1958, and 1961 appeared to limit the growth of *A. desertorum*, *A. intermedium*, and *S. viridula*.

Except for minor fluctuations, herbage yields of most grasses increased until the seventh growing season (1960). The drought in 1961 reduced yields from one-half to one-sixth of the 1960 yields.

A. trichophorum spread rapidly by rhizomes. By 1957, it had filled in to a full stand and reached its peak yield. The poor initial stands of *A. elongatum* and *S. viridula* and the subsequent increase in size of plant during the succeeding year was reflected in gradually increased production.

The growth and production of *E. junceus* appeared to be strongly influenced by moisture from the previous growing season. Good moisture appeared necessary for this grass to produce seed stalks the following year. This in turn affected its total production of forage.

TABLE 69.—*Herbage yield of grasses as affected by row spacing in the Teton grassland type near Threeforks, Mont.*

Species	Yield per acre, oven-dry weight (1955-61 average)	
	7-inch space	14-inch space
	Lb.	*Lb.*
Agropyron desertorum	1,080	1,131
A. intermedium	1,200	1,011
A. trichophorum	931	997
Stipa viridula	903	946
Elymus junceus	614	665
Agropyron elongatum	620	573

Row spacing did affect the growth of individual plants. Basal diameter of plants and seed stalk numbers per unit area were much greater from 14-inch spacings of bunch grasses but not for the rhizomatous grasses since the rhizomatous grasses filled in the spaces between the rows (table 70).

The effect of fertilizers on the grasses was not conclusive. Slight differences were shown among fertilizer treatments and between drill row spacings, but they were not consistent and the various grasses appeared to respond differently to nitrogen and phosphorus fertilizers. The phosphate treatments appeared to decrease yields of the wheatgrasses but increased the yield of *Stipa viridula*, while nitrogen decreased yields of *Stipa*.

A. desertorum showed a striking response to nitrogen. Its seed stalks were slightly taller on fertilized plots, heads appeared heavier, and plants retained their green color 2 weeks longer than plants on unfertilized strips. The nitrogen fertilizer also stimulated growth of *A. intermedium* early in the growing season but caused the leaves to dry and brown as moisture became critical in early summer.

Bromus tectorum and *Salsola kali* also responded strikingly

TABLE 70.—*The effect of row spacing on the basal diameter and number of seed stalks of grasses seeded near Threeforks, Mont.*

Species	Basal diameter of plants	Seed stalks per plant
	Inch	*Number*
7-inch row spacing:		
Agropyron intermedium	3.0	6
A. trichophorum	3.0	-
A. elongatum	2.0	6
Elymus junceus	2.0	-
Stipa viridula	1.7	4
Agropyron desertorum (Nordan)	1.5	4
14-inch row spacing:		
Agropyron intermedium	3.0	6
A. trichophorum	3.0	-
A. elongatum	2.5	11
Elymus junceus	2.5	-
Agropyron desertorum (Nordan)	2.2	6
Stipa viridula	2.0	6

to nitrogen, as the growth of these two annual weeds greatly increased.

Study.—Tocci-species fertilizer study.

Previous use.—Crested wheatgrass field.

Date planted.—April 1957.

Procedures.—The soil was disked in the spring of 1956 and summer-fallowed. Ten grasses were planted in a randomized block-split plot design with fertilizer as major plots and species as subplots. Plots were 3 by 20 feet with three rows spaced 1 foot apart. Seeding was done with a belt-type hand seeder. Fertilizer treatments were applied in September 1956 at three rates (500 pounds N with 225 pounds P_2O_5 per acre; 100 pounds N with 45 pounds P_2O_5 per acre; and control, no fertilizer applied).

Summary of results.—A heavy stand of volunteer *Agropyron desertorum* and annual weeds became established during the summer of 1957. Although most of the seeds germinated, the entire seeding failed to establish. Apparently, competition from volunteer *A. desertorum* was too severe under the low-moisture conditions.

Effects of the fertilizer treatments were clearly seen in increased growth, greener plants, and greater palatability of the volunteer *A. desertorum.* Residual effects were also observed as late as 1962 when the study area was plowed.

Toston

Study location.—Located 2 miles southwest of Toston, Mont., sec. 3, T. 4N, R. 1E. (location 54, fig. 10).

Elevation.—4,200 feet.

Average precipitation.—Annual, 10 inches; April-September, 65 percent.

Soil.—Sandy loam.

Topography.—1 to 2 percent slope to the west on gently rolling lands.

Type of vegetation.—Teton River-Judith Basin grassland.

Dominant and associated species.—*Bouteloua gracilis, Poa secunda, Stipa comata, Carex filifolia,* and *Agropyron smithii.*

Previous use.—Abandoned cropland.

Study.—Toston species adaptation planting.

Date planted.—October 11, 1937.

Procedures.—Thirty-three species of grass were planted in 9- by 18-foot plots with three rows spaced 3 feet apart. The treatments were not replicated.

Results.—Many species failed to establish seedlings in the first year. Those that succeeded to estabiish stands were as follows:

Species	*Percent of row*
Initially established good stands:	
Bromus inermis	95
Elymus canadensis	95
E. junceus	90
Agropyron cristatum	80
Arrhenatherum elatius	80
Bromus marginatus	80
Agropyron pungens	70
Stipa comata	70
Initially established fair stands:	
Stipa viridula	65
Agropyron inerme	50
Established poor stands:	
Dactylis glomerata	40
Agropyron smithii	35
A. pauciflorum	20
A. spicatum	20
Poa nevadensis	15
Oryzopsis hymenoides	10
Poa ampla	8

Species that failed completely were:

Bouteloua curtipendula, B. gracilis, Buchloe dactyloides, Calamovilfa longifolia, Festuca idahoensis, Koeleria cristata, Panicum antidotale, P. virgatum, Phalaris arundinacea, Phleum pratense, Poa compressa, P. pratense, P. secunda, Puccinellia nuttalliana, Sporobolus airoides, and *S. cryptandrus.*

Judith Basin

Study location.—Located 25 miles south of Lewistown near Straw, Judith Basin County, sec. 24, T. 13N., R 14E., (location 55, fig. 10).

Elevation.—4,300 feet.

Average precipitation.—Annual, 15 inches; April-September, 76 percent.

Soil.—Doughty silt loam and Utica gravelly silt loam; subsoil is gravelly and heavily lime coated.

Topography.—1 to 2 percent slope to north.

Type of vegetation.—Teton River - Judith Basin grassland.

Dominant and associated species.—The original vegetation consisted of *Bouteloua gracilis, Agropyron smithii, Stipa comata,* and *Poa secunda*. At time of seeding the area was heavily infested with *Bromus tectorum*, *B. japonicus*, and *Salsola kali*.

Previous use.—Abandoned cropland - varying lengths of abandonment.

Study.—Judith Basin species adaptation plantings were made from April 1943 to April 1946. The procedures for each study are presented separately. The results, however are summarized in table 71.

TABLE 71.—*Establishment of grasses and legumes as affected by time of seeding near Straw, Mont.*

Species	Stand [1] Spring seeded 1943	Spring seeded 1945	Spring seeded 1952	Fall seeded 1944	Fall seeded 1945-46	Fall seeded 1952
	Rating	*Pct.*	*Pct.*	*Rating*	*Pct.*	*Pct.*
Established equally well from spring and fall planting and maintained good stands for 7 to 9 years:						
Poa compressa	F	90	100	P	15	100
Agropyron cristatum	G	90	100	G	90	95
Bromus erectus	G	95	100	[2]	48	89
Agropyron spicatum	G	90	95	G	90	95
Bromus inermis	F	90	95	P	25	95
Festuca ovina duriuscula	G	95	95	F	95	92
Agropyron smithii	F	75	95	F	50	90
A. trachycaulum	G	95	95	G	90	90
Poa ampla	F	80	90	G	90	95
Bromus inermis (Parkland)	G	90	95	P	35	85
Poa stenantha	G	80	90	P	55	90
Medicago falcata	F	95	75	F	95	85
Established best from spring plantings and maintained good stands for 7 to 9 years:						
Agropyron desertorum	G	90	95	G	70	73
Arrhenetherum elatius	G	95	90	G	90	60
Agropyron intermedium	G	55	95	F	67	50
Elymus junceus	G	90	83	G	51	67
Agropyron inerme	G	85	65	G	60	30
Festuca arundinacea	G	85	60	F	85	10

Footnotes at end of table.

TABLE 71.—*Establishment of grasses and legumes as affected by time of seeding near Straw, Mont.*—Continued

Species	Stand[1]					
	Spring seeded			Fall seeded		
	1943	1945	1952	1944	1945-46	1952
	Rating	*Pct.*	*Pct.*	*Rating*	*Pct.*	*Pct.*
Established better from fall than spring plantings and maintained good stands for 7 to 9 years:						
Stipa viridula [3]	-	--	--	-	[4] 60	86
Phleum pratense [3]	-	--	--	-	[4] 50	65
Agropyron caninum	F	5	0	G	90	60
Good stands established but maintained less than 7 years:						
Agropyron sibiricum	F	60	50	G	1	50
Dactylis glomerata [3]	-	--	--	-	[4] 62	41
Agropyron dasystachyum	G	75	10	G	50	10
Elymus canadensis [4]	-	[4] 100	0	-	--	--
Bromus carinatus	G	90	0	-	60	0
Sanguisorba minor [3]	-	--	--	-	[4] 90	1
Bromus marginatus	G	85	0	F	85	0
Good stands established but maintained less than 7 years—Con.						
Elymus dahuricus	G	30	0	P	60	0
Medicago lupulina	G	25	0	P	40	0
Elymus sibiricus	G	15	0	F	40	0
Poa bulbosa	G	40	0	G	0	0
Phalaris arundinacea	G	5	0	F	5	0
Poorly established or failed:						
Agropyron elongatum	F	10	20	F	30	15
A. semicostatum	P	0	0	P	0	0
Bouteloua curtipendula	F	0	20	0	0	1
B. gracilis	P	5	25	P	0	0
Elymus cinereus	F	40	40	P	0	0
E. sibiricus	G	15	0	F	40	0
Elymus x Secale	F	0	0	F	40	0
Eragrostis curvula [4]	-	--	--	-	30	0

Footnotes at end of table.

TABLE 71.—*Establishment of grasses and legumes as affected by time of seeding near Straw, Mont.*

Species	Stand[1]					
	Spring seeded			Fall seeded		
	1943	1945	1952	1944	1945-46	1952
	Rating	*Pct.*	*Pct.*	*Rating*	*Pct.*	*Pct.*
E. trichoides [4]	-	--	--	-	10	0
Festuca rubra	F	35	1	P	5	0
F. scabrella	F	5	35	P	3	1
Phleum boehmeri [4]	-	--	--	-	1	1
P. phleoides [4]	-	--	--	-	1	10
Sorghastrum nutans [4]	-	--	--	-	0	0
Lotus corniculatus [4]	-	--	--	-	40	0
Onobrychis vulgaris [4]	-	--	--	-	30	1

[1] Rating G = good; F = fair; P = poor.
[2] Data not available.
[3] Fall-planted only.
[4] Planted in 1946 only.

Study.—Judith Basin species adaptation plantings (1943).

Date planted.—April 17, 1943; October 14-15, 1943.

Procedures.—Forty species of grasses and legumes were planted in plots 5 by 20 feet with three rows spaced 18 inches apart with a 6-inch border between plots. Seeds were scattered in handmade furrows and covered to simulated drilling. Before spring planting the seedbed was prepared by plowing, harrowing, and packing. The seedbed received no additional preparation before fall seeding.

Summary of results.—Competition from cheatgrass *(Bromus tectorum)* was heavy in both the spring and fall seeding. The poor stands of some species were attributed to the seedbed conditions and cheatgrass competition rather than unadaptability, because many of these species appeared vigorous and their stands increased. In general spring seeding gave better results although many species established about equally well from fall planting. The poorer stands from fall seeding may have been caused by the greater competition of cheatgrass and lack of preparation of the seedbed.

Many species appeared well adapted; although *Poa compressa* and *Medicago falcata* started slowly they became well established. *Festuca ovina* established good stands early in the study and was spreading by seed throughout most of the adjoining plots. *Agropyron caninum* was the only species that established a better stand from fall seeding. Species that appeared outstanding after 10 years included *Agropyron cristatum, A. desertorum, A. intermedium, A. smithii, A. spicatum, A. trachycaulum, Arrhenatherum elatius, Bromus erectus, B. inermis, Elymus junceus, Festuca ovina, Poa ampla, P. compressa, P. stenantha,* and *Medicago falcata* (table 71).

Study.—Judith Basin Nursery row planting.

Previous use.—Previously part of wheat stubble preparatory crop.

Date planted.—October 24, 1945, and April 18, 1946.

Procedures.—Twenty-seven species were planted in plots 3 by 20 feet. Twenty-five of them were planted in the fall and two in the spring. The spring-seeded species were *Elymus canadensis* and *Poa stenantha*. Seeds were drilled with a Planet Junior hand seeder into rows spaced 1 foot apart. Before seeding, the seedbed was prepared by cultivating twice with a spring-tooth harrow followed by a rod weeder. Litter and rocks were hand raked from the area.

Summary of results.—In the first growing season most of the species produced fair to good stands. Those that rated poor were *Dactylis glomerata* (Aberystwyth), *Elymus sibiricus, Eragrostis curvula, Phleum boehmeri, P. phleoides, Poa stenantha,* and *Sorghastrum nutans.*

Species that had maintained good stands by the seventh season included *Agropyron cristatum, Bromus erectus, B. inermis, Festuca ovina,* and *Phleum pratense. Elymus canadensis,* which had a near full stand initially, was completely lost by the seventh growing season.

The failure of some other species to do well is not necessarily lack of adaptation, since they have shown to be fairly well adapted in larger plots, particularly when spring seeded.

Study.—Judith Basin species and mixture seedings.

Previous use.—The area was previously part of a study to compare plowing vs. disking for seedbed preparation.

Date planted.—October 22-24, 1945.

Procedures.—Thirteen species were planted in 16- by 25-foot plots. The plots were seeded with a Planet Junior hand seeder in rows spaced 14 inches apart at rates of 4 to 8 pounds of seed per acre. The plots were replicated four times with two replications on each of the two seedbed plots. Three mixtures of species were also seeded in 33- by 25-foot plots replicated eight times. Seeding was done with a one-horse drill at approximately 5 pounds of seed per acre. Four replications were made on each of two seedbeds. Previously, the seedbeds had been prepared by plowing two strips—one with a moldboard plow, the other with a disk. Both strips were then seeded to wheat in May 1945 and harvested in October. After harvesting, the seedbed was cultivated twice with a springtooth harrow and weeded with a rod weeder.

Summary of results.—Stands of seeded grasses were generally poor to fair in the first growing season. *Stipa viridula*, however, did produce a good stand. In the succeeding years most of the species maintained or improved their stands, and by the seventh growing season all but three of the species, *Agropyron trichophorum*, *Arrhenatherum elatius*, and *Festuca arundinacea*, had produced good stands. Likewise, the mixtures had filled in to nearly complete stands. When planted together, mixtures of *Agropyron cristatum* and *Bromus erectus* were codominant species of equal proportions. When planted with *Bromus inermis*, however, *A. cristatum* was suppressed by *B. inermis* and in mixtures with *Festuca ovina*, it was suppressed by *F. ovina*. Apparently, *F. ovina* and *B. inermis* are the strongest competitors of the species tested.

Although *Medicago falcata* was never abundant in the mixtures, it was able to maintain itself at about 10 percent of the stand.

Study.—Judith Basin range plots.

Date planted.—October 30-31, 1940, and October 13, 1941.

Procedures.—Fifteen grasses and five mixtures were planted in 1/10-acre plots. The plots were seeded so that part of each was in strips of heavy cheatgrass, Russian-thistle sweet clover, and wheat stubble. The cheatgrass area had been abandoned for 4 years and the Russian-thistle for 2 years. Seeding was done with a one-horse drill in October 1940 with rows spaced 14 inches apart.

Two grasses, *Elymus sibiricus* and *E. junceus*, were seeded October 1941. These grasses were not planted in the original seeding. *Festuca ovina* was also planted adjacent to the earlier seedings in wheat stubble.

Summary of results.—In the seedling year, stands were generally poor where *Bromus tectorum* was heavy. They were generally fair to good on plots infested with *Salsola kali* and good when planted in wheat stubble. By the second growing season most plants in the heavy cheatgrass had failed, but *Agropyron cristatum*, *A. desertorum*, and *Bromus erectus* established good stands in the Russian-thistle infested plots. By the fifth growing season, the best stands were maintained on the wheat stubble from *A. cristatum*, *Festuca ovina*, and *Poa compressa*. Other species that appeared promising with good stands were *Agropyron trachycaulum*, *B. erectus*, and *Medicago falcata*. Those with fair stands were *Bromus inermis*, *Arrhenatherum elatius*, *Agropyron spicatum*, *A. intermedium*, *A. inerme*, and *A. smithii*, and those with poor stands were *Agropyron dasystachyum*, *Elymus junceus*, *E. sibirucus*, *Elymus* X *Secale*, and *Poa ampla*.

By 1952, 12 years after seeding, several species had improved. Included in the group with good to excellent stands were *Agropyron cristatum*, *A. desertorum*, *A. intermedium*, *A. trachycaulum*, *A. smithii*, *Arrhenatherum elatius*, *Bromus erectus*, *B. inermis*, *Festuca ovina*, and *Poa compressa* (table 72).

In the mixtures, *P. compressa* appeared to be an important competitive grass, crowding out *A. cristatum*. *A. cristatum*, however, was able to compete with *B. inermis* and *B. erectus*. *Medicago falcata* in mixtures with the grasses maintained its stand from 20 to 40 percent of the stand, while the grasses made up the rest.

Herbage yields averaged for 3 years showed *A. inerme*, *A. intermedium*, *P. ampla*, *F. ovina duriuscula*, *P. compressa*, and *A. spicatum* to be the highest yielding single species, but they were surpassed by two mixtures. One of these yielded 2,864 pounds of which 341 were from *A. cristatum*, 1,240 for *P. compressa*, and 1,283 from *M. falcata*. The other yielded 2,381 pounds of forage per acre of which *A. cristatum* contributed 1,500 pounds and *M. falcata* contributed 881.

Study.—Judith Basin range production plots.

Previous use.—The area was previously a test of two methods of seedbed preparation.

Date planted.—April 18-19, 1946.

Procedures.—Before seeding, the seedbed had been prepared by plowing and by disking two blocks in a test of the two methods. In 1945 wheat was seeded and harvested in a preparatory cropping system. After harvesting the area was cultivated and weeded with a rod weeder. In the spring of 1946 each block was again cultivated with a duck-foot cultivator and harrowed.

Fifteen grasses and alfalfa were planted in 22- by 66-foot plots with treatments replicated twice in a randomized block design. Each species was planted with a one-horse drill. Seeding rates and depths of seeding were controlled to give the best stand possible for the species. Rows were spaced at 7 inches.

Summary of results.—Except for *Bromus inermis*, all the species established good stands (table 73). The poor stand of *B. inermis* in the seedling year was undoubtedly due to seed

TABLE 72.—*Establishment and herbage production of seeded species as affected by seedbed preparation near Straw, Mont.*

Species or mixture	Stand, 1942[1]			Stand, 1952, wheat-stubble seedbed	Yield per acre oven-dry weight, 1946-48[2]
	Cheat-grass seedbed	Russian thistle sweet-clover	Wheat-stubble seedbed		
	Rating	*Rating*	*Rating*	*Percent*	*Pounds*
Good stands maintained for 12 years:					
Poa compressa	0	0	G	100	2,195
Bromus inermis (Parkland)	0	0	F	100	1,866
B. erectus	0	G	G	100	1,830
B. inermis (Lincoln)	0	P	F	100	1,591
Agropyron desertorum (Standard)	0	G	G	100	1,533
A. cristatum (Fairway)	0	G	G	100	1,211
A. intermedium	0	F	F	90	2,674
Festuca ovina duriuscula	-	-	F	90	2,293
Arrhenatherum elatius	0	P	F	60	[3] 1,236
Agropyron pauciflorum	0	0	G	60	1,200
A. smithii	0	0	P	60	[4] 1,006
Fair to poor stands maintained for 12 years:					
Agropyron spicatum	0	P	F	55	2,110
A. inerme	0	0	F	30	[3] 2,826
Elymus junceus	0	0	F	20	1,897
Poa ampla	0	0	P	10	[4] 2,529
Failed completely within 5 years:					
Agropyron dasystachyum	0	0	F	0	---
Elymus sibiricus	0	0	F	0	---
Elymus x Secale	0	0	G	0	---

[1] Stand rating G = good; F = fair; P = poor.
[2] Wheat stubble seedbed.
[3] 2-year average.
[4] 1-year only.

TABLE 73.—*Establishment and herbage yield of species planted in a well-prepared seedbed following a preparatory cropping system near Straw, Mont.*

Species	Stand[1]				Yield per acre, oven-dry weight		
	1946	1950	1952	1959	1947	1948	1959
	Pct.	*Pct.*	*Pct.*	*Rating*	*Lb.*	*Lb.*	*Lb.*
Agropyron intermedium	78	80	G	100	1,052	1,318	1,900
Festuca ovina duriuscula	75	100	G	100	1,244	2,004	1,600
Bromus inermis (Lincoln)	80	100	G	100	[2]	1,952	1,400
Poa compressa	50	90	G	100	1,048	2,105	1,400
Bromus erectus	78	92	G	100	775	1,467	1,200
Poa ampla	80	95	G	95	912	1,560	1,400
Bromus inermis	15	85	G	95	1,296	1,094	1,100
Agropyron cristatum	75	82	G	90	1,131	1,882	1,900
Elymus junceus	75	82	G	90	847	970	900
Agropyron inerme	80	82	G	75	1,193	1,374	1,900
Bouteloua gracilis	78	82	G	75	[2]	196	900
Agropyron spicatum	60	40	F	75	[2]	346	400
Stipa viridula	75	72	G	1	1,147	1,011	1,200
Arrhenatherum elatius	88	82	F	1	1,068	1,607	400
Medicago falcata	78	98	G	[2]	1,296	855	900
Agropyron trachycaulum	85	80	G	0	1,434	1,355	0

[1] Stand rating G = good; F = fair.
[2] Data not available.

quality since it improved to a complete stand by the seventh season.

By the third growing season, species that gave good control of cheatgrass included the following: *Agropyron cristatum*, *Bromus erectus*, *B. inermis* (Lincoln), *Festuca ovina*, *Poa ampla*, and *P. compressa*. Those showing moderate control of cheatgrass were *Agropyron inerme*, *A. intermedium*, *A. trachycaulum*, *Arrhenatherum elatius*, *Bromus inermis*, *Elymus junceus*, and *Medicago falcata*. Those giving the least control were *Agropyron spicatum*, *Bouteloua gracilis*, and *Stipa viridula*.

