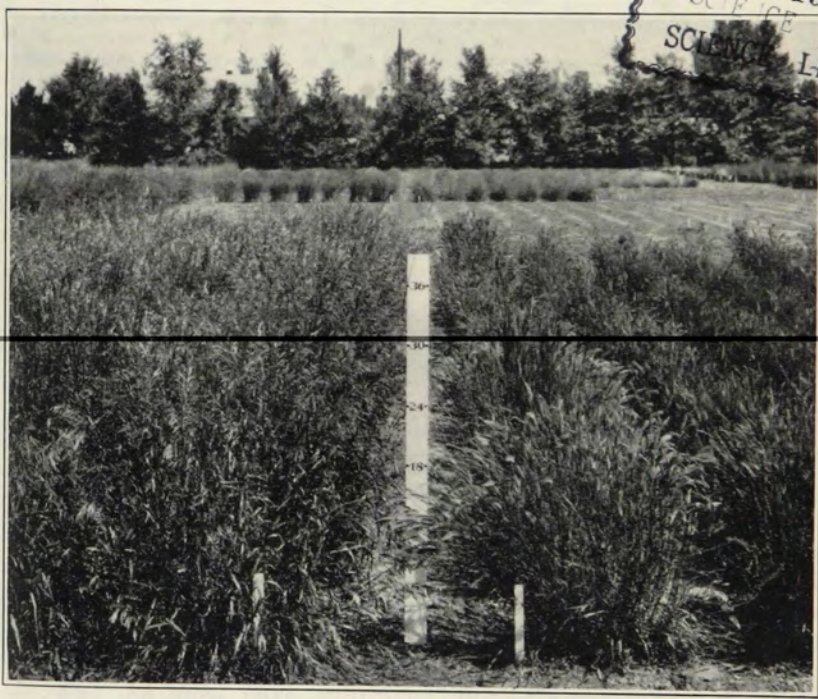


Restoring Colorado's Range and Abandoned Croplands

E. W. NELSON AND W. O. SHEPHERD



Colorado forage lands at higher altitudes may be improved through reseeding with such drought-resistant grass species as smooth brome (left of stake) and crested wheatgrass (right).

« »

Colorado Experiment Station
Colorado State College
Fort Collins

Restoring Colorado's Range and Abandoned Croplands

E. W. NELSON AND W. O. SHEPHERD*

CONTENTS

	Page		Page
Introduction	3	Western wheatgrass.....	14
Types of areas to reseed.....	4	Crested wheatgrass.....	17
Cultural methods.....	4	Smooth brome grass.....	20
Seedbed preparation.....	4	Legumes.....	22
Methods of seeding.....	5	Sweet clovers.....	23
Depth of seeding.....	6	Seeding mixtures for unirrigated pastures.....	25
Rate of seeding.....	6	Pasture mixtures for high moun- tains.....	26
Time of seeding.....	7	Lower mountain elevations and foot- hill plains.....	26
Nurse crops.....	7	Eastern plains.....	27
Management of young stands of grass seedlings.....	7	Summary.....	29
Recommended species.....	8	Literature cited.....	30
Blue grama.....	9		
Slender wheatgrass.....	11		

LIVESTOCK men and farmers of Colorado are showing increased interest in methods and means of augmenting the productivity of their range and pasture lands. The potential significance of this growing consciousness of a greatly neglected resource is suggested by the importance of native range lands to the economy of the State. The range livestock business is the second ranking industry of Colorado, producing nearly 60 million dollars worth of livestock products annually (7).† Because of recurring droughts and overstocking, much of Colorado's native range is greatly reduced in productivity. In addition to the many low-producing range areas, there are hundreds of thousands of acres of abandoned croplands which, if left to revegetate by the slow process of natural plant succession, will be many years in regaining their former grazing capacity. Considering the millions of acres affected throughout the State, the total loss of potential range forage is stupendous.

For the most part, improved management is the practical solution of the problem of increasing forage yields on native ranges. There are, however, certain critical areas, including most of the recently abandoned croplands, where methods such as artificial reseeding are justified. Besides the problem of restoring forage productivity, there may also be the problem of arresting further losses of irreplaceable soil by erosion.

The Great Plains range pastures, the abandoned croplands, and the depleted mountain ranges are probably in greatest need of attention at the present time, and it is with these areas that this report is primarily concerned. Grass trials in Colorado and

*E. W. Nelson, in charge, Range and Pasture Management Section, Colorado Experiment Station; W. O. Shepherd, assistant, resigned.

†Numbers in parentheses refer to bibliography, page 30.

similar areas elsewhere have shown that artificial reseeding of desirable sites with adapted species is a practical undertaking if proper precautions are taken in the selection of sites and in the reseeding operations.

Types of Areas to Reseed

Considerable judgment must be exercised in determining the sites or areas where reseeding is practical. Sites that have a thin or a very poor soil, steep slopes, especially southern exposures, or otherwise are unfavorable are not likely to give sufficient returns to justify reseeding. Seeding should begin on the best sites and proceed to progressively less productive ones. Abandoned cropland fields, as evidenced by the fact that they once were considered suitable for crop production, are potentially some of the most productive of range lands. A soil which is fairly deep, has a good organic matter content, and absorbs water readily is most desirable for reseeding.