By 1952, the seventh growing season, *Poa compressa* and *Festuca ovina* were generally scattered throughout the area. *P. compressa*, in particular, was taking over the plots of *Agropyron inerme*, *A. spicatum*, *A. trachycaulum*, *Arrhenatherum elatius*, and *Bouteloua gracilis*. As late as 1959, in the 14th year, good to excellent stands of all but three species were maintained.

A. trachycaulum died out completely, and only traces of *A. elatius* and *S. viridula* were left. They were replaced by *P. compress* and *F. ovina.*

The highest yielding species in 1947 were *A. trachycaulum, M. falcata, B. inermis,* and *F. ovina* with 1,434, 1,296, 1,296, and 1,244 pounds of herbage per acre, respectively (table 73). In 1948 *P. compressa, F. ovina,* and *B. inermis* produced the most herbage with 2,105, 2,004, and 1,952 pounds per acre. By 1959, *A. cristatum, A. inerme,* and *A, intermedium,* each produced 1,900 pounds per acre. Yields of most of the other species averaged from about 1,000 to 1,500 pounds per acre.

Study.—Judith Basin preparatory crop planting (1943).

Date planted.—April 17, 1943; May 29, 1943; October 15, 1943.

Procedures.—In April, a 1-acre area was plowed and harrowed, one-fourth of which was planted to spring rye, one-fourth to barley and one-fourth to *Agropyron desertorum.* In May, 1/8 acre was seeded to *Sorghum sudanense* leaving 1/8 acre in fallow. In October, *A. desertorum* was drilled across part of the previously seeded treatments and across an adjoining strip of undisturbed *Bromus tectorum.*

Summary of results.—Because the soil was wet, a poor seedbed resulted from the spring plowing. As a result, the ground was left uneven and the litter was not all turned under. Stands of barley and rye were uneven. It was estimated, however, that they would have yielded approximately 15 to 20 bushels per acre. Plowing reduced the *B. tectorum* to about 5 percent stand, but mustard weeds made a heavy growth. Weeds were less dense in the preparatory crop strips than in the fallowed strip.

A. desertorum planted into the freshly plowed area in April 1943 established a good stand of vigorous plants. Because of an exceedingly dry season in 1944, however, *A. desertorum* planted in the fall of 1943 remained dormant on the preparatory cropping strips. It completely failed on the unprepared cheatgrass area, whereas on the plowed area seeded in the spring of 1943 a fair stand of thrifty plants remained. Herbage of *A. desertorum* from the April 1943 planting produced 2,030 pounds per acre in 1946, 1,048 in 1947, and 1,944 in 1948.

Study.—Judith Basin adaptation study following preparatory cropping.

Previous use.—The study site was previously part of preparatory crop planting (1943) in which *Agropyron desertorum,* rye, barley, and sudan grass were planted.

Date planted.—October 15, 1943.

Procedures.—Part of the area used in the preparatory cropping study was seeded to eight species with a one-horse drill. Rows were spaced 7 inches apart in plots 14 by 64 feet. Seeding was done at 8 to 10 pounds per acre.

Summary of results.—Because of the dry season in 1944, initial establishment was not determined, but in 1945 stands of grasses and alfalfa were found on most plots. The poorest stands were found on the strips of *A. desertorum* and rye. The better stands followed barley, sudangrass, and fallow. From 1948 to 1952 all the seeded species on the barley strip had developed good stands (table 74).

In 1946 the highest yielding species were *Medicago falcata*, *Poa ampla*, and *Agropyron cristatum* with 1,539, 1,145, and 1,124 pounds per acre. In 1947 only two species were harvested; then *P. ampla* produced 1,810 and *Elymus junceus*, 863 pounds per acre. In 1948 *M. falcata* again had the highest yields of three species with 2,076 pounds per acre compared with *P. ampla* with 1,881 pounds and *E. junceus* with 1,138 pounds.

Study.—Judith Basin preparatory crop planting (1944).

Date planted.—May 26, 1944.

Procedures.—Four grains—spring rye, spring wheat, barley, and oats—were drilled in 2-acre blocks at 50, 55, 45, and 32 pounds per acre. The seedbed was previously prepared by plowing and harrowing. After harvesting in the fall, one-half of each area

TABLE 74.—*Establishment of forage species as affected by different preparatory crops near Straw, Mont.*

Species	Stand following preparatory crops					
	Crested wheat-grass, 1945	Rye, 1945	Sudan grass, 1945	Fallow, 1945	Barley, 1945	1945
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Agropyron cristatum	30	25	40	35	35	100
Elymus junceus	5	15	18	30	5	85
Poa ampla	35	50	55	35	50	80
Bromus erectus	25	30	30	30	30	80
Agropyron intermedium	15	20	18	55	10	80
Bromus inermis	0	2	3	2	3	80
Arrhenatherum elatius	15	40	8	15	25	60
Medicago falcata	40	35	60	35	45	50

was cultivated. In October 1944 and May 1945, the whole plot was then seeded to perennial grasses.

Summary of results.—At harvesttime oats produced 29.3 bushels of grain per acre while barley, wheat, and rye produced 16.8, 12.8 and 10.1 bushels, respectively.

Cultivation of the stubble in October reduced subsequent stands of cheatgrass (table 75). Less than 5 percent as many mature cheatgrass plants were counted on cultivated areas as on noncultivated. Cultivation did, however, increase the numbers of Russian-thistle, sweet clover, and other weeds. Rye established many volunteer plants most of which were on the cultivated area.

The establishment of grasses following preparatory cropping indicates that stands were best following oats, barley, and wheat; the poorest stands followed rye. Cultivation of the stubble before planting grass increased establishment of both fall and spring seedings, but spring plantings responded more. On areas that were planted to grass but not cultivated, differences in time of seeding were small.

TABLE 75.—*The effect of cultivation following preparatory crops on establishment of weedy plants*

Weedy plants	Established weedy plants per square yard following preparatory crops			
	Barley	Rye	Wheat	Oats
	No.	*No.*	*No.*	*No.*
Cultivated seedbed:				
Cheatgrass seedlings	187	88	158	154
Cheatgrass mature	45	11	64	50
Volunteer grain	0	120	7	5
Russian-thistle	81	154	101	32
Sweetclover	150	7	217	143
Others	78	72	58	104
Noncultivated seedbed:				
Cheatgrass (seedlings)	906	1,007	803	805
Cheatgrass (mature)	1,012	1,056	1,065	582
Volunteer grain	0	0	0	3
Russian-thistle	10	27	14	5
Sweetclover	210	104	199	25
Others	6	14	7	0

Study.—Judith Basin range plantings following preparatory crops.

Previous use.—The study area was previously part of preparatory crop planting (1944).

Date planted.—October 20-21, 1944, and May 5, 1945.

Procedures.—Twelve grasses and three mixtures were planted at rates of 6 to 8 pounds per acre in ¼-acre plots by drilling with a one-horse drill. Rows were 7 inches apart. The seedbed had been prepared by plowing and harrowing in 1944 and planting to preparatory crops. The crops included barley, wheat, oats, and rye. Following the grain harvest in October 1944, each cropped area was double cultivated, harrowed, and planted to grass. No further treatment was made for the spring seeding. The fall planting was made on the areas previously planted to rye and wheat. The spring seeding was on the oat and barley areas.

Summary of results.—Both seedings were generally poor the first year. In succeeding years, however, all the species improved their stands. By 1952, the eighth growing season, species that rated good in at least one planting were *Agropyron cristatum, A. inerme, A. spicatum, A. trachycaulum, Arrhenatherum elatius, Bromus erectus, Elymus junceus, Festuca ovina, Poa ampla,* and *P. compressa* (table 76). Only two grasses rated poor, *Agropyron intermedium* and *Bromus inermis.* These seeds were probably poor quality since they produced fairly good yields in 1959.

In mixtures, *F. ovina* and *B. erectus* were outstanding. Generally, they became the dominant grasses in the mixtures. *Medicago falcata* also became an important part of the mixtures. In spring seedings, *M. falcata* increased to very good stands, while in the fall-seeding treatments it rated fair. *A. cristatum* increased in mixtures with *M. falcata* to very good stands, but in mixtures with *F. ovina* and *B. erectus*, it was crowded out. *F. ovina* and *B. erectus* in the same mixture were intensely competitive as evidenced by a solid ground cover of which *F. ovina* formed 60 percent, and *B. erectus* 40 percent. In these mixtures, the seed crop on both species was extremely light.

Herbage samples were harvested for only two species in 1946 and 1947. *Arrhenatherum elatius* produced 841 pounds per acre in 1946 and 996 in 1947. *Agropyron trachycaulum* yielded 592 pounds in 1946 and 1,171 in 1947. In the 15th growing season, 1959, *Agropyron inerme* was the highest yielding species producing 3,850 pounds per acre. The second highest was *A. cristatum* with 2,600 pounds. Of the mixture harvested in 1959, the one

TABLE 76.—*Establishment and yield of grasses following preparatory crops near Straw, Mont.*

Species	Stand [1]				Yield per acre, oven-dry weight (1959)
	Fall seeded		Spring seeded		
	1945	1952	1945	1952	
	Pct.	*Rating*	*Pct.*	*Rating*	*Lb.*
Agropyron cristatum	10	G	40	G	2,600
Bromus erectus	10	G	40	G	1,700
Festuca ovina duriuscula	1	G	20	G	1,350
Poa ampla	1	G	5	G	1,800
P. compressa	5	G	5	G	2,150
Arrhenatherum elatius	10	F	80	G	2,150
Elymus junceus	1	F	40	G	1,900
Agropyron inerme	0	P	30	G	3,850
A. spicatum	1	P	20	G	2,150
A. trachycaulum	10	P	40	G	1,300
A. intermedium	8	F	20	P	1,500
Bromus inermis (Parkland)	1	P	6	P	1,800

[1] Rating G = good; F = fair; P = poor.

that contained *A. cristatum, A. trachycaulum,* and *M. falcata* had the highest yields, with 3,350 pounds per acre.

Study.—Judith Basin species adaptation following preparatory cropping.

Previous use.—Preparatory cropping study (1944) that had been planted to barley, wheat, oats, and rye.

Date planted.—October 20-21, 1944, and May 9, 1945.

Procedures.—Thirty-two species and selections were planted in plots 14 by 32 feet. The spring seeding was a repetition of species and selections seeded in the fall except that *Onobrychis vulgaris* and a standard selection of *Dactylis glomerata* were included in the spring seeding.

The seedbed had been prepared by plowing, harrowing and preparatory cropping to spring rye. After harvesting, the stubble was cultivated before planting.

Summary of results.—Except for *Stipa viridula*, the initial stands of the fall-seeded plots were relatively poor. By the seventh growing season, however, most of the fall-seeded plots had developed into good stands (table 77). Species that were most outstanding in the fall seeding were *S. viridula, Phleum pratense, P. boehmeri, Poa compressa,* and *Bromus erectus.* Others that had increased to good stands included

Arrhenatherum elatius, Bromus inermis, Festuca arundinacea, F. ovina, Phleum phleoides, and *D. glomerata.*

The spring seeding was much superior to the fall seeding. Most species established with good stands, and most of those with relatively poor stands during the seedling year increased to good and excellent stands by the seventh growing season. Two species *Bromus carinatus* and *B. marginatus*, however, decreased in stand and were completely lost by the fifth growing season. Stands of *Medicago falcata* and *Onobrychis vulgaris* also declined but *M. falcata* apparently recovered sufficiently to produce good yields. By 1959 *Agropyron trachycaulum, Festuca*

TABLE 77.—*Establishment and herbage yield of species planted in the fall and spring following preparatory cropping to spring rye*

Species	Stand				Yield per acre, oven-dry weight (1959)
	Fall seeded		Spring seeded		
	1945	1952	1945	1952	
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Lb.*
Poa compressa	1	85	25	100	1,600
Stipa viridula	75	100	85	95	[1]
Phleum pratense	5	95	95	95	700
Bromus erectus	25	90	60	95	1,500
Festuca ovina duriuscula	1	80	65	95	1,700
Dactylis glomerata	15	65	100	95	700
Bromus inermis	1	65	10	95	1,400
B. inermis (Parkland)	1	45	10	95	600
Elymus junceus	5	30	50	95	700
Agropyron smithii	5	10	85	95	1,300
Festuca arundinacea	35	70	95	90	[1]
Agropyron cristatum	5	5	75	90	2,400
A. intermedium	5	0	10	90	2,000
Phleum boehmeri	5	85	5	80	500
Poa ampla	1	45	75	80	[1]
Agropyron trachycaulum	1	1	90	80	[1]
A. inerme	0	0	25	80	2,300
Phleum phleoides	5	75	5	75	1,000
Agropyron spicatum	1	1	25	65	1,400
Arrhenatherum elatius	5	70	75	60	300
Onobrychis vulgaris	[1]	[1]	75	50	[1]
Medicago falcata	5	45	90	40	2,700
Bromus carinatus	25	0	85	0	[1]
B. marginatus	25	0	75	0	[1]

[1] Data not available.

arundinacea, Poa ampla, and *Stipa viridula* had also decreased to where they were not harvested for herbage yields.

Elymus junceus was the only species harvested in 1947 and *S. viridula* the only one in 1948. These two species yielded 813 and 1,050 pounds per acre, respectively. By 1959, the 15th growing season, *M. falcata* was the highest yielding species with 2,700 pounds per acre. *Agropyron cristatum, A. inerme,* and *A. intermedium* were the next highest species with 2,400, 2,300, and 2,000 pounds per acre.

Moccasin

Study location.—Located 2 miles west of Moccasin, Judith Basin County, at the Central Montana Branch Experiment Station, sec. 21, T. 15N., R. 14E. (location 56, fig. 10).

Elevation.—4,200 feet.

Average precipitation.—Annual, 14 inches; April-September, 73 percent.

Soil.—Moccasin gravelly silt loam.

Topography. —Gentle 1-percent slope to the northeast on gravel-capped benchland.

Type of vegetation.—Teton River-Judith Basin grassland.

Dominant and associated species.–*Bouteloua gracilis, Poa secunda, Stipa viridula, S. comata,* and *Agropyron smithii.*

Previous use.—Cultivated cropland.

Study.—Review of early adaptation studies near Moccasin, Mont.

Results.—From 1922 to 1935 many species and selections were tested for adaptation. The most outstanding species included *Agropyron cristatum, A. repens, A. sibiricum, A. tenerum, Bromus inermis, B. marginatus, Elymus junceus,* and *E. canadensis.* Considerable variation occurred among selections within species. M24-3 the most outstanding selection tested of *A. cristatum* was used in much of the early improvement work at Moccasin. This selection was later identified as belonging to *A. desertorum.*

Planting by drilling was more successful than planting by broadcasting. Except for poor to fair stands of *A. cristatum* and scattered plants of a few other species, broadcasted treatments failed.

Study.—Moccasin single-row adaptation planting.

Date planted.—November 6, 1937.

Procedure.—Eighteen grasses were planted in single-row plots. Rows were 16 feet long spaced 3 feet apart. Seeding was done by spreading seed in handmade furrows and covering with one-fourth inch of soil. The study was plowed out in the spring of 1940.

Results.—In 1938 nine of the grasses, *Agropyron cristatum, A. pauciflorum, A. pungens, A. spicatum, Arrhenatherum elatius, Bromus inermis, B. marginatus, Elymus canadensis,* and *E. junceus,* established good stands. Those that established poor to fair stands were *Agropyron smithii, Oryzopsis hymenoides, Poa ampla, Stipa comata,* and *S. viridula.* Those that failed completely were *Bouteloua curtipendula, B. gracilis, Panicum virgatum,* and *Sporobolus cryptandrus.*

Study.—Moccasin grasses and mixtures for dryland pastures.

Date planted.—May 9, 1939.

Procedure.—Fourteen grasses and two mixture of grasses and alfalfa were planted with three replications per treatment. Plots were 6 by 132 feet with rows 6 inches apart. In 1940 every other row was cultivated out, leaving uneven stands in some plots.

Results.—The initial stand of each species was good, but later *Bouteloua curtipendula* and *B. gracilis* failed almost completely. In the third growing season, stands of these two species were so poor that they were not harvested.

From 1941 to 1948 herbage production varied; only occasionally were *Agropyron smithii, Oryzopsis hymenoides,* and *Poa secunda* harvested.

Most species produced their best yields in 1942, the fourth growing season. By 1946 and 1947, yields had declined to a low level, which they generally maintained in 1948. *Poa secunda* had almost died out by 1944 and was not harvested then or thereafter. Over the 8-year period, strains of *Agropyron desertorum, A. inerme,* and *Poa ampla* were the highest producing selections, but they were outproduced by the two mixtures (table 78).

Chemical analyses of the herbage harvested July 19, 1945, showed little difference among the grasses or the mixtures with the exceptions of *Elymus junceus* and the RN-1 mixture (table 79). Herbage from these two seedings were considerably higher in protein and calcium but lower in nitrogen-free extracts than the other grasses. *E. junceus* was also high in ash content. The high protein content of the mixture probably reflects the influence of alfalfa.

Study.—Moccasin species adaptation planting.

Date planted.—April 17, 1947.

Procedure.—Twenty-three species and strains were planted by drilling in plots 14 by 148 feet on fallowed land.

Results.—Stand ratings were variable. Species that established good initial stands were *Agropyron intermedium* (Ree and Washington), *A. trichophorum*, and *Bromus marginatus*. By 1949

TABLE 78.—*Establishment and herbage yields of grasses and mixtures planted near Moccasin, Mont.*

Species or mixture [1]	Stand (1940)	Average yield per acre, oven-dry weight (1941-48)
	Pct.	*Lb.*
Agropyron desertorum (FC 19537)	93	1,625
Poa ampla	72	1,600
Agropyron desertorum (M 24-3)	92	1,571
A. inerme	70	1,524
A. desertorum (M 24-17)	88	1,471
A. cristatum (Fairway)	93	1,425
Bromus inermis	95	1,259
Stipa viridula	90	1,214
Poa secunda	70	[2] 1,093
Agropyron smithii	88	[2] 1,064
Oryzopsis hymenoides	60	[2] 909
Elymus junceus	87	855
Bouteloua gracilis	70	---
B. curtipendula	60	---
RN-1 mixture	90	2,039
Moccasin mixture	88	1,690

[1] Composition of mixtures:

Species	*Pounds of seed per acre* RN-1	*Moccasin*
A. desertorum	2	2
A. inerme	2	--
A. smithii	1	--
B. curtipendula	1	--
B. inermis	1	3
P. ampla	2	--
Medicago sativa	1	4
E. junceus	--	3

[2] Harvested in 3 years only.

TABLE 79.—*Chemical composition of herbage harvested on July 19, 1945, near Moccasin, Mont.*

Species or mixture	Chemical composition						
	Ether extract	Crude fiber	Crude protein	NFE [1]	Calcium	Phosphorus	Total
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Agropyron cristatum (Fairway)	2.4	31.2	6.3	51.8	0.52	0.12	8.3
A. desertorum (FC 19537)	3.0	31.1	6.2	52.4	.40	.14	7.3
A. desertorum (M24-3)	2.0	33.3	6.1	51.9	.37	.15	6.7
A. desertorum (M24-17)	2.6	36.3	6.1	47.9	.37	.15	7.1
A. inerme	3.0	33.7	6.9	46.2	.56	.15	10.2
A. smithii	3.9	31.4	8.3	46.8	.51	.18	9.6
Bromus inermis	3.3	34.7	7.2	45.9	.52	.14	8.9
Elymus junceus	3.2	31.5	10.4	42.3	.88	.24	12.6
Oryzopsis hymenoides	2.7	37.5	6.7	46.5	.47	.15	6.6
Poa ampla	2.9	35.8	5.6	49.6	.44	.14	6.1
Stipa viridula	2.5	34.4	7.9	47.1	.50	.15	8.2
Moccasin mixture [2]	2.7	30.6	7.8	51.7	.63	.14	7.2
RN-1 mixture [2]	2.0	37.5	9.9	42.6	1.16	.13	8.0

[1] NFE = nitrogen-free extract.
[2] For composition of mixtures, see footnote 1, table 78.

these species continued to maintain good stands, while *Agropyron cristatum, A. desertorum, Bromus inermis* (Lincoln and Manchar), *Elymus junceus, Festuca arundinacea* (Alta), and *Stipa viridula* had improved to good ratings (table 80).

Yield samples harvested in 1948 showed good production of most species. *A. intermedium, A. trichophorum,* and *B. inermis* (Lincoln) produced the most, but differences among species were not significant. Although *E. junceus* maintained a good stand, its production was the lowest of any harvested, and many species with poorer stands outyielded it.

Estimates of grazing readiness ranked *Poa ampla* and *P. bulbosa* as the earliest followed by *Agropyron inerme, A. spicatum, A. desertorum, A. intermedium, A. trichophorum, Bromus erectus, Elymus canadensis,* and *E. junceus.*

Study.—Moccasin adaptation nursery.

Date planted.—October 24, 1950.

Procedure.—Forty-two grasses were planted in plots 3 by 20 feet with three rows per plot spaced 1 foot apart. The seedbed had been in fallow before seeding.

TABLE 80.—*Hay yields, establishment, and grazing readiness of grasses seeded in the spring 1947, near Moccasin, Mont.*.

Species	Stand 1949	Yield per acre, oven-dry weight (1948)	Grazing readiness, April 1949 [1]
	Pct.	*Lb.*	*Rating*
Festuca arundinacea (Alta)	88	3,817	6
Agropyron desertorum (Standard)	87	3,081	3
Bromus inermis (Manchar)	85	3,035	4
Agropyron intermedium (Ree)	83	4,093	3
A. trichophorum	83	4,093	3
A. intermedium (Washington)	80	3,863	3
Bromus marginatus (Bromar)	80	3,495	5
Elymus junceus	78	1,012	3
Stipa viridula	78	1,748	5
Agropyron cristatum (Fairway)	69	2,805	5
Bromus inermis (Lincoln)	60	4,599	5
Agropyron desertorum (M24-3)	58	3,633	3
A. inerme	57	2,253	2
A. spicatum	57	[2]	2
Arrhenatherum elatius	55	2,483	4
Agropyron trachycaulum	53	3,495	4
A. trachycaulum (Primar)	53	3,495	4
Elymus canadensis (Mandar)	50	2,897	3
Phalaris arundinacea	47	2,065	7
Bromus inermis (Parkland)	43	[2]	4
Poa ampla	40	3,587	1
P. bulbosa	38	[2]	1
Bromus erectus	13	[2]	3

[1] Ratings 1 to 9 with 1 being the earliest.
[2] Data not available.

Results.—Stands were variable in 1951 with the best initial stands established by *Agropyron subsecundum*, *A. sibiricum*, *A. desertorum* (M24-3), *Bromus erectus*, *Elymus junceus*, *E. canadensis*, *Stipa viridula*, *Phleum pratense*, *Agropyron desertorum* (Standard), *A. intermedium*. *A. trichophorum*, *A. inerme*, *Festuca rubra*, and *Dactylis glomerata* (table 81). The only species in this group that failed to maintain a good stand through 1954 was *A. subsecundum*.

Species that improved their stands during the 4-year period were *Agropyron inerme*, *A. intermedium*, *A. trichophorum*, *A. smithii*, *Bromus inermis*, *Elymus triticoides*, *Festuca rubra*, *F. ovina*, *Poa pratensis*, *P. compressa*, and *Phalaris arundinacea*.

Study.—Moccasin grass and legume hay production.
Date planted.—1956.
Procedure.—Four grasses and two legumes were planted in pure stands and in simple grass-legume mixtures.

TABLE 81.—*Establishment of grasses near Moccasin, Mont.*

Species	Stand 1951	Stand 1954
	Pct.	*Pct.*
Good stands maintained through 4 years:		
Elymus triticoides	72	95
Bromus inermis (Lincoln)	62	95
Agropyron desertorum (M24-3)	93	93
A. trichophorum	77	93
Elymus junceus	88	87
Stipa viridula	92	86
Agropyron sibiricum	92	84
Phleum pratense	84	84
P. pratense (Hopkins)	91	82
Agropyron intermedium	72	80
Festuca rubra	70	80
A. desertorum (Standard)	79	79
Bromus erectus	88	78
Elymus canadensis	87	77
Dactylis glomerata	78	73
Agropyron smithii	60	73
Festuca ovina duriuscula	47	73
Poa pratensis	20	68
Alopecurus pratensis	68	65
Oryzopsis hymenoides	63	63
Agropyron trachycaulum	62	62
Poor to fair stands established initially but maintained fair stands for 4 years:		
Agropyron inerme	50	50
A. cristatum	37	37
Phalarus arundinacea	20	37
Poa compressa	10	29
Agropyron elongatum	53	27
Poa ampla (Robust)	30	26
Good stands established initially but declined to fair or poor stands within 4 years:		
Agropyron subsecundum	92	50
Festuca arundinacea (Alta)	68	27
Festuca elatior	60	22

TABLE 81.—*Establishment of grasses near Moccasin, Mont.*—Continued

Species	Stand 1951	Stand 1954
	Pct.	*Pct.*
Poorly established and generally failed:		
Agropyron spicatum	1	0
Agrostis alba	28	13
A. tenuis	2	0
Arrhenatherum elatius	22	15
Bouteloua curtipendula	20	10
B. gracilis	1	0
Bromus marginatus	17	0
Elymus glaucus	10	10
Panicum virgatum	33	7
Poa ampla (Sherman)	2	1
P. bulbosa	7	9

Results.—Except for *Astragalus falcata*, all species in pure seedings and in mixtures established good initial stands (table 82). By 1961 all stands were good.

Yields of most species were good in 1957. *Astragalus falcata* was the lowest producing legume and *Stipa viridula*, lowest producing grass. Yields of these two species and *Medicago falcata* increased to their peak in 1959 then declined in 1960 and 1961. The other grass species produced their highest yields in 1957 and generally declined in each of the four following years. Average yields over the 5-year period are given in table 82.

The grass-alfalfa mixtures yielded slightly less than the grass in pure stand the first year. However, production was generally good. Yields of the mixtures declined in 1958 then reached their peak production in 1959. In 1958, except for *S. viridula* the mixtures outproduced the grass alone. Over the 5-year period, alfalfa-grass mixtures also outyielded any of the grasses alone.

Apparently mixtures of grasses with *A. falcata* were not harvested for production weights.

Study.—Moccasin alfalfa hay varieties.

Data planted.—1916, 1921, 1923.

Procedure.—Seventeen strains of *Medicago sativa* and *M. falcata* were seeded. Only two of these strains (Montana common and Grim) were seeded each year.

Results.—Yields of herbage harvested in 1924 were generally good for all strains. Grim, however, was the highest producing strain from the 1916 and 1923 seedings but was surpassed slightly by Montana common, Ladak, Dakota, and Italian from the 1921 seeding. These five strains appeared to be the best adapted of those tested (table 83).

Study.—Moccasin bromegrass strain test.

Date planted.—Spring 1945.

Procedure.—Seventeen strains of *Bromus inermis* were seeded in triplicate randomized plots with six rows per plot, 20 feet long, and spaced 1 foot apart.

Results.—This study has been reported by R. E. Stitt (1949). In summary, the report indicated that by the third growing

TABLE 82.—*Establishment and herbage production of grasses alone and in mixtures with sickle milk vetch and ladak alfalfa near Moccasin, Mont.*

Species or mixture	Stand 1957	Stand 1961	Average herbage yields per acre, oven-dry weight (1957-61)
	Pct.	*Pct.*	*Lb.*
Pure species:			
Medicago falcata (Ladak)	100	100	1,903
Agropyron intermedium	100	100	1,535
A. desertorum	92	97	1,491
Stipa viridula	83	95	1,227
Bromus inermis	100	100	989
Astragalus falcata	25	75	591
Mixtures: [1]			
Agin and Mefa	100	100	2,208
Agde and Mefa	100	100	2,199
Stvi and Mefa	100	100	2,092
Brin and Mefa	98	100	1,771
Agde and Asfa	100	100	[2]
Agin and Asfa	100	100	[2]
Brin and Asfa	98	100	[2]
Stvi and Asfa	73	97	[2]

[1] Agin = *Agronpyron intermedium*; Mefa = *Medicago falcata*; Stvi = *Stipa viridula*; Agde = *Agropyron desertorum*; Brin = *Bromus inermis*; Asfa = *Astragalus falcata*.

[2] Data not available.

TABLE 83.—*Yield of alfalfa strains near Moccasin, Mont., 1924*

Strain	Herbage yield per acre		
	Seeded 1916	Seeded 1921	Seeded 1923
	Lb.	*Lb.*	*Lb.*
Kansas	3,789	--	--
Utah	3,735	--	--
Black Hills	3,609	--	--
Canada variegated	3,490	2,690	--
Baltic	3,903	3,364	--
Montana common	3,800	3,977	3,366
Liscomb	3,880	3,334	--
Grimm	4,573	3,780	4,158
Orenberg	--	3,520	--
Cossack	--	3,169	--
Ladak	--	4,123	--
Dakota	--	3,840	--
Italian	--	3,980	--
Turkestan	--	3,395	--
Lebeau	--	--	3,366
Argentine	--	--	3,663
Chubut	--	--	3,663

season most of the strains had filled in to near complete stands regardless of initial establishment.

In the second year after seeding, hay yields were in direct correlation with stands, but differences between strains were not significant. Average hay production was about 1,500 pounds per acre.

Seed production appeared to be inherent in the different strains and was not related to stand establishment.

Study.—Moccasin renovation of grass and grass-legume stands.

Date planted.—April 1939. Renovated in 1947.

Procedure.—Twelve species and varieties of grass and two mixtures of grasses and alfalfa were seeded with three replications per treatment. In 1947 four renovation treatments were applied across nine of the grass plots and the two mixtures. Treatments were as follows: (1) Check without treatment; (2) cultivated to kill out one-half of the grass in alternate bands 6 inches wide; (3) fertilized with 150 pounds ammonium nitrate and 50 pounds treble superphosphate per acre; and (4) cultivated and fertilized combined treatment.

Results.—Fertilizer treatments more than doubled hay yields of the grasses but were less effective on the grass-alfalfa mixtures in 1947. In 1948 residual effects were present with increased yields above the nontreated plots, but yields were considerably less than those received in 1947 (table 84).

Renovation by cultivation decreased yields in 1947, but the plants were larger. In 1948 yields were generally increased above the check. Only two grasses, *Agropyron desertorum* (M24-3) and *Elymus junceus*, failed to show higher yields the year after treatment.

Fertilizers combined with cultivation generally increased yields in 1947 and nearly doubled yields of most species in 1948. It also increased yields above cultivation alone, but yields from the combined treatment were often lower than from fertilization alone especially in the 1947 harvest.

Study.—Moccasin row spacing and cultural treatments of Russian wildrye.

Date planted.—Spring 1946.

Procedure.—*Elymus junceus* was planted in the spring of 1946 in plots with rows spaced at 0.5, 2, 3.5, 7, and 10 feet. Each plot consisted of four rows except the 0.5 spacing where 24 rows were seeded. The plots, 132 feet long, were split into a randomized split block design with five treatments: (1) Check; (2) clipped in April 1947 to 1949; (3) burned in April 1947 to 1949; (4) 100 pounds per acre of 10-20-0 fertilizer applied each spring 1946 to 1952; (5) 500 pounds per acre ammonium sulfate fertilizer applied each spring 1948 to 1952.

Results.—Increasing the distance between rows, up to 10 feet, and the rates of nitrogen fertilizer, up to 500 pounds of ammonium sulfate per acre, raised seed yields. At times clipping and burning treatments appeared to favor seed production, but this response was not consistent from year to year (table 85).

Windham

Study location.—Located 5 miles south and 1 mile east of Windham, Judith Basin County, along the road to Utica, sect. 7, T. 14N., R. 13E. (location 57, fig. 10).

Elevation.—4,500 feet.

Average precipitation.—Annual, 16.4 inches; April-September, 75 percent.

Soils.—Moccasin gravelly silt loam.

Topography.—1 percent slope on gravel-capped benchland.

Type of vegetation.—Teton River-Judith Basin grassland.

Dominant species.—*Bouteloua gracilis, Poa secunda, Stipa viridula, S. comata,* and *Agropyron smithii.*

Previous use.—Abandoned cropland.

TABLE 84.—*The effect of cultivation and fertilization on the yield of grasses and grass-alfalfa mixtures near Moccasin, Mont.*

Species, strain, or mixture [1]	Herbage yield per acre, oven-dry weight from renovation treatments			
	Check	Cultivated	Fertilized	Cultivated & fertilized
	Lb.	*Lb.*	*Lb.*	*Lb.*
Harvested in 1947:				
Agropyron desertorum (Standard)	613	453	1,583	913
A. desertorum (M24-3)	580	263	1,343	677
Poa ampla	567	283	1,310	710
Stipa viridula	523	313	1,300	587
Agropyron inerme	583	323	1,247	777
A. desertorum (M24-17)	563	207	1,197	917
A. cristatum (Fairway)	316	160	1,060	780
Bromus inermis	317	180	977	527
Elymus junceus	340	123	667	337
RN-1 mixture	1,357	1,003	1,783	1,570
Moccasin mixture	1,276	627	1,407	943
Harvested in 1948:				
Poa ampla	1,040	1,764	1,411	1,962
Agropyron desertorum (Standard)	637	1,205	1,122	1,031
Stipa viridula	637	1,031	1,036	1,251
Agropyron inerme	720	953	885	1,288
A. cristatum (Fairway)	307	701	857	898
Bromus inermis	706	802	820	1,017
Agropyron desertorum (M24-3)	715	724	788	862
A. desertorum (M24-17)	568	962	770	1,150
Elymus junceus	339	280	453	697
RN-1 mixture	2,356	2,754	3,094	2,822
Moccasin mixture	1,233	1,952	1,865	1,251
Least significant difference at 5 percent level:				
1947	349	264	445	293
1948	321	654	486	967

[1] Mixtures were primarily *Agropyron desertorum* and *Medicago sativa.*

TABLE 85.—*Seed yields of Russian wildrye as affected by fertilizers, row spacing, and cultural treatments*

Treatment and year	Seed yield per acre from different row spacings				
	1/2 ft.	2 ft.	3 1/2 ft.	7 ft.	10 ft.
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Harvested in 1948:					
Control	0	9	48	94	121
Clipped in April 1947	0	64	66	100	106
Burned in April 1947	0	33	80	104	105
Fertilizer applied per acre annually:					
100 pounds	0	18	40	94	70
500 pounds	0	7	24	110	101
Harvested in 1950:					
Control	0	0	0	5	21
Clipped in April 1947-49	0	18	0	13	34
Burned in April 1947-49	0	0	0	27	47
Fertilizer applied per acre annually:					
100 pounds	0	0	0	4	19
500 pounds	3	9	20	17	22
Harvested in 1952:					
Control	0	0	0	21	71
Clipped in April 1947-49	0	0	0	27	162
Burned in April 1947-49	0	0	0	25	90
Fertilizer applied per acre annually:					
100 pounds	0	0	0	33	95
500 pounds	0	74	184	187	138

Study.—Contour furrow planting.

Date planted.—November 1, 1938.

Procedure.—Seven grasses were planted in contour furrows that were 4 inches deep and 8 inches wide at the furrow crest. The furrows were spaced not more than 25 feet apart. The seed was broadcast in strips 4 feet by 200 feet along the furrow. Seeding treatments were repeated five times.

Results.—In 1939 *Agropyron cristatum*, *A. desertorum*, and *Bromus inermis* established excellent stands. Stands of *Agropy-*

ron smithii were fair, and those of *Arrhenatherum elatius*, *Bouteloua gracilis*, and *Oryzopsis hymenoides* were poor.

Fort Benton

Study location.—Located 2 miles west of Fort Benton, Chouteau County, on the south side of Highway 29, sect. 29, T. 24N., R. 8E. (location 58, fig. 10).

Elevation.—2,800 feet.

Average precipitation.—Annual, 12 inches; April-September, 82 percent.

Soil.—Joplin loam.

Topography.—1- to 2-percent slope to southeast.

Type of vegetation.—Teton River-Judith Basin grassland.

Dominant species.—*Bouteloua gracilis*, *Agropyron smithii*, and *Stipa comata*.

Previous use.—Cultivated cropland.

Study.—Fort Benton adaptation nursery.

Date planted.—Fall 1950 and 1952.

Procedure.—Forty-two grasses were planted in plots 3 by 20 feet with three rows per plot spaced 1 foot apart. Planting was done on summer-fallowed ground. The 1950 planting was plowed in 1952 and replanted.

Results.—Only a few species established well from the 1950 seeding. By 1952, *Agropyron desertorum* (M24-3), *Festuca ovina*, *Poa pratensis*, *P. compressa*, *Dactylis glomerata*, and *Phleum pratense* were the only species that had maintained fair to good stands. Most species from the 1952 seeding became better established than they did in the 1950 seeding.

By 1954, *Agropyron trachycaulum*, *A. trichophorum*, *Bromus erectus*, *B. inermis*, *B. marginatus*, *Elymus junceus*, *Festuca elatior*, *F. ovina*, *Agropyron desertorum (Nordan)*, *Dactylis glomerata*, and *Festuca arundinacea* had established good stands, but of this group *B. marginatus* and *F. elatior* died out by 1956, while stands of *D. glomerata* and *F. arundinacea* had declined. On the other hand, species that improved their stands included *Agropyron desertorum* (Standard), *A. cristatum*, *A. trichophorum*, *A. sibiricum*, *A. smithii*, *A. elongatum*, *Bromus inermis*, *B. erectus*, *Elymus junceus*, *E. triticoides*, and *Phleum pratense* (table 86). These species appeared adapted to the site.

Chouteau

Study location.—Located one-half mile east of Chouteau, Teton County, along the Dutton road, sec. 19, T. 24N., R. 4W. (location 59, fig. 10).

TABLE 86.—*Establishment of grasses planted near Fort Benton, Mont.*

Species	Seeded 1950: stand, 1952	Seeded 1952; stand — 1954	Seeded 1952; stand — 1956
	Pct.	*Pct.*	*Pct.*
Good stands established in both plantings:			
Festuca ovina duriuscula	67	92	90
Dactylis glomerata	87	92	79
Phleum pratense	67	48	60
Good stands established in the 1950 planting but fair or poor in 1952:			
Agropyron desertorum (M24-3)	73	50	55
Poa pratensis	90	1	1
P. compress	67	1	1
Good stands established in the 1952 planting but fair or poor in 1950:			
Bromus inermis (Lincoln)	47	73	95
Agropyron trachycaulum	10	88	93
Bromus erectus	27	87	93
Agropyron trichophorum	13	70	90
A. desertorum (Nordan)	1	77	80
Elymus junceus	10	70	78
Agropyron elongatum	43	67	78
A. intermedium	35	67	65
Phleum pratense (Hopkins)	30	48	65
Fair stands maintained in both plantings:			
Stipa viridula	27	53	57
Festuca arundinacea	43	73	52
Agropyron desertorum (Standard)	35	33	48
Alopecurus pratensis	37	38	43
Agropyron inerme	20	38	41
Poa ampla (Robust)	50	27	32
Fair stands maintained from one planting but poor or failed in the other:			
Elymus triticoides	0	16	47
Agropyron sibiricum	0	25	43
A. cristatum (Fairway)	0	28	38
A. smithii	0	1	30
Phalaris arundinacea	1	33	27
Elymus canadensis	10	67	20
Festuca rubra	23	32	17
Elymus glaucus	27	18	8

TABLE 86. —*Establishment of grasses planted near Fort Benton, Mont.* —Continued

Species	Seeded 1950; stand, 1952	Seeded 1952; stand — 1954	1956
	Pct.	*Pct.*	*Pct.*
Fair stands maintained from one planting but poor or failed in the other—Continued			
Poa ampla (Sherman)	57	0	1
P. bulbosa	50	7	1
Festuca elatior	50	83	0
Bromus marginatus	47	73	0
Agrostis alba	33	1	0
Failed in both plantings:			
Agropyron spicatum	7	0	
Bouteloua curtipendula	0	0	
B. gracilis	0	1	
Oryzopsis hymenoides	0	1	
Panicum virgatum	0	2	

Elevation.—3,800 feet.

Average precipitation.—Annual, 11.5 inches; April-September, 82 percent.

Soil.—Clay loam.

Topography.—2 percent slope to the south.

Type of vegetation.—Teton River-Judith Basin grassland.

Dominant species.—*Agropyron smithii*, *Bouteloua gracilis*, and *Stipa comata*.

Previous use.—Cultivated cropland previously in small grains.

Study.—Chouteau adaptation nursery.

Date planted.—Spring 1952.

Procedure.—Forty-two grasses were planted in plots 3 by 20 feet with three rows per plot spaced 1 foot apart.

Results.—Generally fair to good stands of grass were established in 1952. Except for a few species, they improved by 1954 and continued to improve or maintain themselves through 1956 (table 87). At that time 25 grasses were maintaining good to excellent stands. A second group of five species had fair stands while 11 species generally failed.

TABLE 87.—*Establishment of grasses planted near Chouteau, Mont.*

Species	Stand 1952	Stand 1956
	Pct.	*Pct.*
Good stands established for 5 years:		
Bromus inermis	68	100
B. erectus	85	99
Agropyron trichophorum	90	98
A. desertorum (Nordan)	52	98
Dactylis glomerata	90	97
Phleum pratense (Hopkins)	87	97
P. pratense	75	97
Arrhenatherum elatius	93	96
Elymus junceus	87	96
Agropyron desertorum (M24-3)	83	96
A. sibiricum	77	92
A. cristatum (Fairway)	48	92
Festuca rubra	91	91
Alopecurus pratensis	80	91
Festuca ovina duriuscula	53	90
Agropyron desertorum (Standard)	85	89
A. intermedium	92	88
Poa ampla (Robust)	42	88
Agropyron smithii	23	87
Stipa viridula	10	87
Poa pratensis	42	75
Phalaris arundinacea	67	72
Elymus canadensis	55	72
E. triticoides	55	70
Agropyron trachycaulum	72	67
Fair stands maintained for 5 years:		
Agropyron elongatum	85	52
A. inerme	50	44
Poa ampla (Sherman)	42	40
Festuca arundinacea (Alta)	62	34
Poa compressa	58	27
Poorly established or failed completely in 5 years:		
Agropyron spicatum	0	0
A. subsecundum	88	0
Agrostis alba	50	3
Bouteloua curtipendula	0	1
B. gracilis	0	0
Bromus marginatus	85	0

TABLE 87.—*Establishment of grasses planted near Chouteau, Mont.* —Continued

Species	Stand	
	1952	1956
	Pct.	*Pct.*
Poorly established or failed completely in 5 years —Con.		
Elymus glaucus	55	1
Festuca elatior	66	15
Oryzopsis hymenoides	3	2
Panicum virgatum	15	11
Poa bulbosa	15	0

Conrad

Study location.—Located 13 miles west of Conrad, Pondera County, T. 28N., R. 5W. (location 60, fig. 10).

Elevation.—3,500 feet.

Average precipitation.—Annual, 12.5 inches; April-September, 77 percent.

Soil.—Morton gravelly loam.

Topography.—3 to 5 percent slope to the north on rolling upland area above sandstone escarpment.

Type of vegetation.—Teton River-Judith Basin grassland.

Dominant species.—*Bouteloua gracilis*, *Poa secunda*, and *Stipa comata.*

Previous use.—Cultivated cropland.

Study.—Conrad adaptation nursery.

Date planted.—October 1950.

Procedure.—Forty-four grasses were seeded in 3- by 20-foot plots with three rows per plot spaced 1 foot apart.

Results.—Fair to good stands of most species were established in 1951. Species that maintained good stands through 1954 included *Agropyron intermedium, A. trichophorum, A. inerme, A. sibiricum, A. smithii, A. desertorum, A. elongatum, Bromus inermis, B. erectus, Elymus canadensis, E. junceus, E. triticoides, Festuca rubra, F. ovina, F. arundinacea, F. elatior, Alopecurus pratensis, Stipa viridula, Dactylis glomerata, Phleum pratense, Arrhenatherum elatius,* and *Phalaris arundinacea* (table 88).

Bromus marginatus and *Agropyron subsecundum* established

TABLE 88.—*Establishment of grasses planted near Conrad, Mont.*

Species	Stand 1951	Stand 1954
	Pct.	*Pct.*
Good stands maintained for 4 years:		
Agropyron trichophorum	95	100
Festuca arundinacea	95	98
Agropyron intermedium	85	98
Bromus inermis (Lincoln)	83	98
B. inermus (Manchar)	[1]	96
Agropyron desertorum (M24-3)	82	94
Dactylis glomerata	92	91
Bromus erectus	88	90
Phleum pratense (Hopkins)	75	89
Elymus triticoides	50	88
Agropyron sibiricum	72	87
Phleum pratense	83	85
Agropyron inerme	67	83
A. smithii	40	83
Festuca rubra	78	77
Elymus canadensis	40	77
Agropyron elongatum	82	73
Alopecurus pratensis	70	73
Stipa viridula	55	73
Festuca ovina duriuscula	45	73
F. elatior	85	70
Elymus junceus	80	67
Arrhenatherum elatius	75	67
Agropyron desertorum (Standard)	68	63
Phalaris arundinacea	14	60
Fair stands maintained for 4 years:		
Agropyron cristatum	23	47
A. subsecundum	88	43
Elymus glaucus	58	40
Poa ampla (Robust)	23	32
P. ampla (Sherman)	18	32
P. pratensis	6	30
P. bulbosa	23	27
Bromus marginatus	78	23
Poorly established or failed in 4 years:		
Agropyron michnoi	0	0
A. spicatum	0	0
A. trachycaulum	1	3

Footnotes at end of table.

TABLE 88. —*Establishment of grasses planted near Conrad, Mont.* —Continued

Species	Stand 1951	Stand 1954
	Pct.	*Pct.*
Poorly established or failed in the 4 years—Continued		
Agrostis alba	57	17
A. tenuis	0	0
Bouteloua curtipendula	1	0
B. gracilis	0	0
Oryzopsis hymenoides	33	5
Panicum virgatum	13	0
Poa compressa	1	5

[1] Data not available.

good initial stands but declined rapidly by 1954. Others that established poor stands or failed completely are listed in table 88.

Northern Grassland

This type, comprising about 9,474,000 acres, is located mostly north of the Missouri River and east of the Continental Divide to Daniels and Roosevelt Counties. A few small areas also occur in Jefferson and Cascade Counties. Throughout northern Montana it is often found adjacent to and intermixed with other plains and mountainous types.

The elevation is from 2,000 to 4,000 feet where precipitation varies from 12 to 16 inches annually and where the growing season is from 80 to 140 days. The soils are mostly moderately dark loams of the Mollisol order, primarily of the Joplin and Schobey series.

Bouteloua gracilis, *Stipa comata*, *Carex filifolia*, and *Selaginella densa* are common species with *Agropyron smithii* becoming more important on the heavier soils and higher precipitation areas. *Koeleria cristata*, *Artemesia frigida*, *Agropyron trachycaulum*, and *Opuntia polyacantha* are often found on the more gravelly, overused, or disturbed sites.

Much of this type has been cultivated; however, vast areas of rolling lands still remain as native range.

The heavy cover of *Selaginella densa* and *B. gracilis* that covers much of the area also lowers the carrying capacity of the native ranges. Methods that tend to break up the dense sod and establish adapted forage species increase forage production. Studies near Havre, Mont., showed that plowing reduced competition from these native plants and increased the success of most seeded species.

Grasses that appear adapted to this type include *Agropyron cristatum, A. dasystachyum, A. desertorum, A. intermedium, A. michnoi, A. sibiricum A. smithii, A. trachycaulum, Bromus erectus, B. inermis, B. marginatus, Elymus canadensis, E. junceus, Poa ampla,* and *Stipa viridula. Festuca ovina* also showed some promise.

Medicago falcata and *M. sativa* started well near Havre but died back after 3 or 4 years. Field stands of alfalfa, however, are found throughout this type, particularly in the western part and nearer the mountains.

Dunkirk

Study location.—Located 1 mile west and 3/4 mile south of Dunkirk, Toole County, sect. 1, T.31 N., R. 1W. (location 61, fig. 10).

Elevation.—3,400 feet.

Average precipitation.—Annual, 11.5 inches; April-September, 76 percent.

Soil.—Joplin loam.

Topography.—3 percent slope to the northeast on rolling glaciated till.

Type of vegetation.—Northern grassland.

Dominant and associated species.—*Bouteloua gracilis, Agropyron trachycaulum, Carex filifolia, Selaginella densa, Stipa comata,* and *Opuntia polyacantha.*

Previous use.—Cultivated cropland.

Study.—Dunkirk adaptation nursery.

Date planted.—October 1950.

Procedure.—Forty-two grasses were planted in plots 3 by 20 feet with three rows per plot spaced 1 foot apart.

Results.—In 1951 the initial stands of many species were fair to poor. *Festuca ovina,* however, established good stands. By 1956 most species had improved, and those rated good or otherwise appeared well established included *Agropyron cristatum, A. desertorum* (Standard and M 24-3), *A. trichophorum, A. sibiricum, A. smithii, Bromus inermis, B. erectus, Elymus junceus, E. canadensis, E. triticoides, Festuca ovina, Poa pratensis,* *P. compressa*, *Stipa viridula*, *Phalaris arundinacea*, and *Phleum pratense* (table 89).

TABLE 89.—*Establishment of grasses near Dunkirk, Mont.*

Species	Stand 1951	Stand 1956
	Pct.	*Pct.*
Good stands established by the 6th year:		
Bromus inermis	43	100
Agropyron trichophorum	33	97
Phleum pratense	56	87
Festuca ovina duriuscula	85	80
Bromus erectus	63	77
Elymus junceus	63	75
Poa pratensis	27	73
Phalaris arundinacea	31	68
Dactylis glomerata	66	66
Phleum pratense (Hopkins)	61	63
Agropyron smithii	8	62
Fair stands established by the 6th year:		
Elymus triticoides	1	57
Agropyron cristatum (Fairway)	1	53
A. desertorum (Standard)	7	53
Elymus canadensis	26	53
Festuca rubra	48	50
Stipa viridula	1	50
Festuca arundinacea (Alta)	61	47
Agropyron desertorum (M24-3)	18	40
A. inerme	37	40
A. sibiricum	16	40
Festuca elatior	67	43
Poa compressa	5	37
Alopecurus pratensis	30	37
Agrostis alba	25	33
Poa ampla (Sherman)	19	28
Agropyron elongatum	9	28
Poa ampla (Robust)	3	27
Poor stands established or failed:		
Agropyron intermedium	28	10
A. spicatum	0	2
A. subsecundum	58	7
A. trachycaulum	5	13
Agrostis tenuis	5	17
Arrhenatherum elatius	17	13
Bouteloua curtipendula	0	0
B. gracilis	0	0

TABLE 89. —*Establishment of grasses near Dunkirk, Mont.* — Continued

Species	Stand 1951	Stand 1956
	Pct.	*Pct.*
Poor stands established or failed—Continued		
Bromus marginatus	28	0
Elymus glaucus	12	0
Festuca idahoensis	1	1
Oryzopsis hymenoides	0	1
Panicum virgatum	0	15
Poa bulbosa	3	1

Species that established poor stands or failed are listed in table 89.

Cutbank

Study location.—Located 8 miles north and 1 mile west of Cutbank, Glacier County, T. 34N, R. 6W. (location 62, fig. 10).

Elevation.—3,800 feet.

Average precipitation.—Annual, 11.4 inches; April-September, 78 percent.

Soil.—Cutbank gravelly loam.

Topography.—At base of hill; 5 percent slope to southwest.

Type of vegetation.—Northern grassland.

Dominant and associated species.—*Bouteloua gracilis, Agropyron trachycaulum, Carex filifolia, Selaginella densa,* and *Opuntia polyacantha.*

Previous use.—Farmed and abandoned.

Study.—Cutbank adaptation nursery.

Date planted.—September 15, 1952.

Procedures.—Forty-two grasses were planted in plots 3 by 20 feet with three rows per plot spaced 1 foot apart. The species planted were the same as those planted at Dunkirk (table 89).

Summary of results.—By 1954 most species were poorly established. Those that appeared best adapted, however, were *Agropyron intermedium, A. trachycaulum, A. trichophorum, Bromus erectus, B. inermis, Dactylis glomerata, Festuca arundinacea, F. elatior,* and *Poa ampla.* Although the other species failed or established poorly, all these species cannot be considered as not adapted.

Havre

Study location.—Located at the Northern Montana Branch Experiment Station, 8 1/2 miles southwest of Havre, Hill County, T. 32N., R. 15E. (location 63, fig. 10).

Elevation.—2,700 feet.

Average precipitation.—Annual, 11.4 inches; April-September, 77 percent.

Soil.—Scobey loam.

Topography.—2 percent slope to the west on rolling land.

Type of vegetation.—Northern grassland.

Dominant and associated species.—*Bouteloua gracilis*, *Carex filifolia*, *Stipa comata*, *Koeleria cristata*, and *Artemesia frigida*.

Previous use.—Plowed and cropped in various experimental plantings since 1917.

Study.—Review of early adaptation studies (1917-32) near Havre, Mont.

Results.—Several plantings of grass were made each spring from 1917 to 1920, but none were considered successful until 1920 when *Agropyron cristatum*, *A. imbricatum*, *A. tenerum*, and *Bromus inermis* established fair to good stands. *Elymus canadensis*, *E. dahuricus*, and *E. sibiricus* also established good stands, but they winter-killed in 1922. The failure of these early seedings was attributed to drought.

In the 1930 and 1931 plantings, two additional species showed some promise. They were *Calamagrostis epigeios* and *Agropyron repens*. *C. epigeios* made good growth and produced seed stalks for the first time in 1932 but no seed. It was considered more rhizomatous than *A. repens*.

Study.—Havre species adaptation plantings (1938-51).

Date planted.—May 1, 1938; spring 1948; fall 1951.

Procedures:

1938 planting.—Thirty-five grasses were planted in 16-foot rows spaced 3 feet apart. The seed was hand spread in furrows and covered with 1/2 inch of soil.

1948 planting.—Eighteen grasses were planted by drilling seed in 6- by 40-foot plots with rows spaced 1 foot apart.

1951 planting.—Forty-four grasses were seeded in plots 3 by 20 feet with rows spaced 1 foot apart.

Results.—Seven grasses that were planted in each study appeared well adapted. These were *Agropyron desertorum*, *A. cristatum*, *A. inerme*, *Bromus erectus*, *B. inermis*, *Elymus junceus*, and *Stipa viridula* (table 90). Thirty-one others showed

TABLE 90.—*Establishment of grasses planted near Havre, Mont.*

Species	Stand, spring planted 1938 planting (1938)	Stand, spring planted 1948 planting (1951)	Stand, fall planted, 1951: 1951	Stand, fall planted, 1951: 1954
	Pct.	*Pct.*	*Pct.*	*Pct.*
Fair to good stands established in all plantings:				
Bromus inermis	95	15	33	77
B. erectus	90	27	57	72
Elymus junceus	85	93	42	70
Stipa viridula	80	65	28	33
Agropyron desertorum	75	93	62	68
A. cristatum	75	87	13	57
A. inerme	50	12	33	67
Fair to good stands established from spring plantings:				
Agropyron pauciflorum	100	--	--	--
A. pungens	100	--	--	--
Bromus marginatus	95	--	6	1
B. polyanthus	97	--	--	--
Agropyron dasystachyum	90	--	--	--
A. spicatum	90	22	0	0
Poa nevadensis	85	--	--	--
Brachypodium micronatum	80	--	--	--
Poa ampla	80	12	1	6
Agropyron trachycaulum	--	80	8	4
Elymus canadensis	75	12	44	0
Poa canbyi	75	--	--	--
Festuca elatior	70	--	31	0
Agropyron smithii	65	10	1	24
Poa palustris	60	--	--	--
Fair to good stands established from fall plantings:				
Agropyron sibiricum	--	--	58	80
A. michnoi	--	--	--	53
A. intermedium	--	12	33	40
A. trichophorum	--	5	22	37
Festuca ovina duriuscula	--	--	1	37
Poa bulbosa	--	--	0	37
Poorly established or generally failed:				
Agropyron elongatum	1	--	11	0
A. subsecundum	--	--	52	10
Agrostis alba	--	--	0	0

TABLE 90. —*Establishment of grasses planted near Havre, Mont.* — Continued

Species	Stand, spring planted 1938 planting (1938)	Stand, spring planted 1948 planting (1951)	Stand, fall planted, 1951: 1951	Stand, fall planted, 1951: 1954
	Pct.	*Pct.*	*Pct.*	*Pct.*
Poorly established or generally failed—Con.				
A. tenuis	--	--	0	0
Alopecurus pratensis	--	--	2	10
Arrhenatherum elatius	--	1	1	0
Bouteloua curtipendula	20	--	16	0
B. gracilis	1	--	1	0
Brachypodium sylvaticum	10	--	--	--
Dactylis glomerata	--	--	63	0
Elymus glaucus	--	--	17	0
E. triticoides	5	--	1	0
Festuca arundinacea	--	0	2	0
F. rubra	--	--	12	4
Koleria cristata	30	--	--	--
Muhlenbergia foliosa	0	--	--	--
Oryzopsis hymenoides	0	--	19	27
Panicum virgatum	40	--	45	0
Phalaris arundinacea	--	--	31	0
Phleum pratense	--	--	29	0
Poa compressa	1	--	0	0
Sporobolus cryptandrus	0	--	--	--
Stipa capillata	0	--	--	--
S. comata	1	--	--	--
S. vaseyi robusta	10	--	--	--

promise in at least one planting. Another group of 21 species established poorly or failed completely.

Study.—Havre smooth brome variety tests.

Date planted.—May 1945 and May 24, 1950.

Procedures:

1945 planting.—Eighteen varieties were planted in plots 6 by 20 feet with rows spaced 1 foot apart. Seeding was done with a beltseeder at 15 pounds per acre; at planting time, the soil was dry.

1950 planting.—Twelve strains of smooth brome and one of meadow brome were planted in single-row plots with 3 feet between rows.

Results.—Emergence from the 1945 planting was variable and the continued drought through 1947 reduced stands of all but one strain. A Nebraska selection (B. in. 9) improved its stand and maintained it at 82 percent. Another Nebraska selection (Lincoln) was second best at 72 percent.

In the 1950 planting the strains were not significantly different. Most of them established stands of 85 to 95 percent.

Study.—Havre wheatgrass planting.

Date planted.—1954.

Procedure.—Nineteen species and strains of wheatgrasses were planted in plots 5 by 20 feet with 1 foot between rows. Seeding treatments were replicated four times in a randomized block design.

Results.—In 1955 all species and strains, except *Agropyron elongatum*, established good stands (table 91). *A. elongatum* generally failed. By 1957 stands of *Agropyron cristatum*, *A. desertorum*, and *A. sibiricum* had improved but *Agropyron intermedium* and *A. trichophorum* declined.

Yields in 1955 were generally good where stands were good. *A. desertorum* was the highest yielding species with Nordan and Nebraska-10 the highest yielding strains. By 1957, yields of all selections except *A. intermedium* (Amur) and *A. sibiricum* (P-27) had declined markedly below those of 1955. That year *A. sibiricum* was the highest yielding species closely followed by *A. desertorum* and *A. intermedium*.

Study.—Havre alfalfa varieties and alfalfa-grass hay planting.

Date planted.—Spring 1951.

Procedure.—Eight strains of *Medicago falcata-sativa* were planted in pure stand. and with crested wheatgrass in simple alfalfa-grass mixtures.

Results.—Stands of *Medicago* were generally good in 1951 (table 92). Except for Sevelra, the alfalfa-grass mixtures produced more than the alfalfa strain alone. Differences among strains were significant except for Alaska falcata, which yielded much less than the other varieties when grown alone.

Study.—Havre grass and grass-alfalfa hay study.

Date planted.—Spring 1954.

Procedure.—Ten grasses and *Medicago falcata* were planted in pure stands and in simple grass-alfalfa mixture. The grasses and alfalfa were seeded in alternate rows in the mixtures. Plots, 5 by 20 feet with rows 1 foot apart, were replicated four times

TABLE 91.—*Establishment and herbage yield of wheatgrasses near Havre, Mont.*

Species and strain	Stand 1955	Stand 1957	Yield per acre, oven-dry weight 1955	Yield per acre, oven-dry weight 1957
	Pct.	*Pct.*	*Lb.*	*Lb.*
Agropyron cristatum:				
Fairway	90	95	3,825	1,734
S-131	90	90	4,520	2,200
A-1770	80	75	3,085	1,111
Agropyron desertorum:				
42-a	85	85	4,015	2,477
Nordan	80	85	5,185	2,348
Nebraska-10	80	90	4,590	2,244
Standard	85	90	4,097	2,253
Agropyron elongatum:				
PI-119603	30	5	1,530	381
Agropyron intermedium:				
Ree	85	60	3,969	2,097
M2-10820—52	85	85	3,629	2,159
A-12496	80	45	3,460	2,097
Amur	70	65	2,575	2,455
Agropyron sibiricum:				
P-27	85	90	3,357	2,796
Agropyron trichophorum:				
Utah-109	75	70	3,085	1,098
Topar P-41	70	20	2,014	1,142
A-1488	80	50	2,890	1,017

in a randomized block design. The grasses were harvested when in bloom.

Results.—In 1955, *Bromus inermis, Agropyron desertorum, A. inerme, A. intermedium,* and *Elymus junceus* established fair to good stands both in pure stands and in mixtures (table 93).

By 1957, stands of most grasses in pure seedings had improved. *M. falcata*, however, had decreased to a poor stand and in most mixtures appeared to be killed out.

Yields in 1955 were good for species with good stands. The presence of alfalfa in the mixture did not increase yield above the grass alone where stands were good, but where stands of grass were poor the presence of alfalfa did increase yields.

Yield differences between 1955 and 1957 for the different grasses were not consistent. Some species yielded higher in 1955, while others yielded higher in 1957.

Study.—Havre cultivation methods for preparing seedbeds.

Date planted.—1941, 1942, and November 30, 1951.

Procedure.—Different studies were made in which a moldboard plow and a spike-tooth harrow were used to prepare seedbeds from sites previously in wheat stubble. At planting time the seedbeds were free from weeds, and they were firm but mellow.

Nine grasses and one mixture were seeded in pasture-sized plots in 1941 and 1942 on plowed and nonplowed seedbeds.

In 1951, fourteen grasses were seeded in 5-row plots with rows 1 foot apart. Previous to planting, the seedbed was spike-tooth harrowed.

Results.—Because of the dry years that followed planting, only fair to poor stands were established, but better stands were established on the plowed seedbed.

On the 1951 seedbed that was spike-tooth harrowed, weeds were abundant. Only a few grass seedlings emerged, and none of them established satisfactory stands. It was obvious that the spike-tooth harrow did not adequately prepare the seedbed.

TABLE 92.—Establishment and yield of alfalfa strains, *Medicago falcata-sativa*, near Havre, Mont.

Strain	Stand 1951	Herbage yields per acre, oven-dry weight (1954): Alfalfa alone	Herbage yields per acre, oven-dry weight (1954): With *Agropyron desertorum*
	Pct.	*Lb.*	*Lb.*
Buffalo	87	1,341	2,685
Pilca butta	58	1,313	2,137
Ladak	75	1,831	2,045
Alaska falcata	72	657	2,004
Rhizoma	89	1,507	1,837
Ranger	83	1,065	1,810
Nomad	78	1,545	1,749
Sevelra	84	1,991	1,569

TABLE 93.—*Establishment and herbage yield of grasses and alfalfa seeded in pure stands in simple grass-alfalfa mixtures near Havre, Mont.*

Species or mixture	Stand: Grass 1955	Stand: Grass 1957	Stand: Legume 1955	Stand: Legume 1957	Yield per acre, oven-dry weight 1955	Yield per acre, oven-dry weight 1957
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Lb.*	*Lb.*
Species:						
Agropyron desertorum (Standard)	75	80	--	--	4,760	2,925
A. desertorum (Nordan)	80	82	--	--	4,940	2,603
A. elongatum	0	1	--	--	--	318
A. inerme	50	75	--	--	1,680	2,890
A. intermedium	60	58	--	--	3,000	1,268
Bromus erectus	35	--	--	--	2,680	--
B. inermis (Lincoln)	85	90	--	--	3,740	1,841
Elymus junceus	75	80	--	--	1,860	2,477
Oryzopsis x Stipa (Mandan ricegrass)	15	60	--	--	--	1,693
Poa ampla	15	10	--	--	980	2,415
Medicago falcata (Ladak)	--	--	90	10	1,900	255
Mixtures of *Medicago falcata* with grass:						
Agropyron desertorum	85	90	80	0	3,200	2,079
A. desertorum (Nordan)	85	93	80	0	2,900	2,159
A. elongatum	0	--	90	--	1,780	--
A. inerme	80	70	90	25	2,140	1,778
A. intermedium	80	60	65	5	2,580	1,330
Bromus erectus	80	--	80	--	3,080	--
B. inermis	85	85	80	0	3,620	1,568
Elymus junceus	60	80	85	0	2,320	2,500
Oryzopsis x Stipa	10	--	90	--	1,860	--
Poa ampla	30	15	90	1	1,920	762

Glasgow

Study location.—Located about 11 miles from Glasgow and 8 to 9 miles from Fort Peck, Valley County, SW¼ sec. 27 T. 27N., R. 40E. (location 65, fig. 10).

Elevation.—2,300 feet.

Average precipitation.—Annual, 13 inches; April-September, 75 percent.

Soil.—Scobey loam.

Topography.—1 percent slope to the east.

Type of vegetation.—Northern grassland.

Dominant and associated species.—*Bouteloua gracilis*, *Carex* spp., *Selaginella densa*, *Agropyron smithii*, *Stipa comata*, and *Poa secunda*.

Previous use.—Abandoned cropland previously in barley.

Date planted. —December 3, 1945.

Study.—Glasgow range plantings.

Procedures.—No seedbed preparation was made. Twenty-five grasses were seeded in handmade furrows that were chiseled into frozen ground and covered with frozen soil.

Results.—The study failed and was abandoned. In 1961, the area was in wheat.

Central Grassland

This shortgrass plains type extends through central Montana from Canada to Wyoming and is often integrated with the Northern and Judith Basin grassland types. It covers approximately 9,088,000 acres.

The elevation is from 2,000 to 4,000 feet where the precipitation varies from 12 to 16 inches and the growing season ranges from 100 to 125 days.

The soils are clays and clay loams, usually over bedrock or shale. In northern Montana, it is found primarily on Phillips loamy soils that have a desolate appearance because of "slick spots" or "blowouts" that cover from 20 to 60 percent of the area. Also Pierre and Lismas clay loams, found in the shale region, support scant cover of grass with many bare spots. These soils are generally not suited for farming and mechanical seeding usually is not successful.

South of the Missouri River and in areas adjacent to the Musselshell and Yellowstone Rivers, the soils are more favorable for seeding. These soils include Billings, Beaverton, Farland, Arvada, and Cushman clay loams. Most of the Cushman clay loam soils were cultivated but abandoned because of drought and wind erosion. Recently, some of these abandoned areas have again been cultivated. The Beaverton and Farland clay loams occur on benches and terraces above the Yellowstone River, they are dryfarmed for cereal grains and are especially productive.

The primary species are *Bouteloua gracilis*, *Agropyron smithii*, *Stipa comata* and *Artemesia tridentata nova*. Where precipitation is heavier, *A. smithii* becomes more abundant. On the lighter textured soils, *S. comata* becomes more important. On some of the heavy soils, particularly the Pierre and Lismas soils, *Sarcobatus vermiculatus* and numerous annual weeds are prevalent.

Studies are reported from only three sites in this type, and one, Roy, Mont., appears to be a gradation with the Judith Basin grassland type. Initial stands of grass at all three areas were relatively poor, but a few species established fair stands, and the more adapted species improved their stands as they matured.

The best adapted grasses for this type include *Agropyron desertorum*, *A. sibiricum*, *Bromus erectus*, and *B. inermis*. Others that appeared to be adapted at one or more locations were *Agropyron cristatum*, *A. smithii*, *A. trachycaulum*, *Alopecurus pratensis*, *Arrhenatherum elatius*, *Bromus marginatus*, *Dactylis glomerata*, *Elymus canadensis*, *E. junceus*, *Phleum pratense*, and *Stipa viridula*.

Molt

Study location.—Located 4 miles southwest of Molt, Stillwater County, T. 1N., R. 22E. (location 66, fig. 10).

Elevation.—4,000 feet.

Average precipitation.—Annual, 12.8 inches; April-September, 71 percent.

Soil.—Clay loam.

Topography.—5 percent slope to the east on undulating to rolling land.

Type of vegetation.—Central grassland.

Dominant species.—*Bouteloua gracilis*, *Stipa comata*, *Agropyron smithii*, and *Artemesia tridentata*.

Previous use.—Abandoned cropland.

Study. — Molt adaptation nursery.

Date planted. — October 9, 1951.

Procedures.—Forty-two grasses were planted in plots 3 by 20 feet with three rows per plot spaced 1 foot apart. The seedbed was not treated before seeding.

Results.—Stands in 1952 were relatively poor with a few grasses establishing fair stands. The next year most were improved. Those that appeared adapted included *Agropyron desertorum*, *A. trachycaulum*, *A. intermedium*, *A. sibiricum*, *Bromus erectus*, *B. inermis*, *B. marginatus*, *Elymus canadensis*, *Arrhenatherum elatius, Alopecurus pratensis, Dactylis glomerata,* and *Phleum pratense* (table 94).

TABLE 94.—*Establishment of grasses planted at 3 locations in the central grassland type*

Species	Stand[1]			Yield per acre (oven-dry)
	Molt, 1953	Round-up, 1952	Round-up, 1959	Roy, 1959
	Pct.	*Pct.*	*Pct.*	*Lb.*
Fair to good stands established at all locations:				
Agropyron desertorum (Nordan)	72	[2]	54	800
Bromus inermis (Lincoln)	68	50	87	700
B. erectus	68	40	39	333
Agropyron desertorum (M24-3)	62	63	32	633
A. desertorum (Standard)	43	60	57	933
A. sibiricum	42	53	54	833
A. cristatum	37	27	54	600
Fair to good stands established at 1 or 2 of the 3 locations:				
Agropyron trachycaulum	80	23	0	[2]
Bromus marginatus	80	10	1	[2]
Phleum pratense (Hopkins)	67	12	1	[2]
Dactylis glomerata	48	28	17	[2]
Phleum pratense	48	27	0	[2]
Alopecurus pratensis	45	10	1	[2]
Elymus canadensis	43	30	0	[2]
Arrhenatherum elatius	42	0	0	[2]
Agropyron intermedium	40	43	14	[2]
A. trichophorum	40	42	12	[2]
A. elongatum	37	43	7	[2]
Festuca arundinacea	33	27	0	[2]
A. subsecundum	27	47	1	[2]
Stipa viridula	27	18	53	533
Phalaris arundinacea	25	1	0	[2]
Agropyron inerme	23	33	1	[2]
Elymus junceus	8	33	57	566
Agropyron smithii	1	1	49	566
Poor stands established or failed completely at all 3 locations:				
Agropyron spicatum	2	1	1	[2]
Agrostis alba	0	0	0	0

Footnotes at end of table.

TABLE 94.—*Establishment of grasses planted at 3 locations in the central grassland type* —Continued

Species	Stand[1]			Yield per acre (oven-dry)
	Molt, 1953	Roundup, 1952	Roundup, 1959	Roy, 1959
	Pct.	*Pct.*	*Pct.*	*Lb.*
Poor stands established or failed completely at all 3 locations—Con.				
Bouteloua curtipendula	1	0	0	0
B. gracilis	0	0	0	0
Elymus glaucus	17	2	0	0
E. triticoides	5	1	0	0
Festuca elatior	18	22	0	0
F. rubra	7	17	0	0
Oryzopsis hymenoides	3	2	7	[2]
Panicum virgatum	2	0	0	0
Poa ampla	3	5	3	[2]
P. bulbosa	3	18	1	[2]
P. compressa	1	15	1	[2]
P. pratensis	5	5	1	[2]

[1] Grasses planted as follows: Molt and Roundup, 1951; Roy, 1954.
[2] Data not available.

The study was overrun by *Bouteloua gracilis* and was abandoned.

Roundup

Study location.—Located 12 miles north and 2 miles west of Roundup, Musselshell County, T. 9N., R. 25E. (location 67, fig. 10).

Elevation.—3,300 feet.

Average precipitation.—Annual, 10.8 inches; April-September, 74 percent.

Soil.—Cushman clay loam.

Topography.—5 percent slope to the east on rolling lands.

Type of vegetation.—Central grassland.

Dominant and associated species.—*Bouteloua gracilis, Agropyron smithii, Stipa comata* and *Artemesia* spp.

Previous use.—Abandoned cropland.

Study.—Roundup adaptation nursery.

Date planted.—October 1950.

Procedure.—Forty-two grasses were planted in plots 3 by 20 feet with three rows per plot spaced 1 foot apart.

Results.—In 1952 stands were relatively poor. Only a few species rated fair, but those that appeared best adapted included *Agropyron desertorum, A. elongatum, A. intermedium, A. sibiricum, A. subsecundum, A. trichophorum, Bromus erectus*, and *B. inermis* (table 94).

By 1958 the area was overrun with *Bouteloua gracilis* and *Stipa comata*.

Roy

Study location.—Located 5 miles east of Roy, Fergus County, sec. 17, T. 18N., R. 23E. (location 68, fig. 10).

Elevation.—3,500 feet.

Average precipitation.—Annual, 12 inches; April-September, 76 percent.

Soil.—Silty clay loam.

Topography.—2 percent slope to the north near the swale bottom of rolling lands.

Type of vegetation.—Central grassland-Judith Basin grassland.

Dominant species.—*Bouteloua gracilis, Agropyron smithii, Stipa comata*, and *Artemesia tridentata.*

Previous use.—Cropped to small grains.

Study.—Roy adaptation nursery.

Date planted.—1954.

Procedures.—Forty-two species were planted in plots 3 by 20 feet with three rows spaced 1 foot apart. Seeding treatments were replicated three times in a randomized block design.

Results.—Stands of grasses were relatively poor in 1955, and only few species rated fair. By 1959, stands of some species had improved, and those that appeared best adapted included *Agropyron cristatum, A. desertorum, A. sibiricum, A. smithii, Bromus inermis, B. erectus, Elymus junceus*, and *Stipa viridula* (table 94). In 1959 the highest yielding species were *Agropyron desertorum* and *A. sibiricum.*

Eastern Ponderosa Pine Forest and Ponderosa Savannah Type

These two types were located in the southeast quarter of the State at an elevation of 3,000 to 5,000 feet. Precipitation varies from 12 to 16 inches annually, and the growing season ranges from 95 to 130 days. The forest type covers approximately 3,391,000 acres and the savannah type, approximately 2,477,000 acres.

The vegetation is predominantly *scopulorum* variety of *Pinus ponderosa* with *Agropyron spicatum*, *A. smithii*, *Bouteloua gracilis*, *Carex filifolia*, and *Stipa comata*. *Pinus ponderosa* is more dense in the forest type and scattered in the savannah type.

Soils are thin loams and stony loams over bedrock primarily of the Bainville, Travessilla, and Flasher series. The topography is rolling to broken. These areas are not suited to cultivation but are used for grazing.

Studies have not been reported for these two types. Because of the characteristic topography and shallow soils, seeding would be difficult and expensive. Management of native species appears to be the most efficient method for range improvement. Where artificial seeding is practical and desirable, species that are considered as being adaptable include *Agropyron desertorum*, *A. cristatum*, *A. sibiricum*, *A. smithii*, *Bromus erectus*, *B. inermis*, *Elymus junceus*, and *Stipa viridula*.

Missouri River Breaks Scrub Pine

This type is located along the Missouri River and northern end of the Musselshell River in the north-central part of the State at an elevation of 2,000 to 3,000 feet. It includes about 1,744,000 acres. Precipitation varies from 12 to 16 inches, and the growing season is from 105 to 125 days. The soil, primarily Pierre and Lismas clays, is mostly bare of vegetation. However, *Juniperus scopulorum* and *Pinus flexilis* are found on the shaded slopes. *Agropyron smithii*, *A. spicatum*, *Bouteloua gracilis*, and *Muhlenbergia cuspidata* are also found in favorable sites. Generally, this type is not suited for seeding because of the adverse soil conditions and topography. Studies have not been made on this type. It is doubtful if any attempt to plant grass would be successful without research into methods of seeding.

Beartooth Juniper-Limber Pine

This type is primarily located in the Pryor Mountains in Carbon County. A few scattered areas are also located near the Missouri River headwaters. It covers approximately 149,000 acres at elevations from 4,000 to 5,000 feet. Precipitation averages from 6 to 12 inches, and the growing season ranges from 95 to 130 days.

The soils are light-colored thin loams over bedrock, usually sparsely timbered with *Juniperus scopulorum* and *Pinus flexilis*. *Bouteloua gracilis*, *Agropyron spicatum*, and *Carex filifolia* are also common. The topography is rolling to steep slopes. Because of the adversity of these sites, studies have not been made in this type and artificial seeding is not recommended.

Prairie County Grassland

This type is located in the central part of eastern Montana in Prairie County and adjoining counties. It covers an area of 3,361,000 acres at elevations from 2,500 to 3,500 feet. Precipitation varies from 12 to 16 inches, and the growing season ranges from 100 to 150 days. The soils are shallow loams over bedrock and clay.

At one time most of this type was planted to wheat but was abandoned in the 1930's. From 1940 to 1950 much of the abandoned land was seeded to crested wheatgrass. Some areas, however, are still cultivated and planted to small grains. Failures from drought and grasshoppers are still a problem in this area. Primary vegetation is *Bouteloua gracilis*, *Stipa comata*, and *Carex fiilfolia*. *Andropogon scoparius* is also found on the more favorable sites, annual weeds dominate abandoned croplands.

In studies at Rock Springs, cultivation before planting was necessary to success. Also, date of planting was critical for *Bouteloua gracilis* and *Poa bulosa*, which established best from spring planting. Date of seeding (spring versus fall) made little difference in the establishment of cool-season grasses.

None of the studies on this type were extended over more than 3 years. Therefore, conclusive results on longevity of species cannot be made. Species that establish well and appeared adapted to the area, however, included *Agropyron cristatum*, *A. desertorum*, *A. inerme*, *A. intermedium*, *A. smithii*, *Elymus junceus*, and *Medicago falcata*.

Rock Springs

Study location.—Located 1 mile southeast of Rock Springs, E½NE¼ sec. 18, T. 12N., R. 44E. (location 69, fig. 10).

Elevation.—2,500 feet.

Average precipitation.—Annual, 9.6 inches; April-September, 80 percent.

Soil.—Sandy clay loam underlain by clay.

Topography.—2 to 3 percent slope to the west.

Type of vegetation.—Prairie County grassland.

Dominant and associated species.—*Agropyron smithii*, *Stipa comata*, and *Bouteloua gracilis*.

Previous use.—Cultivated for cereal farming from about 1915 to 1935 then abandoned; annual weeds including mustards, Russian-thistle, peppergrass, and wild lettuce were abundant.

Study.—Rock Springs adaptation planting (1940).

Date planted.—November 6-7, 1940.

Procedures.—Thirteen grasses were planted without seedbed preparation in plots 33 by 132 feet. Planting was done with a one-horse drill in rows spaced 14 inches apart. Plots were arranged in a randomized block design with two replications.

Summary of results.—With the exception of *Bouteloua gracilis* and *Poa compressa*, most of the species germinated and began growth in the spring of 1941. Many seedlings died between July and October 1941. The loss of stand was attributed to a combination of weed competition, grasshopper damage, and low-soil moisture.

Species that appeared best adapted were *Agropyron cristatum*, *A. desertorum*, *A. intermedium*, *A. sibiricum*, and *Bromus erectus* (table 95).

Study.—Rock Springs adaptation planting (1942).

Date planted.—Fall 1942.

Procedures.—Thirteen grasses were planted. The seedbed was prepared by cultivating before planting.

Summary of results.—By 1945 *Agropyron desertorum*, *A. smithii*, *Oryzopsis hymenoides*, and *Stipa viridula* had established good stands while *Agropyron cristatum*, *A. trachycaulum*, *Bromus erectus*, and *Festuca arundinacea* rated fair. Species that failed or established poor stands were *Bouteloua gracilis*, *Bromus marginatus*, *B. inermis*, *Panicum virgatum*, and *Phleum pratense*.

Study.—Rock Springs preparatory crop planting.

Date planted.—October 11, 1943.

Procedures.—Two strips, 66 by 396 feet, were plowed in the late fall of 1942 when the soil was frozen. Although a packer was pulled behind the plow, the soil was left rough through the winter. In the spring of 1943 the plowed strips were double disked with a tandem disk. At the same time two 14- by 396-foot

TABLE 95.—*Ratings of establishment of species planted near Rock Springs, Mont.* [1]

Species	Fall seeded		Spring seeded, 1943	
	Stand 1941 [2]	Stand 1944 [3]	Stand, 1943	Stand 1944
	Rating	*Rating*	*Rating*	*Rating*
Fair to good stands established from both spring and fall plantings:				
Agropyron cristatum	G	8	8	6
A. desertorum	G	9	8	5
A. inerme	F	8	8	5
A. intermedium	G	9	9	4
Elymus junceus	P	8	8	5
Elymus x Secale	F	9	9	10
Medicago falcata	O	10	8	7
Agropyron dasystachyum	-	8	8	3
A. sibiricum	G	8	7	2
A. smithii	F	7	8	4
Arrhenatherum elatius	-	7	8	1
Bromus erectus	G	6	8	1
B. inermis (Parkland)	F	8	8	1
Elymus dahuricus	-	8	9	1
E. sibiricus	-	9	9	4
Poa ampla	P	7	7	3
Festuca arundinacea	-	8	8	1
Stipa viridula	-	9	8	1
Established best from spring plantings:				
Bouteloua gracilis	P	1	6	0
Poa bulbosa	-	0	8	1

[1] Rating scale G = good; F = fair; P = poor; 10 = excellent; 1 = failure.

[2] Planted 1940.

[3] Planted 1943.

strips of unprepared soil were disked. Half of each cultivated strip was seeded to sudangrass on May 28, 1943, and the other half was seeded to millet. The grain was not harvested. In the fall *Agropyron cristatum* was seeded across one end of the study area so that both sudan and millet strips, as well as an unprepared strip, were all drilled in one operation. Seeding was made with a one-horse grain drill at 8 to 10 pounds per acre.

Summary of results.—Although the preparatory crops were not harvested, good stands of both sudan and millet were established except on the unplowed but disked area. Disking without plowing was ineffective in destroying *Agropyron smithii* that formed rather dense patches. The millet seemed to have produced more forage than sudan. Yields of sudan were estimated at 1-½ tons per acre and that 1-½ to 2 tons per acre.

In general, the *Agropyron cristatum* planting was satisfactory but uneven. Better stands were established on the disked areas, but the plants were larger and more vigorous on the plowed areas. Vigor and size were both better on the millet than on the sudan areas and poorest on the unprepared seedbed.

Study.—Rock Springs adaptation plantings (1943).

Previous use.—The area used was previously part of the preparatory crop study that had been in millet and sudangrass.

Date planted.—April 16 and October 12, 1943.

Procedures.—Twenty-four species of grass and legumes were planted in plots 5 by 16 feet in three rows 18 inches apart. Seeds were spread in furrows made with a hoe and then covered and packed with a garden rake. Before spring seeding the area was plowed, harrowed, and hand raked. The fall seeding was made into millet stubble.

Summary of results.—Data were available for only two seasons from the spring seeding and only one season from the fall seeding because the area was plowed out in 1945. Initial establishment was about equal for spring and fall seedings, with good establishment for most species. In the second growing season (spring seeded), most species rated poor to fair. Species that rated best included *Agropyron cristatum*, *A. desertorum*, *A. inerme*, *Elymus junceus; Elymus* x *Secale*, and *Medicago falcata* (table 95). Although *Elymus* x *Secale* established good initial stands; in other studies it was short lived and soon died out.

Study.—Rock Springs range plots.

Date planted.—October 11, 1943.

Planting procedures.—Six grasses and alfalfa were seeded in plots 8 by 135 feet so that they crossed three seedbed-preparatory cropping treatments. The seedbed treatments included plowed millet stubble, plowed sudan stubble, and unprepared seedbed. Seeding was done with a one-horse drill at 10 pounds seed per acre in rows spaced 7 inches apart. Seeding depth was about three-fourth inch except for blue grama that was planted ¼ inch deep. Plots were replicated three times in a randomized block design.

Summary of results.—Ratings in 1944 were made only from the plowed sudan stubble treatment. Initial establishment, of all species except *Bouteloua gracilis*, was good. *B. gracilis* was nearly a complete failure (table 95). The other species included *Agropyron desertorum, A. inerme, A. intermedium, Bromus erectus, Elymus junceus*, and *Medicago falcata*.

Study.—Rock Springs blue grama and blue grama-wheatgrass planting.

Date planted.—April 15 and May 15, 1944.

Procedures.—Bouteloua gracilis, Agropyron cristatum, and *A. smithii* were planted alone and in mixtures through a Planet Junior hand seeder into an area that had grown sudan and millet the previous year. The area was covered with a heavy growth of Russian-thistle and tumble mustard that was raked and burned before seeding.

Seeding combinations and rates were as follows:

1. *A cristatum* (180) — 8 to 10 pounds per acre
2. *A. smithii* (247) — 18 to 20 pounds per acre
3. *B. gracilis* (245) — 6 to 8 pounds per acre
4. *A. cristatum* — 4 to 5 pounds
   B. gracilis — 3 to 4 pounds
5. *A. smithii* — 9 to 10 pounds
   B. gracilis — 3 to 4 pounds
6. *A. cristatum* — 2 to 3 pounds
   A. smithii — 4 to 5 pounds
   B. gracilis — 3 to 4 pounds

Summary of results.—On June 23, 1944, stands of all species were good from both plantings, but seedlings from the April planting were larger than those from the May planting. At that time, the plantings showed no signs of competition between species in the mixtures. Apparently, the study was abandoned soon after, and no additional information was recorded.

Badlands Grassland

This type of the Shortgrass Region is found adjacent to the Yellowstone River in eastern Montana along the Missouri River in Garfield and Valley Counties and along the Musselshell River. It covers approximately 2,499,000 acres at elevations from 2,000 to 3,000 feet. Precipitation varies from 12 to 16 inches, and the growing season is 110 to 140 days long. The topography is characteristic badlands with steep and broken terrain.

The badlands of the Missouri River area are cut from clayey parent material. These soils are similar to the Lismas clay, which was probably the original soil type. The primary species include *Artemesia tridentata nova*, *Sarcobatus vermiculatus*, and a sparse growth of *Agropyron smithii*.

Along the Yellowstone River the parent material from which the badlands were cut is an integration of the clay-shale and sandstone types. Grass production on the sandstone formation is generally better than on the clay and shale formations. Production, however, is extremely low on all badland types.

Because of the adverse soil and topography of this type, none of it has been cultivated and today is used only for grazing. Whether these sites will ever be successfully revegetated by artificial seeding is doubtful. No research studies have been made on this type.

Sagebrush-Saltbush Rangeland

This type of the Northern Desert Shrub Region is found scattered throughout eastern Montana. Large areas occur in Carter, Carbon, Musselshell, Rosebud, Fergus, and Valley Counties. It covers approximately 3,932,000 acres at elevations from 3,000 to 5,000 feet. Precipitation ranges from 8 to 14 inches, and the growing season is 100 to 135 days long.

The soils are thin clay loams over shale, which include the Lismas and Pierre clay loams and the badland basin soils. The permeability of the soil is poor, and the rate of infiltration is slow. Most of the precipitation is lost as overflow.

The vegetation is primarily *Atriplex nuttallii*, *A. confertifolia*, *Artemesia tridentata nova*, *Sarcobatus vermiculatus*, and *Opuntia polyacantha*. On the flood plains, *Agropyron smithii* is an important species, while on the higher and light-textured soils, scattered plants of *Bouteloua gracilis*, *Stipa comata*, and *Poa secunda* are found.

Studies on this type were conducted near Glasgow, Mont., in 1958 by the Animal Industry and Range Management Department of Montana Agricultural Experiment Station. All species, which were seeded by drilling in a water-spreading project, failed to become established although some showed good germination and initial emergence.

Other management practices on this type near Glasgow showed that fairly good stands of *Agropyron desertorum* could be established by seeding in contour trenches and by protecting the seedings from grazing.

Although soil conditions and precipitation are adverse to establishment of good grass stands, artificial seeding on the more level sites appears possible. Reasonable care, however, must be taken in preparing a seedbed to reduce runoff and increase water infiltration. Salt-tolerant and drought-tolerant species should be seeded, and the seeded stands must be given adequate protection from overgrazing.

Sandy Grassland

This type occurs in relatively small areas along the Yellowstone River and in northern Montana. Most often it is found intermingled with other grassland types on the light-textured, droughty soils. It covers an area of approximately 2,832,000 acres at elevations from 2,000 to 3,000 feet. Precipitation varies from 12 to 14 inches, and the growing season varies from 80 to 140 days. Soils are gravelly to silty loams primarily in the Cheyenne, Bainville, and Turner series.

The primary vegetation consists of *Bouteloua gracilis*, *Carex filifolia*, *Stipa comata*, and *Calamovilfa longifolia*. Much of this type was cultivated, but because of the lower water-holding capacity of the soil, grain crops often failed and the fields were abandoned. Most of the abandoned areas have been seeded to *Agropyron desertorum*.

Studies have shown that *Agropyron cristatum*, *A. desertorum*, and *E. junceus* are all well adapted to this type. Other species which have established fair to good stands include *Bouteloua curtipendula*, *B. gracilis*, and *Stipa viridula*.

Deer Creek

Study location.—Located 20 miles northwest of Glendive, Dawson County, on the north fork of Deer Creek, along a diversion ditch, sec. 29, T. 18N., R. 53E. (location 71, fig. 10).

Elevation.—2,600 feet.

Average precipitation.—Annual, 13 inches; April-September, 77 percent.

Soil.—Bainville silt loam.

Topography.—1 percent slope to southeast.

Type of vegetation.—Sandy grassland.

Dominant and associated species.—*Bouteloua gracilis* and *Carex filifolia.*

Previous use.—Abandoned cropland.

Study.—Deer Creek adaptation planting.

Date planted.—April 13, 1938.

Procedures.—Nineteen grasses were planted on abandoned cropland. Three rows per plot were planted by scattering seed in handmade furrows and covering with one-half inch of soil. The distance between rows was about 3 feet.

Summary of results.—In 1938 the nursery was rated a medium success without reference to species. The seeding was rated just as good in 1945. In 1950 eight species were observed, three of which were maintaining full stands. They were *Agropyron cristatum*, *A. desertorum*, and *Elymus junceus*. The first two species had spread extensively throughout the area but had not been able to invade between rows of *E. junceus*. Other species with fair to good stands were *Bouteloua curtipendula*, *B. gracilis*, *Bromus inermis*, and *Stipa viridula*. Only a trace *Oryzopsis hymenoides* was found.

Species that completely failed were *Agropyron inerme*, *A. pauciflorum*, *A. smithii*, *A. spicatum*, *Arrhenatherum elatius*, *Bromus marginatus*, *Elymus canadensis*, *Panicum virgatum*, *Phleum pratense*, *Poa nevadensis*, and *Stipa comata*.

Study.—Deer Creek contour furrow planting.

Date planted.—April 13, 1938.

Procedure.—The study was located on rangeland adjacent to the Deer Creek adaptation study. Eight grasses were planted in 4-inch furrows made by plowing on the contour. Each grass was seeded along 200 feet of each furrow at five different locations in the area. The seed was broadcast in bands about 5 feet wide with 2 feet on either side of the furrow.

Results.—By 1950 four grasses were established. *Agropyron cristatum* had spread to 12 feet below the original seeding. Good stands of *Bouteloua gracilis* and scattered plants of *Bromus inermis* and *Oryzopsis hymenoides* were found in the furrows.

Southeastern Grassland

This type is located in the southeastern corner of the State. It covers approximately 2,683,000 acres at elevations from 3,000 to 5,000 feet. Precipitation varies from 12 to 16 inches annually, and the growing season is 100 to 150 days.

The soil, mostly shallow loams over bedrock, supports native stands of *Buchloe dactyloides*, *Bouteloua gracilis*, and *Carex filifolia*.

Species that appear adapted to this type include *Agropyron cristatum*, *A. desertorum*, *A. smithii*, *A. trachycaulum*, *Bouteloua gracilis*, and *Stipa viridula*.

Baker

Study location.—Located in a shelterbelt area on the fair grounds at Baker, Mont., T. 7N., R. 59E. (location 72, fig. 10).

Elevation.—3,000 feet.

Average precipitation.—Annual, 13 inches; April-September, 78 percent.

Soil.—Clay loam.

Topography.—5 percent slope to the east.

Type of vegetation.—Southeastern grassland.

Dominant and associated species.—*Buchloe dactyloides, Bouteloua gracilis*, and *Carex filifolia.*

Previous use.—Abandoned cropland and windbreak.

Study.—Baker species adaptation.

Date planted.—1938.

Planting procedures.—Thirteen grasses were seeded.

Summary of results.—By 1945, good stands of *Agropyron cristatum, A. desertorum*, and *A. smithii* and fair stands of *Agropyron trachycaulum, Bouteloua gracilis*, and *Stipa viridula* were established. Species that failed or had poor stands were *Agropyron spicatum, A. inerme, Poa nevadensis, P. secunda, Bromus inermis, Elymus canadensis*, and *E. junceus.*

Northeastern Grassland

This type, located in the northeastern corner of the State, extends down the eastern border. It covers approximately 4,110,000 acres at elevations from 2,000 to 3,000 feet. Precipitation varies from 12 to 16 inches, and the growing season ranges from 80 to 140 days.

The soils are moderately dark loams developed from glacial deposits. Glaciated boulders and stones are found throughout the soil layer. These soils, which are productive, have been dry farmed in areas not too stony or eroded. The stony phases are used predominantly for grazing.

The dominant native species are *Agropyron smithii, Bouteloua gracilis*, and *Carex filifolia.* On the drier sites *Stipa comata* is also important, while on the more favorable northern slopes *Andropogon scoparius* is commonly dominant.

Species that appeared adapted to this type include *Agropyron cristatum, A. desertorum, A. intermedium, Arrhenatherum elatius, Bouteloua gracilis, Bromus inermis, Stipa viridula*, and *Phleum pratense.*

Moen Farm

Study location.—Located near Culbertson, Mont. (location 73, fig. 10).

Elevation.—2,000 feet.

Average precipitation.—Annual, 13 inches; April-September 80 percent.

Soil.—Williams sandy loam.

Type of vegetation.—Northeastern grassland.

Dominant species.—*Andropogon scoparius, Agropyron smithii, Stipa comata,* and *Bouteloua gracilis.*

Study.—Moen farm range planting.

Date planted.—1950.

Procedure.—Five grasses were seeded in strips one drill width wide across variable slopes and soil. "Low-ground" areas received supplemental moisture.

Results.—In 1956 the species were rated in decending order as follows: On high ground, *Agropyron cristatum, A. intermedium, Bromus inermis, Stipa viridula,* and *Elymus junceus*; on low ground, *Bromus inermis, Stipa viridula, Agropyron intermedium, A. cristatum,* and *Elymus junceus.*

Scobey

Study location.—Located 5 miles west of Scobey, Mont., W½ sec. 30, T. 35N., R. 48E. (location 74, fig. 10).

Elevation.—2,500 feet.

Average precipitation.—Annual, 11 inches; April-September 85 percent.

Soil.—Williams loam.

Topography.—5 percent slope to the northeast on undulating land.

Type of vegetation.—Northeastern grassland.

Dominant and associated species.—*Agropyron smithii, Stipa comata, Andropogon scoparious,* and *Bouteloua gracilis.*

Previous use.—Abandoned cropland.

Study.—Scobey adaptation planting.

Date planted.—April 26, 1938.

Procedure.—Fourteen grasses were planted in plots 9 by 32 feet with three rows spaced 3 feet apart. Planting was done by scattering seed in shallow furrows and covered with ½ inch of soil.

Summary of results.—By 1945 most species rated fair to poor, but *Agropyron cristatum* and *Bromus inermis* were rated good. Other species that appeared adapted to the area were *Agropyron desertorum*, *Arrhenatherum elatius*, and *Phleum pratense*. Those with poor stands were *Agropyron inerme*, *A. smithii*, *A. spicatum*, *A. trachycaulum*, *Bouteloua gracilis*, *Bromus marginatus*, *Elymus canadensis*, *Oryzopsis hymenoides*, and *Poa nevadensis*.

Flaxville

Study location.—Located one-half mile south of Flaxville, Mont., NW¼SW¼ sec. 9, T. 35N., R. 50E. (location 75, fig. 10).
Elevation.—2,500 feet.
Average precipitation.—Annual, 11 inches; April-September, 84 percent.
Soil.—Daniels gravelly loam.
Topography.—3 percent slope to the southeast on a high gravelly bench.
Type of vegetation.—Northeastern grassland.
Dominant and associated species.—*Bouteloua gracilis*, *Stipa comata*, and *Andropogon scoparius*.
Previous use.—Rangeland.

Study.—Flaxville contour planting.
Date planted.—October 1939.
Procedures.—Eight grasses were planted by broadcasting seed across contoured furrows. Plots were 4 feet wide by 200 feet long and replicated five times. The furrows were spaced 20 feet apart. They were 4 inches deep and 8 inches wide.
Summary of results.—By 1945 stands rated from poor to good. Species that rated highest included *Agropyron cristatum*, *A. desertorum*, *Arrhenatherum elatius*, *Bouteloua gracilis*, and *Bromus inermis*. Species with poor stands were *Agropyron smithii*, *A. trachycaulum*, and *Oryzopsis hymenoides*. These plots were heavily grazed before the 1945 observations.

Undifferentiated Stream and Lake Bottoms

This type is highly variable depending on location, soils, and surrounding types of vegetation. It occurs throughout Montana but has been designated primarily to the eastern two-thirds of the State as being separate from the Intermountain Valley grasslands and meadows of the western part of the State. It is found along the streams and dry lake beds. Most of its 2,629,000 acres are cultivated and irrigated. Elevation, precipitation, and growing season vary depending on location.

The soils range from clays to gravel with large variations occurring in small distances. Likewise, a large variety of species is found. Deciduous trees including *Salix amygdaloides*, *Populus sargentii*, *Prunus americana*, *P. virginiana*, *Acer negundo*, and *Fraxinus pennslyvanica* are found along with *Juniperus scopulorum*. Some more important grasses and grasslike plants include *Agropyron smithii*, *Agrostis alba*, and species of *Carex*, *Junceus*, and *Bechmannia*. The more saline areas support *Sarcobatus vermiculatus*, *Atriplex* spp., *Eurotia lanata*, *Distichlis stricta*, and *Sheperdia argentea*. *Artemesia tridentata* is also locally common in undisturbed areas; several introduced species have escaped. Introduced grasses that have become naturalized and are spread throughout this type include *Poa pratensis*, *Bromus inermis*, and *Agropyron repens*. *Bromus tectorum* is also found on disturbed sites.

Seedbed preparation to eliminate competing vegetation is essential for successful seedling establishment. Grasses seeded at Huntley in a stand of *B. tectorum* established poor to fair stands, while on cultivated areas stands were good. Near Miles City about twice as many seedlings were established where the seedbed had been plowed or disked as compared with nontreated abandoned cropland. Seedings of *Bouteloua gracilis*, however, indicated that the best stands were established on a nonprepared seedbed. Probably, the firmness of the unprepared seedbed was responsible for the increased success.

Plants established better from drilling than from broadcasting, which generally failed. In one study near Miles City, however, broadcasting was equal to drilling on prepared seedbeds. In this study, the seeding rates of the broadcast treatments were doubled.

In depth-of-seeding studies *B. gracilis* established better from very shallow seeding, whereas *A. desertorum* established successfully when seeded to 1-½ inches deep. The time of seeding also affected the establishment of grasses differently. *Agropyron desertorum*, *A. intermedium*, *A. trichophorum*, *Festuca ovina*, *Poa ampla*, and *Stipa viridula* established better stands from fall seedings, whereas *B. gracilis* consistently established better from spring seeding. Although stands of the wheatgrass were better from fall seedings, stands from spring seeding were adequate.

Species which were generally adapted to this type included *Agropyron cristatum*, *A. desertorum*, *A. intermedium*, *A. sibiricum*, *A. trichophorum*, *A. elongatum*, *A. trachycaulum*, *A.*

smithii, Agrostis alba, Bromus erectus, B. inermis, Elymus junceus, Poa pratensis, P. compressa, and *Stipa viridula.*

Huntley

Study location.—Located at the Huntley Branch Experimental Station (Field G) near Huntley, Mont., T. 2N., R. 28E. (location 77, fig. 10).

Elevation.—3,000 feet.

Average precipitation.—Annual, 11.6 inches; April-September, 69 percent.

Soil.—Very fine sandy loam.

Topography.—Level.

Type of vegetation.—Undifferentiated stream bottom.

Dominant and associated species.—*Agropyron smithii, Stipa comata, Poa pratensis.*

Previous use.—Farmland.

Study.—Huntley adaptation planting (1948-49).

Date planted.—October 8, 1948 and March 1949.

Procedures.—Fifteen grasses were planted in plots 12 by 40 feet with 12 rows spaced 1 foot apart. The seedbed was prepared by summer fallowing in 1948. No further treatment was made before the spring seeding in 1949.

Results.—In 1949, growth on all fall-seeded grasses was taller than from spring-seeded, in 1950 this difference was not evident. *Agropyron desertorum, A. trichophorum, Elymus junceus,* and *Bromus erectus* had the best stands on both fall and spring seedings, and the fall seeding gave the best stands for all species (table 96). This, however, should not discount spring plantings that resulted from weed competition or soil factors related to the lack of seedbed preparation.

Study.—Huntley adaptation plantings (1945-46).

Date of planting.—Fall 1945 and 1946.

Procedure.—Sixteen grasses and legumes were planted in the fall of 1945 and 13 in the fall of 1946 in plots 14 by 148 feet. Seeding was done with a single-disk drill into a thick stand of cheatgrass.

Results.—In 1946 poor to fair stands had established. The following year, stands of *Agropyron desertorum* (Standard) and *A. trichophorum* were good, while *A. cristatum, A. desertorum* (M24-3), *A. intermedium* (Ree), *A. elongatum, Bromus erectus,* and *B. inermis* rated fair.

TABLE 96.—*Establishment of grasses near Huntley, Mont., on stream bottom lands*

Species	Planted spring 1949, stand 1950	Planted fall 1949, stand, 1950	Planted fall 1951, stand 1952	1958
	Pct.	*Pct.*	*Pct.*	*Pct.*
Fall and spring seeded				
Good stands established and maintained for 7 years:				
Agropyron desertorum:				
Standard	85	98	20	67
Nordan	--	--	48	88
M24-3	--	--	27	83
Fair to good stands established and maintained fair stands for 7 years:				
Agropyron inerme	26	54	10	53
A. intermedium	37	63	15	53
A. trichophorum	52	88	12	57
Bromus erectus	76	80	50	22
B. inermis (Lincoln)	62	69	50	20
Elymus junceus	71	80	3	33
Fall seeded				
Fair stands maintained for 7 years:				
Agropyron cristatum (Fairway)	--	--	13	43
Agropyron sibiricum	--	--	8	55
A. trachycaulum	--	--	65	28
Poorly established or failed within 7 years:				
Agropyron elongatum	28	64	13	2
A. smithii	6	23	1	1
A. spicatum	4	3	0	2
A. subsecundum	--	--	15	18
Agrostis alba	--	--	0	0
Arrhenatherum elatius	30	40	30	1
Bouteloua curtipendula	--	--	1	0
B. gracilis	--	--	0	0
Bromus marginatus	--	--	68	13
Dactylis glomerata	--	--	43	3
Elymus canadensis	--	--	33	1
E. glaucus	--	--	3	1
E. triticoides	--	--	1	8

TABLE 96. —*Establishment of grasses near Huntley, Mont., on stream bottom lands* —Continued

Species	Planted spring 1949, stand 1950	Planted fall 1949, stand, 1950	Planted fall 1951, stand 1952	1958
	Pct.	*Pct.*	*Pct.*	*Pct.*
Poorly established or failed within 7 years—Con.				
Festuca arundinacea	34	42	8	0
F. elatior	--	--	13	0
F. rubra	--	–	1	0
Oryzopsis hymenoides	–	--	1	1
Panicum virgatum	--	--	1	0
Phalaris arundinacea	--	--	17	0
Phleum pratense	--	--	18	1
Poa ampla	4	19	1	1
P. bulbosa	--	--	0	12
P. compressa	--	--	1	0
P. pratensis	--	--	1	0
Stipa viridula	44	68	20	2

Study.—Huntley adaptation nursery (1951).

Date planted.—September 29, 1951.

Procedure.—Forty-two grasses were seeded in plots 3 by 20 feet with three rows per plot spaced 1 foot apart. Seeding treatments were replicated three times. The seedbed was prepared by summer fallowing in 1951.

Summary of results.—Initial stands in 1952 were generally poor. However, a few species established fair stands. By the next year, stands were generally improved. Species that appeared best adapted included *Agropyron cristatum, A. desertorum, A. intermedium, A. trichophorum., A. inerme* and *A. sibiricum* (table 96).

Species which maintained poor stands or failed completely are listed in table 96.

Reed Point

Study location.—Located between Grey Cliff and Reed Point, Mont., across the railroad tracks from the historical marker on Highway 10, T. 1S., R. 16E. (location 76, fig. 10).

Elevation.—3,800 feet.

Average precipitation.—Annual, 13.5 inches; April-September, 68 percent.

Soil.—Gravelly loam.

Topography.—1 percent slope to the north.

Type of vegetation.—Undifferentiated stream bottom.

Dominant species.—*Artemesia tridentata*, *Stipa comata*, and *Agropyron smithii*.

Previous use.—Farmland.

Study.—Reed Point adaptation nursery.

Date planted.—April 12, 1951.

Procedure.—Forty-two grasses were planted in 3- by 20-foot plots with three rows spaced 1 foot apart. Seeding treatments were replicated three times in a randomized block design.

Results.—Stands in 1952 were generally fair to good for most species, but by 1956 most grasses had declined to poor ratings. Species that appeared best adapted, however, included *Agropyron desertorum*, *A. trichophorum*, *Bromus inermis*, *B. erectus*, *Poa compressa*, *Stipa viridula*, and *Alopecurus pratensis* (table 97).

Worden

Study location.—Located east and north of Worden, Mont., on the Worden Saline Reclamation Project, T. 3N., R. 29E. (location 78, fig. 10).

Elevation.—3,000 feet.

Average precipitation.—Annual, 12 inches; April-September, 70 percent.

Soil.—Clay loam saline phase.

Topography.—Level.

Type of vegetation.—Undifferentiated stream bottom.

Dominant species.—*Sarcobatus vermiculatus*, *Atriplex* spp., *Distichlis stricta*, and *Sheperdia argentea*.

Previous use.—Unused except for grazing.

Study.—Worden adaptation nursery.

Date planted.—1952.

Procedure.—Forty-two grasses were planted on plowed seedbed in 3- by 20-foot plots with three rows per plot spaced 1 foot apart. Seeding treatments were replicated three times.

Results.—In 1953 stands of the grasses were poor to good. Species that established good initial stands were *Agropyron desertorum* (Nordan), *A. elongatum*, *A. trachycaulum*, *A.*

TABLE 97.—*Establishment of grasses near Reed Point, Mont.*

Species	Stand	
	1952	1956
	Pct.	*Pct.*
Fair stands maintained for 5 years:		
Agropyron desertorum (Standard)	70	53
Alopecurus pratensis	60	50
Stipa viridula	17	47
Agropyron trichophorum	57	40
Bromus erectus	57	40
B. inermis (Lincoln)	78	40
Poa compressa	17	40
Agropyron cristatum	53	30
A. inerme	63	30
Festuca elatior	73	33
Agrostis alba	42	27
Elymus canadensis	30	27
Fair to good stands established initially but declined to poor stands by the 5th year:		
Bromus marginatus	67	23
Elymus junceus	63	23
Festuca ovina duriuscula	57	23
Poa ampla	50	23
Agropyron desertorum (M24-3)	73	20
Festuca arundinacea	73	20
F. rubra	63	20
Poa pratensis	28	20
Agropyron sibiricum	60	17
A. intermedium	47	10
Dactylis glomerata	78	7
Poorly established or failed completely:		
Agropyron elongatum	8	7
A. smithii	0	20
A. spicatum	0	0
A. subsecundum	20	23
A. trachycaulum	53	0
Agrostis tenuis	25	0
Arrhenatherum elatius	78	0
Bouteloua curtipendula	0	0
B. gracilis	0	0
Elymus glaucus	0	0
E. triticoides	0	17
Oryzopsis hymenoides	0	0

TABLE 97.—*Establishment of grasses near Reed Point, Mont.*—Continued

Species	Stand 1952	Stand 1956
	Pct.	*Pct.*
Poorly established or failed completely—Continued		
Panicum virgatum	0	0
Phalaris arundinacea	35	0
Phleum pratense	75	0
Poa bulbosa	47	13

trichophorum, Arrhenatherum elatius, Elymus canadensis, and *Festuca arundinacea.*

By 1956, stands of several species had improved while others had failed. Those that appeared to be adapted to the saline site included *Agropyron cristatum, A. desertorum* (Standard, M24-3, and Nordan), *A. michnoi, A. trachycaulum, A. intermedium, A. trichophorum, A. subsecundum, A. sibiricum, A. smithii, A. elongatum, Bromus erectus, B. inermis, Elymus canadensis, E. junceus, E. triticoides,* and *Stipa viridula* (table 98).

E. junceus and *E. triticoides* appeared particularly adapted. *E. junceus* produced a seed crop of 200 pounds per acre, and *E. triticoides* was spreading to adjoining plots.

Forsyth

Study location.—Located on the Rosebud County fair grounds at Forsyth, T. 6N., R. 40E. (location 79, fig. 10).

Elevation.—2,800 feet.

Average precipitation.—Annual, 10 inches; April-September, 80 percent.

Soil.—Very fine sandy loam.

Topography.—1 percent slope to the north.

Type of vegetation.—Undifferentiated stream bottom.

Dominant species.—*Agropyron smithii, Bouteloua gracilis,* and *Stipa comata.*

Previous use.—Fairgrounds.

Study.—Forsyth adaptation plantings.

Date planted.—1942 and spring 1944.

Procedure.—In 1942, 15 grasses were planted by drilling into

TABLE 98.—*Establishment of grasses on saline soils near Worden, Mont.*

Species	Stand 1953	Stand 1956
	Pct.	*Pct.*
Good stands maintained for 4 years:		
Elymus triticoides	17	93
Agropyron trachycaulum	78	90
A. desertorum (Nordan)	62	85
A. intermedium	57	85
Elymus canadensis	70	83
Bromus inermis (Lincoln)	47	83
Agropyron desertorum (M24-3)	45	83
A. elongatum	70	82
A. desertorum (Standard)	22	80
Elymus junceus	37	77
Agropyron subsecundum	1	75
A. sibiricum	22	73
A. cristatum (Fairway)	15	73
A. trichophorum	67	70
A. michnoi	32	67
A. smithii	1	63
Poor to fair stands maintained:		
Bromus erectus	30	58
Stipa viridula	55	53
Arrhenatherum elatius	75	37
Alopecurus pratensis	8	24
Festuca arundinacea (Alta)	60	22
Phalaris arundinacea	17	22
Panicum virgatum	47	13
Generally failed within 4 years:		
Agropyron inerme	30	0
Agrostis alba	1	0
Bouteloua curtipendula	4	0
B. gracilis	2	0
Bromus marginatus	25	0
Dactylis glomerata	33	0
Elymus glaucus	9	0
Festuca elatior	53	0
F. ovina duriuscula	1	1
F. rubra	3	1
Oryzopsis hymenoides	7	5
Phleum pratense	8	0

TABLE 98. —*Establishment of grasses on saline soils near Worden, Mont.* — Continued

Species	Stand 1953	Stand 1956
	Pct.	*Pct.*
Generally failed within 4 years—Continued		
Poa ampla	2	1
P. bulbosa	1	1
P. compressa	1	1
P. pratensis	1	1

a scattered stand of *Buchloe dactyloides* that had been previously seeded. In 1944, 16 grasses were planted into a prepared seedbed.

Summary of results.—By 1945 *Buchloe dactyloides* had spread into all of the vacant area. Nevertheless, the following species established good stands: *Agropyron cristatum, A. desertorum, A. trachycaulum, Bromus erectus*, and *B. inermis*. Apparently, competition from *B. dactyloides* had not become severe by 1945.

In plots seeded in 1944, species that established good stands included *A. cristatum, A. desertorum, A. trachycaulum, Bouteloua gracilis, Bromus erectus, B. inermis, B. marginatus, Panicum virgatum, Phleum pratense*, and *Poa ampla*.

Poor to fair stands were established by *Agropyron smithii, Arrhenatherum elatius, Elymus glaucus, Festuca arundinacea, Oryzopsis hymenoides*, and *Stipa viridula*. *Agropyron spicatum* was the only species planted that failed completely.

Highway 10

Study location.—Located south of Highway 10 in the west end of field No. 2 at the U.S. Range Livestock Experiment Station near Miles City, Custer County, sec. 13, T. 7N., R. 46E. (location 80, fig. 10).

Elevation.—2,360 feet.

Average precipitation.—Annual, 13 inches; April-September, 72 percent.

Soil.—Moderately heavy texture with pH of 8.0.

Topography.—Level flood plain.

Type of vegetation.—Undifferentiated stream bottom.

Dominant and associated species.—*Agropyron smithii*, *Stipa comata*, and *Bouteloua gracilis*.

Previous use.—The field was formerly irrigated and cropped, but cultivation was discontinued in 1937 because of the heavy soil.

Study.—Highway 10 adaptation planting.

Date planted.—September 24, 1937.

Procedure.—Thirty-six species of grass were seeded in plots 6 by 18 feet with three rows per plot spaced 2 feet apart.

Results.—By November several grasses showed good emergence. By June 1939, however, only four of them, *Agropyron smithii*, *Andropogon scoparius*, *Elymus canadensis*, and *Stipa comata*, had become established and nine had failed completely. Those that failed were *Agropyron pauciflorum*, *Arrhenatherum elatius*, *Bromus marginatus*, *Dactylis glomerata*, *Festuca idahoensis*, *Panicum virgatum*, *Poa nevadensis*, *P. secunda*, and *Stipa viridula*.

Species that appeared best adapted included *Agropyron cristatum*, *A. desertorum*, *A. inerme*, *A. pungens*, *A. smithii*, *A. spicatum*, and *Poa canbyi* (table 99).

Species that established very poor stands or failed completely were *Andropogon furcatus*, *Bouteloua curtipendula*, *B. gracilis*, *Buchloe dactyloides*, *Calamovilfa longifolia*, *Koeleria cristata*, *Oryzopsis hymenoides*, *Panicum antidotale*, *Phalaris arundinacea*, *Phleum pratense*, *Poa pratensis*, *Puccinellia nuttalliana*, *Sorghastrum nutans*, and *Sporobolus cryptandrus*.

Study.—Highway 10 method study.

Date planted.—November 1-3, 1939.

Procedures.—The purpose of this study was to determine the effects of soil preparation and methods of seeding upon the germination and establishment of four species of grasses and a grass-legume mixture. Three types of seedbeds used were plowed, disked, and no treatment. Seeding methods included broadcasting, drilling with a double-disk drill, and drilling with a deep furrow drill. The broadcast treatment was harrowed to cover the seed. Seeding rates were 5 pounds per acre on the drilled plots and 10 pounds per acre on the broadcast plots. Plots 10 by 40 feet were replicated three times in a split-plot design.

Summary of results.—Because *Bouteloua gracilis* failed to establish, this species was dropped from the study. It was omitted from analyses of the data also.

In the first growing season, *Agropyron cristatum* established twice as many seedlings as *Bromus inermis* or *Agropyron smithii* (table 100). Since *A. cristatum* has about twice as many seeds per pound as the other two species, probably little difference occurred in the initial germination and establishment percentage based on number of seeds.

About twice as many seedlings became established on the disked and on the plowed as on the unprepared seedbeds. More

TABLE 99.—*Establishment rating of planted species near Miles City, Mont.* [1]

Species	Highway 10, planted fall 1937, stand		Yellowstone Bridge, planted	
	1937	1939	1938-39; stand, 1940	Spring 1939, stand, 1939
	Rating	*Pct.*	*Rating*	*Pct.*
Fair to good stands established at both locations:				
Agropyron cristatum (Fairway)	G	95	G	45
A. desertorum (Standard)	G	95	G	45
A. pungens	G	90	-	30
Good to fair stands established and maintained at 1 location:				
Agropyron inerme	G	95	P	20
A. smithii	0	95	F	10
Poa canbyi	G	95	-	--
Agropyron spicatum	G	70	-	--
Poa ampla	G	40	-	5
Elymus junceus	G	30	-	20
Agropyron sibiricum	-	--	-	35
Poor stands maintained at 1 location:				
Bromus erectus	-	--	-	15
B. inermis	G	10	F	20
Elymus canadensis	0	10	-	0
Stipa comata	0	10	0	0
Poa compressa	-	--	P	5
Lespedeza stipulacea	-	--	F	0
Medicago falcata	-	--	0	10
Melilotus alba	-	--	0	5
M. officinalis	-	--	0	10

[1] Rating G = good; F = fair; P = poor; 0 = failure.

seedlings were established from drilling into the unprepared seedbed than by broadcasting.

In 1943, *A. cristatum* was the outstanding species with good to excellent stands. *A. smithii* also was good but generally was not as good as *A. cristatum*. *B. gracilis* failed almost completely on all plots. Since other studies have shown that *B. gracilis* can be successfully established in the spring on a firm seedbed with only slight covering, apparently the time, depth, or seedbed

TABLE 100.—*Establishment of seeded species as affected by seedbed preparation and seeding methods near Miles City, Mont.*

Species and seeding method	Plants established per square foot (1940)			Stand rating [1] (1943)		
	Plow	Disk	Check	Plow	Disk	Check
	No.	*No.*	*No.*	*No.*	*No.*	*No.*
Agropyron cristatum:						
Deep furrow	8.1	12.1	7.3	9.0	8.7	8.7
Disk-drill	6.9	88.2	4.3	8.3	8.0	8.3
Broadcast	18.8	15.2	3.1	9.3	9.0	8.3
Agropyron smithii:						
Deep furrow	4.4	3.2	2.6	9.3	8.3	8.3
Disk-drill	4.4	2.6	1.5	9.0	8.0	6.3
Broadcast	5.8	5.3	.4	8.3	8.7	8.0
Bouteloua gracilis:						
Deep furrow	[2]	[2]	[2]	.7	0	0
Disk-drill	[2]	[2]	[2]	.3	0	0
Broadcast	[2]	[2]	[2]	1.0	.3	0
Bromus inermis:						
Deep furrow	2.2	1.2	2.0	3.3	1.7	2.0
Disk-drill	1.0	3.2	.9	2.7	1.0	2.7
Broadcast	9.0	6.4	1.0	3.3	4.7	3.3
Mixture: [3]						
Deep furrow	6.1	6.0	3.4	9.3	8.3	8.0
Disk-drill	6.4	4.8	4.4	9.0	8.3	8.3
Broadcast	4.0	4.5	1.6	8.7	8.3	7.7

[1] Rating 1 to 10, with 10 = excellent stand.

[2] Data not available.

[3] The mixture consisted of *Agropyron cristatum*, *Medicago falcata*, and *Poa compressa*.

conditions for planting in this study were unfavorable. *B. inermis* (Parkland) was fair to poor on all plots.

The mixture rated good to excellent. However, *A. cristatum* made up approximately 75 percent of the stand. *M. falcata* made up the remaining 25 percent, while *P. compressa* failed almost completely on all plots.

On the cultivated seedbeds, *A. cristatum* and *A. smithii* established slightly better stands than on unprepared soil and broadcasting appeared equal to the drilling methods. However, since broadcasting was done at twice the seeding rate, it is assumed that broadcasting would not have been as good at comparable rates.

Of the two drills, the deep furrow seemed to be slightly better than the double disk.

Study.—Highway 10 range planting.

Date planted.—November 8, 1940.

Procedures.—Nine species of grass and legumes were planted in plots 33 by 132 feet. The seed was planted with a one-horse drill.

Summary of results.—At the end of the first growing season, *Agropyron smithii*, *Elymus junceus*, *Medicago lupulina*, *Melilotus alba*, and *M. suaveolens* were complete failures. *Medicago falcata* established good stands, while stands of *Agropyron cristatum* (Fairway and Standard) and *A. intermedium* were thin.

Yellowstone Bridge Field

Study location.—Located at the U.S. Range Livestock Experiment Station near Miles City, Mont., W½ sec. 6, T. 7N., R. 47E. (location 80, fig. 10).

Elevation.—2,358 feet.

Average precipitation.—Annual, 13 inches; April-September, 72 percent.

Soil.—Fine sandy loam.

Topography.—Flat flood plain bordering the Yellowstone River that periodically has been flooded with overflow from high water.

Type of vegetation.—Undifferentiated stream bottoms.

Dominant and associated species.—*Agropyron smithii*, *Stipa comata*, and *Bouteloua gracilis*.

Previous use.—Plowed and cropped from 1910 to 1933, most crops had failed.

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Study.—Yellowstone Bridge adaptation planting (1933-39).

Date planted.—Several plantings were made from 1933 to 1939.

Procedures.—This series of seedings included 20 species of grasses and legumes each of which was planted from 1 to 17 times. Before spring of 1937, most seedings were made with a double-disk grain drill with 12-inch spacing. Usually, the seedbed received no preparation before seeding. From 1937 to 1939, the seedings were made with a deep furrow drill. Blue-grama was seeded by broadcasting and covered by harrowing or by running an empty drill over the plot.

Summary of results.—Because these studies lacked statistical design, the results have limited value. The studies were conducted during the droughty years, 1933 to 1937, without seedbed preparation. Those species that were successful may be considered promising. Because of the extreme adverse conditions, those that failed, however, should not be disregarded as they may have become successfully established with better seeding methods.

In 1940, 19 successful species were summarized (table 99). *Agropyron cristatum* and *A. desertorum* appeared best adapted, while *A. smithii, Bromus inermis,* and *Lesperdeza stipulacea* established fair stands.

Study.—Yellowstone Bridge adaptation planting (1938-39).

Date planted.—October 11 and November 7, 1938; April 14 and May 13, 1939.

Planting procedure.—Forty-six species were planted in the fall of 1938. Forty-four of these and three additional grasses were also planted in the spring of 1939. Plantings were made by drilling with a Planet Junior seeder in rows spaced 2 feet apart, with seed placed from ¼ to ¾ inches deep, depending on seed size. Plots were 5 by 16-½ feet. Spring and fall seedings were made adjacent to each other in dry soil.

Summary of results.—Fall-planted species did not emerge until the following spring, and because of the very dry season, which was accompanied by heavy grasshopper infestation, establishment of all species was poor. Plants that were present in July appeared dead and many of these had disappeared by fall. Species that appeared best adapted included *Agropyron cristatum, A. desertorum, A. inerme, A. sibiricum,* and *Elymus junceus* (table 99).

Study.—Yellowstone Bridge adaptation planting (1941).

Date planted.—October 13, 1941.

Procedures.—The seedbed was prepared by plowing out volunteer crested wheatgrass. It was then harrowed several times with a spike-tooth harrow.

Five strains of *Agropyron cristatum* and two each of *A. smithii, Bouteloua gracilis*, and *B. curtipendula* were planted by hand. A furrow ½ inch deep was opened with a Planet Junior hand seeder, and the seed was distributed evenly along the furrow by hand, covered with soil, and packed. Plots consisted of single rows spaced 2 feet apart, 16 feet long.

Summary of results.—*Agropyron cristatum* strains, C-1, C-2, C-3, and FC-22755, all established good stands but not noticeably better than the commercial strain. *Bouteloua gracilis* strain, Bg-1, grew well and appeared somewhat larger and more robust and produced much longer seed heads than the native selection. *A. smithii* and *B. curtipendula* failed completely.

Study.—Yellowstone Bridge date and depth of seeding.

Date planted.—Fall 1936, spring and fall 1937, spring 1938.

Procedure.—*Agropyron cristatum* and *A. trachycaulum* were each planted in two fall and two spring periods. The seedbed was prepared by harrowing with a spike-tooth harrow on an area that had been previously cultivated and planted to grain, then, abandoned about 1933. Seeding was made with a Planet Junior hand seeder at rates of 7 pounds of seed per acre for *A. cristatum* and 13 pounds per acre for *A. trachycaulum*. Plots were 6 by 6 feet with rows spaced 1 foot apart. Early, mid, and late seedings were made for each season, but the seedings were averaged since differences were small.

Summary of results.—*A. trachycaulum* generally failed in all treatments except where planted ½ inch deep in the fall of 1936. Seeding at greater depths reduced plant establishment significantly (table 101).

A. cristatum established better from fall seedings than from spring seeding. Depth of seeding, however, was not consistent. The better stands established from the ½-inch depth seeded in 1936, but in 1937 the 1-½-inch depth was best in the fall. The 1-inch depth gave relatively good stands in most seedings.

Study.—Yellowstone Bridge range plot planting.

Date planted.—Spring 1940.

Procedures.—Six grasses, two legumes, and three mixtures were seeded in ½-acre plots by drilling with a deep-furrow drill.

Summary of results.—Except for an occasional plant of *Agropyron inerme*, the only other species to become established

TABLE 101.—*Establishment as affected by date and depth of seeding near Miles City, Mont.*

Species and date of seeding	Plants per square foot from different seeding depth		
	1/2 inch	1 inch	1-1/2 inch
	No.	*No.*	*No.*
Agropyron cristatum:			
Fall:			
1936	10.1	6.7	3.9
1937	6.6	8.8	9.8
Spring:			
1937	.9	.1	.1
1938	1.5	1.7	1.1
A. trachycaulum: [1]			
Fall 1936	2.4	.3	.1

[1] No emergence from the 1937 fall and spring seedings.

were *Agropyron cristatum* and *Medicago falcata*. These two species each averaged about four plants per square foot. *Bouteloua gracilis, Bromus inermis, Poa compressa, Agropyron smithii*, and *Medicago lupulina* failed completely.

Study.—Yellowstone Bridge bluegrama planting.

Date planted.—October 15, 1941; April 20 and May 20, 1942; also October 20, 1942, and April 27 and May 18, 1943.

Procedures.—*Bouteloua gracilis* from North Dakota seed was planted in plots 5 by 16 feet. Seeding treatments consisted of planting in three seasons (fall, early spring, late spring); two soil treatments (disked and packed and no treatment); and three depths of seeding (slight, ½ inch, and ¾ inch). The seedbed was prepared approximately 2 weeks before seeding, and the seeding was done with a Planet Junior seeder with five rows per plot. Rows were spaced 1 foot apart and a 4-foot alley was left between plots. Plots were arranged in a randomized split-plot design with three replications. The study was duplicated in 2 years. Before seedbed preparation, the area was covered with a dense stand of cheatgrass.

Summary of results.—Seeding depth and season of seeding significantly affected the establishment of *B. gracilis* (table 102). Seeding at shallow depths late in the spring, gave the best stands. Early spring seeding was slightly poorer than late spring seeding but considerably better than fall seeding. Increases in seeding depth generally reduced the establishment.

Establishment from the nonprepared seedbed was slightly better than from the cultivated; however, differences were not significant. The unprepared plots, however, had been cultivated 4 to 5 years previously and were not in native perennial plants.

TABLE 102.—*Establishment of bluegrama as affected by season and depth of seeding and by seedbed preparation, Miles City, Mont.*

Season and seedbed preparation	Percentage of row occupied at different seeding depths		
	Surface	½ inch	¾ inch
	Pct.	*Pct.*	*Pct.*
Fall:			
1941:			
Disked	3	1	1
None	3	2	2
1942:			
Disked	1	2	1
None	4	1	1
Early spring:			
1942:			
Disked	10	7	5
None	12	9	9
1943:			
Disked	17	31	13
None	25	26	31
Late spring:			
1942:			
Disked	10	9	8
None	14	11	8
1943:			
Disked	36	32	26
None	55	42	42

Note.—Least significant difference at 5 percent level of significance for seasons = 4.

Study.—Yellowstone Bridge range plot planting.

Date planted.—November 14-15, 1949, and April 27, 1950.

Procedures.—The area was previously in crested wheatgrass from seedings made in 1934 and 1939. The area was plowed, disked, and harrowed in October 1949. Six species of grass were then drilled in 20- by 1,270-foot strips with rows spaced 1 foot apart. Duplicate seedings were made in the fall and in the spring. Seeding rates were as follows:

	Pounds per acre
Agropyron desertorum	4.0
A. intermedium	9.6
A. trichophorum	8.4
Festuca ovina duriuscula	3.6
Poa ampla	4.8
Stipa viridula	4.2

Summary of results.—Weeds, sweetclover, and volunteer *A. desertorum* comprised from 5 to 15 percent of the vegetative cover. Nevertheless, the initial stands were good to excellent for all species seeded in the fall. All the wheatgrasses also established good stands from spring seeding (table 103).

In the fourth growing season (1953), *A. desertorum* was the highest yielding species. Yields from fall seeding were higher than from the spring, whereas *A. intermedium, P. ampla,* and *S. viridula* yielded twice as much herbage from spring as from fall plantings. *F. ovina* yielded about the same from both plantings.

Study.—Yellowstone Bridge black medic planting.

TABLE 103.—*Establishment and herbage yield of fall- and spring-seeded grasses near Miles City, Mont.*

Species	Stand (1950)		Yield per acre, oven-dry weight (1953)	
	Fall planted	Spring planted	Fall planted	Spring planted
	Pct.	*Pct.*	*Lb.*	*Lb.*
Agropyron desertorum	100	95	1,855	1,635
A. intermedium	100	95	580	1,258
A. trichophorum	95	90	---	---
Festuca ovina duriuscula	90	35	898	831
Poa ampla	50	15	226	463
Stipa viridula	50	15	221	814

Date planted.—March 30, 1944.

Procedures.—About 1 pound of *Medicago lupulina* seed was broadcast on each of two 1/10-acre plots. At the time of seeding the unprepared seedbed was moist with some puddles of water and patches of snow.

Summary of results.—Good stands of *M. lupulina* were established in the first growing season. Many seedlings were found on the small bare areas and were also found growing fairly well in the thickest and most vigorous patches of *Buchloe dactyloides*. It did best in the low areas.

Study.—Yellowstone Bridge birdsfoot trefoil planting.

Date planted.—April 25, 1952.

Procedure.—Granger birdsfoot trefoil *(Lotus corniculatus)* was planted by scattering seed in furrows with about 25 seeds per foot of row. The seed was then covered with 1/2 inch of soil. The plots were 6 feet wide with 2 feet between rows. The ground, dry at seeding time, remained dry through the following summer and fall.

Summary of results.—Only six plants emerged and died.

Wagner Corner

Study location.—Located 1 mile northeast of Wagner Corner on U.S. Highway 2, T. 30 N., R. 29 E (location 81, fig. 10).

Elevation.—2,300 feet.

Average precipitation.—Annual, 12.4 inches; April-September, 75 percent.

Soil.—Clay loam.

Topography.—1 percent slope to the south.

Type of vegetation.—Undifferentiated stream bottom.

Dominant species.—*Agropyron smithii*, *Stipa comata*, and *Bouteloua gracilis*.

Previous use.—Cropland.

Study.—Wagner Corner adaptation planting.

Date of seeding.—August 1939; overplanted with *A. desertorum* in 1943.

Procedure.—Fourteen grasses were seeded in plots 9 by 40 feet with three rows per plot spaced 3 feet apart.

Summary of results.—By 1950, *Agropyron cristatum, A. desertorum, Elymus junceus*, and *Stipa viridula* had established excellent stands. *Bouteloua gracilis* and *Bromus inermis* established fair stands.

Species that failed completely were *Agropyron smithii, A. trachycaulum, Andropogon furcatus, A. scopularis, Bouteloua curtipendula, Elymus junceus, Oryzopsis hymenoides*, and *Panicum virgatum*.

Sidney

Study location.—Located at the Eastern Montana Branch Experiment Station near Sidney, Mont., T. 23 N., R. 59 E. (location 82, fig. 10).

Elevation.—2,000 feet.

Average precipitation.—Annual, 14 inches. April-September, 72 percent.

Soil.—Clay loam.

Topography.—1 percent slope to the east.

Type of vegetation.—Undifferentiated stream bottom.

Dominant species.—*Agropyron smithii, Bouteloua gracilis*, and *Stipa comata*.

Previous use.—Farmed.

Study.—Sidney yield study.

Date planted.—April 11, 1956.

Procedures.—Twenty-two grasses were planted in plots 3 by 16 feet with three rows per plot spaced 1 foot apart.

Summary of results.—Herbage samples harvested from 1956 through 1960 average 1/2 to 3/4 tons per acre. The highest yields of most species and strains were produced in the third growing season. All strains of *Agropyron trichophorum*, however, yielded their highest in the second growing season. Generally, *Agropyron intermedium* yielded more than any other species (table 104).

TABLE 104.—*Yield of wheatgrass species and strains at Sidney, Mont.*

Species and strains	PI or FC number	Herbage yield per acre, oven-dry weight				
		1957	1958	1959	1960	Av. [1]
		Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Agropyron cristatum:						
Fairway	32032	1,440	1,580	920	1,420	1,340cde
A-1770	32013	860	1,060	980	1,300	1,035g
A. desertorum:						
Nordan	31968	1,620	1,740	1,060	1,500	1,480abc
W-1	32628	1,400	1,900	940	1,480	1,430abc
Nebraska	32661	1,580	1,780	800	1,480	1,410cd
42-1	31976	1,600	1,600	1,000	1,380	1,395cd
Summit	210337	1,260	1,480	1,000	1,640	1,245cde
Manadan-2194B	32596	1,320	1,500	840	1,340	1,250def
A. elongatum:						
S-64	21[illegible]01	1,640	1,980	980	1,120	1,430bc
Do	32604	1,460	1,960	680	1,360	1,365cd
A-1876	109452	1,800	1,300	560	820	1,120fg
A. inerme: (Whitmar)	32167	0	0	0	0	0
A. intermedium:						
Amur	32058	2,220	2,040	660	1,660	1,645a
Ree	32009	2,120	1,920	720	1,840	1,650a
M-2-10820	24707	2,000	1,840	860	1,680	1,595ab
A-12496	25000	2,000	1,880	640	1,380	1,475abc
Nebraska 50	31969	1,920	1,860	640	1,360	1,445bc
A. sibiricum (P-27)	32060	1,180	1,380	1,040	1,160	1,190ef
A. trichophorum:						
Mandan	32126	2,240	1,860	660	1,[illegible]20	1,595ab
A-1488	32014	1,540	1,180	580	1,100	1,100fg
Utah	31975	1,420	1,340	580	960	1,075g
Topar	24607	1,040	580	660	760	760h

[1] Values followed by the same letter do not differ significantly at the 5-percent level (Duncan 1955).

BOTANICAL AND COMMON NAMES OF SPECIES[5]

Abies grandis (Dougl.) Lindl.	Grand fir
Abies lasiocarpa (Hook.) Nutt.	Alpine fir
Acer negundo L.	Boxelder
Achillea lanulosa Nutt.	Western yarrow
Aegilops mutica Boiss.	Goatgrass
Agoseris glauca (Pursh) D. Dietr.	Pale agoseris
Agropyron amurense Drob.	Amur wheatgrass
Agropyron caninum (L.) Beauv.	---
Agropyron ciliare (Trin. ex Bunge) Franch.	---
Agropyron cristatum (L.) Gaertn.	Fairway wheatgrass
Agropyron dasystachyum (Hook.) Scribn.	Thickspike wheatgrass
Agropyron desertorum (Fisch. ex Link) Schult.	Crested wheatgrass
Agropyron divaricatum Boiss. & Bal.	Turkish wheatgrass
Agropyron elongatum (Host) Beauv.	Tall wheatgrass
Agropyron griffithsii Scribn. & Smith	Griffiths wheatgrass
Agropyron imbricatum (Bieb.) Roem, & Schult.	---
Agropyron inerme (Scribn. & Smith) Rydb.	Beardless wheatgrass
Agropyron intermedium (Host) Beauv.	Intermediate wheatgrass
Agropyron junceum (L.) Beauv.	Rushleaf wheatgrass
Agropyron longearistatum (Boiss.) Boiss.	---
Agropyron michnoi Roshev.	Transbaikal wheatgrass
Agropyron orientale (L.) Roem. & Schult.	Oriental wheatgrass
Agropyron panormitanum Parl.	---
Agropyron pauciflorum (A. trachycaulum)	---
Agropyron pungens (Pers.) Roem. & Schult.	Stiffleaf quackgrass
Agropyron repens (L.) Beauv.	Quackgrass
Agropyron richardsonii (A. subsecundum)	---
Agropyron riparium Scribn. & Smith	Streambank wheatgrass

[5] Scientific names in parentheses are the accepted synonomy and correctly identified species.

Agropyron semicostatum (Nees ex Steud.) Boiss.	Drooping wheatgrass
Agropyron sibiricum (Willd.) Beauv.	Siberian wheatgrass
Agropyron smithii Rydb.	Western wheatgrass
Agropyron spicatum (Pursh) Scribn. & Smith	Bluebunch wheatgrass
Agropyron strigosum (Bieb.) Boiss.	---
Agropyron subsecundum (Link) Hitchc.	Bearded wheatgrass
Agropyron tenerum (A. trachycaulum)	---
Agropyron trachycaulum (Link) Malte ex H. F. Lewis	Slender wheatgrass
Agropyron trichophorum (Link) Richt.	Pubescent wheatgrass
Agropyron ugamicum Drob.	Ugam wheatgrass
Agropyron violaceum (Hornem.) Lange	Violet slender wheatgrass
Agropyron trachycaulum X. *Hordeum jubatum*	---
Agrostis alba L.	Redtop
Agrostis hiemalis (Walt.) B.S.P.	Winterbent (Ticklegrass)
Agrostis palustris Huds.	Creeping bentgrass
Agrostis racemosa (Muhlenbergia racemosa)	---
Agrostis tenuis Sibth.	Colonial bentgrass
Alopecurus aequalis Sobol.	Short-awn foxtail
Alopecurus arundinaceus Poir.	Creeping foxtail
Alopecurus geniculatus L.	Water foxtail
Alopecurus pratensis L.	Meadow foxtail
Alopecurus ventricosus (A. arundinaceus)	---
Ammophila arenaria (L.) Link	European beachgrass
Amelanchier spp.	Serviceberry
Andropogon annulatus Forsk.	Diaz bluestem
Andropogon furcatus (A. gerardi)	---
Andropogon gerardi Vitman	Big bluestem
Andropogon hallii Hack.	Sand bluestem
Andropogon perforatus Trin.	Pinehole bluestem
Andropogon saccharoides Swartz	Silver bluestem
Andropogon scoparius Michx.	Little bluestem
Antennaria spp.	Pussytoes
Arctostaphylos uva-ursi (L.) Spreng.	Bearberry
Aristida longiseta Steud.	Red three-awn
Arnica spp.	Arnica
Arrhenatherum elatius (L.) Presl	Tall oatgrass
Artemisia cana Pursh.	Silver sagebrush

Artemisia frigida Willd.	Fringed sagebrush
Artemisia nova A. Nels.	Black sagebrush
Artemisia tridentata Nutt.	Big sagebrush
Arundinella anomala Steud.	---
Aster spp.	Aster
Astragalus chinensis L.f.	Chinese milkvetch
Astragalus cicer L.	Chickpea milkvetch
Astragalus falcatus Lam.	Sicklepod milkvetch
Astragalus rubyi (Oxytropis rubyi)	Ruby valley milkvetch
Astragalus semibilocularis DC	---
Atriplex canescens (Pursh) Nutt.	Fourwing saltbush
Atriplex confertifolia (Torr. & Frem.) Wats.	Shadscale
Atriplex nuttalli (A. gardneri)	Gardner saltbush
Atriplex spp.	Saltbush
Avena barbata Pott ex Link	Slender oat
Avena sativa L.	Oat
Balsamorhiza sagittata (Pursh) Nutt.	Arrowleaf balsamroot
Beckmannia erucaeformis (L.) Host	European sloughgrass
Beckmannia syzigachne (Steud.) Fernald	American sloughgrass
Bouteloua curtipendula (Michx.) Torr.	Sideoat grama
Bouteloua gracilis (H.B.K.) Lag. ex Steud.	Blue grama
Bouteloua hirsuta Lag.	Hairy grama
Bouteloua trifida Thurb.	Red grama
Brachypodium mucronatum Willk.	Beardless falsebrome
Brachypodium phoenicoides (L.) Roem. & Schult.	---
Brachypodium pinnatum (L.) Beauv.	Japanese falsebrome
Brachypodium sylvaticum (Huds.) Beauv.	Slender falsebrome
Bromus anomalus Rupr.	Nodding brome
Bromus carinatus Hook. & Arn.	Mountain brome (Calif. brome)
Bromus catharticus Vahl	Rescue brome
Bromus ciliatus L.	Fringed brome
Bromus commutatus Schrad.	Hairy chess
Bromus erectus Huds.	Meadow brome

Bromus gracillimus Bunge	---
Bromus inermis Leyss.	Smooth brome
Bromus japonicus Thunb.	Japanese brome
Bromus lanatipes (B. anomalus)	---
Bromus macrostachys Desf.	Mediterranean brome
Bromus marginatus Nees	Mountain brome
Bromus polyanthus Scribn.	Foothills brome
Bromus porteri (B. anomalus)	---
Bromus purgans L.	Canada brome
Bromus racemosus L.	Baid brome
Bromus richardsoni (B. ciliatus)	---
Bromus secalinus L.	Chess brome
Bromus tectorum L.	Cheatgrass
Bromus tomentellus Boiss.	Subalpine brome
Buchloe dactyloides (Nutt.) Engelm.	Buffalograss
Calamagrostis canadensis (Michx.) Beauv.	Bluejoint reedgrass
Calamagrostis epigeios (L.) Roth	Chee reedgrass
Calamagrostis inexpansa A. Gray	Northern reedgrass
Calamagrostis koelerioides Vasey	Fire reedgrass
Calamagrostis montanensis Scribn.	Plains reedgrass
Calamagrostis rubescens Buckl.	Pinegrass
Calamagrostis viridi-flavescens (Poir.) Steud.	---
Calamovilfa longifolia (Hook.) Scribn.	Prairie sandreed
Carex filifolia Nutt.	Threadleaf sedge
Carex geyeri Boott	Elk sedge
Centaurea maculosa Lam.	Spotted knapweed
Cerastium spp.	Chickweed
Chloris virgata Swartz	Showy chloris
Chrysopogon aucheri (Boiss.) Stapf	Golden beard
Chrysothamnus spp.	Rabbitbrush
Cirsium arvense (L.) Scop.	Canada thistle
Claytonia lanceolata Pursh	Spring beauty
Coronilla varia L.	Crownvetch
Cymbopogon schoenanthus (L.) Spreng.	---
Cynodon dactylon (L.) Pers.	Bermudagrass
Cynosurus echinatus L.	Hedgehog dogtail
Dactylis glomerata L.	Orchardgrass
Danthonia californica Boland	California danthonia
Danthonia spicata (L.) Beauv.	Poverty oatgrass
Delphinium spp.	Larkspur
Deschampsia caespitosa (L.) Beauv.	Tufted hairgrass

Distichlis stricta (Torr.) Rydb.	Saltgrass
Dodecatheon spp.	Shooting star
Elymus ambiguus Vasey & Scribn.	Colorado wildrye
Elymus angustus Trin.	Altai wildrye
Elymus canadensis L.	Canada wildrye
Elymus canadensis var *robustus* (Scribn. & Smith) Mack. & Bush	Robust canada wildrye
Elymus chinensis (Trin.) Keng	Chinese wildrye
Elymus cinereus Scribn. and Merr.	Basin wildrye
Elymus condensatus Presl	Gaint wildrye
Elymus dahuricus Turcz. ex Griseb.	Dahurian wildrye
Elymus giganteus Vahl	Mammoth wildrye
Elymus glaucus Buckl.	Blue wildrye
Elymus junceus Fisch.	Russian wildrye
Elymus macounii Vasey	Macoun wildrye
Elymus pseudo-agropyrum Trin. ex Turcz.	---
Elymus sabulosus Bieb. *(E. giganteus)*	Russian dune wildrye
Elymus sibiricus L.	Siberian wildrye
Elymus triticoides Buckl.	Beardless wildrye (Creeping wildrye)
Elymus virginicus L.	Virginia wildrye
Elymus X *Secale*	---
Equisetum hyemale L.	Scouringrush
Eriogonum spp.	Eriogonum
Eragrostis curvula (Schrad.) Nees	Weeping lovegrass
Eragrostis ferruginea (Thunb.) Beauv.	Korean lovegrass
Eragrostis trichodes (Nutt.) Wood	Sand lovegrass
Eriochloa villosa (Thunb.) Kunth	Hairy cupgrass
Erodium cicutarium (L.) L'Her	Alfileria
Erodium moschatum (L.) L'Her	Musk heronbill
Euphorbia esula L.	Leafy spurge
Eurotia lanata (Pursh) Moq.	Winterfat
Festuca arundinacea Schreb.	Tall fescue
Festuca brachyphylla (F. ovina var. *brachyphylla)*	---
Festuca elatior L.	Meadow fescue
Festuca idahoensis Elmer	Idaho fescue
Festuca kingii (Hesperochloa kingii)	---
Festuca ovina L.	Sheep fescue
Festuca ovina var. *brachyphylla* (Schult.) Piper	Alpine fescue

Festuca ovina var. *duriuscula* (L.) Koch	Hard fescue
Festuca ovina ssp *sulcata* Hack.	Groved sheep fescue
Festuca pratensis (F. elatior)	---
Festuca rubra L.	Red fescue
Festuca rubra var. *commutata* Gaud.	Chewings fescue
Festuca rubra var. *fallax* (Thuill.) Hack.	*(F. rubra* var. *commutata)*
Festuca scabrella Torr.	Rough fescue
Festuca thurberi Vasey	Thurber fescue
Festuca viridula Vasey	Greenleaf fescue
Fragaria bracteata Heller	Wild strawberry
Fraxinus pennsylvanica Marsh.	Red ash
Galium spp.	Bedstraw
Gayophytum spp.	Groundsmoke
Geranium viscosissimum Fisch. & Mey	Sticky geranium
Geum triflorum Pursh	Prairie smoke (Old Man's whiskers)
Glyceria elata (Nash) Hitchc.	Tall mannagrass
Hesperochloa Kingii (S. Wats.) Rydb.	Spikefescue
Hilaria jamesii (Torr.) Benth.	Galleta
Hordeum brachyantherum Nevski	Meadow barley
Hordeum brevisubulatum (Trin.) Link	Short-awned barley
Hordeum bulbosum L.	Bulbous barley
Hordeum pusillum Nutt.	Little barley
Hordeum vulgare L.	Barley
Hypericum perforatum L.	St. Johnswort
Ivesia spp.	Ivesia
Juncus spp.	Rush
Juniperus scopulorum Sarg.	Rocky Mt. juniper
Koeleria cristata (L.) Pers.	Prairie junegrass
Larix occidentalis Nutt.	Western larch
Lathyrus japonicus Willd.	Maritime peavine
Lathyrus maritimus (L. japonicus)	---
Lepidium spp.	Pepperweed
Lespedeza stipulacea Maxim.	Korean lespedeza
Linaria dalmatica (L.) Mill.	Dalmation toadflax
Lolium perenne L.	Perennial ryegrass
Lolium remotum Schrank	---
Lomatium dissectum (Nutt.) Math. & Const.	Wildcarrot
Lotus corniculatus L.	Birdsfoot trefoil
Lepidium spp.	Lupine
Mahonia aquifolium (Pursh) Nutt.	Oregongrape
Medicago falcata L.	Sickle alfalfa

Medicago lupulina L.	Black medic
Medicago sativa L.	Alfalfa
Melica spectabilis Scribn.	Showy oniongrass
Melilotus alba Desr.	White sweetclover
Melilotus officinalis (L.) Lam.	Yellow sweetclover
Melilotus suaveolens Ledeb.	Redfield sweetclover (Daghestan sweetclover)
Mertensia spp.	Bluebells
Muhlenbergia asperifolia (Nees & Mey.) Parodi	Alkali muhly
Muhlenbergia cuspidata (Torr.) Rydb.	Stonyhills muhly
Muhlenbergia foliosa (Roem. & Schult.) Trin.	Leafy muhly
Muhlenbergia porteri Scribn.	Bush muhly
Muhlenbergia racemosa (Michx.) B.S.P	Green muhly
Muhlenbergia richardsonis (Trin.) Rydb.	Mat muhly
Muhlenbergia squarrosa (M. richardsonis)	---
Onobrychis viciifolia Scop.	Sainfoin
Onobrychis vulgaris (O. viciifolia)	---
Opuntia polyacantha Haw.	Prickly pear
Oryzopsis exigua Thurb.	Little ricegrass
Oryzopsis hymenoides (Roem. & Schult.) Ricker	Indian ricegrass
Oryzopsis miliacea (L.) Benth. & Hook.	Smilograss
Oryzopsis hymenoides X *Stipa viridula*	Mandan ricegrass
Osterdamia japonica (Zoysia japonica)	---
Osterdamia pungens (Zoysia matrella)	---
Oxytropis sericea Nutt.	White point loco (Silky crazyweed)
Oxytropis riparia Litv.	---
Panicum antidotale Retz.	Blue panicum
Panicum miliaceum L.	Broomcorn millet (Proso)
Panicum obtusum H.B.K.	Vine-mesquite
Panicum virgatum L.	Switchgrass
Phalaris arundinacea L.	Reed canarygrass
Phalaris brachystachys Link	Shortspike canarygrass
Phalaris canariensis L.	Canarygrass
Phalaris tuberosa var. *stenoptera* (Hack) Hitchc.	Hardinggrass
Phleum alpinum L.	Alpine timothy
Phleum boehmeri (P. phleoides)	---
Phleum phleoides (L.) Karst.	Dryland timothy
Phleum pratense L.	Timothy
Phlox spp.	Phlox

Physocarpus malvaceus (Greene) Kuntze	Ninebark
Picea engelmanni Parry ex Engelm.	Engelmann spruce
Pinus albicaulis Engelm.	Whitebark pine
Pinus contorta Dougl. ex Loud.	Lodgepole pine
Pinus flexilis James	Limberpine
Pinus ponderosa Dougl ex P.&C. Lawson	Ponderosa pine
Pinus ponderosa var. *scopulorum* Engelm.	Bull pine (Rocky Mt. Ponderosa pine)
Poa alpina L.	Alpine bluegrass
Poa ampla Merr.	Big bluegrass
Poa arachnifera Torr.	Texas bluegrass
Poa bulbosa L.	Bulbous bluegrass
Poa canbyi (Scribn.) Piper	Canby bluegrass
Poa compressa L.	Canada bluegrass
Poa epilis Scribn.	Skyline bluegrass
Poa juncifolia Scribn.	Alkali bluegrass
Poa longifolia Trin.	---
Poa lucida (P. canbyi)	---
Poa macrantha Vasey	Seashore bluegrass
Poa nemoralis L.	Wood bluegrass
Poa nervosa (Hook.) Vasey	Wheeler bluegrass
Poa nevadensis Vasey	Nevada bluegrass
Poa palustris L.	Fowl bluegrass
Poa pratensis L.	Kentucky bluegrass
Poa scabrella (Thurb.) Benth.	Pine bluegrass
Poa secunda Presl	Sandberg bluegrass
Poa sphondylodes Trin.	---
Poa stenantha Trin.	Trinius bluegrass
Poa trivialis L.	Roughstalk bluegrass
Polygonum spp.	Knotweed
Polypogon monspeliensis (L.) Desf.	Rabbitfoot polypogon
Populus sargentii Dode	Plains cottonwood
Potentilla spp.	Cinquefoil
Prunus americana Marsh.	Wild plum
Prunus virginiana L.	Chokecherry
Pseudotsuga menziessi (Mirbel) Franco	Douglasfir
Pteridium aquilinum (L.) Kuhn	Bracken
Puccinellia airoides (Nutt.) Wats. & Coult.	Alkaligrass
Puccinellia nuttalliana (P. airoides)	---
Purshia tridentata (Pursh) DC.	Antelope bitterbrush
Ranunculus spp.	Buttercup
Rosa spp.	Wildrose
Rudbeckia occidentalis Nutt.	Niggerhead
Salix amygdaloides Anderss.	Peachleaf willow

Salsola kali var. *tenuifolia* Tausch	Tumbling Russian-thistle
Sambucus microbotrys Rydb.	Elderberry
Sanguisorba minor Scop.	Small burnet
Sarcobatus vermiculatus (Hook.) Torr.	Greasewood
Schizachne purpurascens (Torr.) Swallen	Falsemelic
Secale cereale L.	Rye
Secale montanum Guss.	Mountain rye
Selaginella densa Rydb.	Clubmoss
Sesleria spp.	---
Setaria macrostachya H.B.K.	Plains bristle grass
Shepherdia argentea Nutt.	Silver buffaloberry
Sisymbrium altissimum L.	Tumblemustard
Sitanion hystrix (Nutt.) J. G. Smith	Bottlebrush squirreltail
Solidago spp.	Goldenrod
Sonchus arvensis L.	Sowthistle
Sorghastrum nutans (L.) Nash	Yellow Indiangrass
Sorghum almum Parodi	Sorghum almumgrass
Sorghum halepense (L.) Pers.	Johnsongrass
Sorghum sudanense (Piper) Stapf	Sudangrass
Sorghum bicolor (L.) Moench	Sorghum
Spartina gracilis Trin.	Alkali cordgrass
Spartina pectinata Link	Prairie cordgrass
Spiraea spp.	Spirea
Spodiopogon sibiricus Trin.	---
Sporobolus airoides (Torr.) Torr.	Alkali sacaton
Sporobolus asper (Michx.) Knuth	Tall dropseed
Sporobolus cryptandrus (Torr.) A. Gray	Sand dropseed
Sporobolus flexuosus (Thurb.) Rydb.	Mesa dropseed
Sporobolus heterolepis (A. Gray) A. Gray	Prairie dropseed
Stipa californica Merr. and Davy	Pacific needlegrass
Stipa capillata (S. comata)	---
Stipa columbiana Macoun	Subalpine needlegrass
Stipa columbiana var. *nelsonii* (Scribn.) Hitchc.	Big subalpine needlegrass
Stipa comata Trin. and Rupr.	Needle-and-thread
Stipa lettermanii Vasey	Letterman needlegrass
Stipa neomexicana (Thurb.) Scribn.	New Mexico feathergrass
Stipa occidentalis Thurb.	Western Needlegrass
Stipa pulchra Hitchc.	California needlegrass
Stipa richardsonii Link	Richardson needlegrass
Stipa robusta (Vasey) Scribn.	Sleepygrass

Stipa spartea Trin.	Porcupinegrass
Stipa speciosa Trin. and Rupr.	Desert needlegrass
Stipa splendens Trin.	Cheatgrass
Stipa vaseyi (S. robusta)	---
Stipa viridula Trin.	Green needlegrass
Stipa viridula X *Oryzopsis hymenoides*	Stiporyza
Stipa williamsii Scribn.	Williams needlegrass
Symphoricarpos spp.	Snowberry
Taraxacum officinale Weber	Dandelion
Taxus brevifolia Nutt.	Pacific yew
Thalictrum spp.	Meadowrue
Themeda anathera (Nees) Hack.	Kangaroograss
Thuja plicata Donn ex D. Don	Red cedar (Gaint arborvitae)
Trifolium agrarium L.	Hop clover
Trifolium ambiguum Bieb.	Kura clover
Trifolium fragiferum L.	Strawberry clover
Trifolium hybridum L.	Alsike clover
Trifolium pratense L.	Red clover
Trifolium repens L.	White clover
Trifolium subterraneum L.	Subterranean clover
Trisetum spicatum (L.) Richt.	Spike trisetum
Triticum aestivum L.	Wheat
Tsuga heterophylla (Raf.) Sarg.	Western hemlock
Vaccinium spp.	Huckleberry (Blueberry)
Wyethia amplexicaulis (Nutt.) Nutt.	Mules-ears wyethia
Zoysia japonica Steud.	Korean lawngrass
Zoysia matrella (L.) Merr.	Manilagrass

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