Seeding of foothill and mountain ranges has been successful where the soil is fertile and the site is of high enough quality to support desirable vegetation. Vigorous growth of big sagebrush, oak brush, serviceberry, mountain snowberry, and remnants of palatable grasses, especially slender wheatgrass, mountain brome, native bluegrasses, needlegrasses, or fescues, indicates a favorable site for reseeding. Where only unpalatable and weedy plants or annuals occur and where advanced erosion indicates serious soil deterioration, it will probably be difficult to obtain stands of the better forage species. Sites where erosion is active, especially on depleted watersheds, may take precedent in reseeding for reasons other than for range feed production.

Cultural Methods

The method of preparing the soil for seeding will depend upon the site and the previous land use. Abandoned cultivated lands, especially in the Great Plains area, present a vastly different problem than depleted, eroding mountain slopes. The operator must decide which procedure is most likely to accomplish the desired results most economically.

Seedbed Preparation

The first requisite of successful seeding is a well-prepared seedbed. If a site is worth planting at all, the extra effort required to properly prepare the soil will usually be justified by the better results obtained. An ideal seedbed is mellow, firm, and free from living weeds although a covering of dead plant

material such as crop refuse is usually desirable. On land which has formerly been cultivated, weed and erosion control are the main problems. Some form of cultivation which will eradicate the weeds and will not leave the soil too loose is desirable. Where wind erosion is a problem, every effort should be made to leave a trashy surface on the seedbed. Leaving strips of weeds between seeded strips is often effective in controlling blowing. Natural revegetation can sometimes be depended upon to fill in the intervening spaces, especially when aggressive species such as western wheatgrass or crested wheatgrass are being seeded. Also, after the first grass strips have become established, additional strips may be planted between the original rows. Under either plan the cost per acre the first year would be reduced, thereby decreasing the degree of speculation involved. In certain instances it may be desirable to drill a rapidly growing species in widely spaced rows to protect the soil until the newly seeded grass can produce an effective cover. Sorghums and sudan grass are useful for such cover crops and, if a high stubble is left, some forage may be harvested without seriously impairing their utility for erosion control. The stubble should be left standing on the surface when the land is seeded.

In mountainous areas seedbed preparation is often difficult and sometimes not feasible because of topographic features or expense involved. Disking or harrowing has been found suitable for preparing a seedbed in small, open areas of mountain brush types. Plowed contour furrows, spaced several feet apart, afford an effective and inexpensive seedbed on slopes. Such seedbeds may be compacted and the seed covered in one operation with a brush drag or a spike-tooth harrow.

Methods of Seeding

Drilling has invariably been found to be the most successful method of sowing grass seed. An ordinary grain drill will handle the seed of most of the recommended species; therefore this method should be used wherever conditions permit. To alter the spacing from the usual close-drilled rows, part of the drops can be plugged.

Row spacings of from 14 to 35 inches have usually given higher yields of forage and seed than have close-drilled rows. Where grass is being grown for a seed crop, cultivation between wide rows is necessary to keep down weed growth.

Broadcast sowing by hand or with a hand seeder may be more practical when the seed is very fine or light or when the site is inaccessible to a grain drill. However, some provision should be made for covering the seed. For this purpose either

a spike-tooth harrow or a brush drag is of value. On level areas, crisscrossing with an empty drill set at shallow depths or using a disk harrow with the disks set straight is a good practice if the soil is firm enough to avoid covering the seeds too deeply. A close-set surface packer is advisable where there is sufficient crop residue to prevent soil blowing. Where a herd of sheep is available, the broadcast seed may be trampled in, particularly on rough or brush-covered lands.

Broadcasting hay of mature grass is a method which has proven successful for species that have a limited supply of commercial seed. On a prepared seedbed or fallow ground the hay may be pressed into the ground by a pointed-wheeled packer or may be partially covered by disking. Such a practice is particularly well adapted for wind-blown sites. Similarly, native grass stands have been improved by broadcasting seed-bearing hay on the thin stand. Some reproduction of forage plants may be expected from feeding seed-bearing hay to range animals on such areas.

Depth of Seeding

A good rule is to plant grasses and other small-seeded species as shallowly as soil moisture conditions will permit. The seed should be in contact with firm, moist soil but it must not be covered so deeply as to prevent emergence of the young, weak seedlings. For most soils recommended depths are from three-fourths inch to 1 inch. The depth may be increased to 1½ inches in sandy soil for certain species.

Rate of Seeding

The method of sowing, the character of the site, and the species affect the optimum rate of seeding. Heavier seeding rates are required for satisfactory stands when seed is broadcast than when it is drilled. Heavy rates of seeding where soil moisture is limited are not only detrimental to the future development of the seedlings but also are expensive.

On depleted native range land one-half or one-third the amount of seed used for cultivated lands usually suffices. Cultivated lands which are being converted to pastures or other especially productive range areas may warrant extra expense in seeding. For large-seeded grasses such as brome grass and for the legume, sweet clover, from 5 to 10 pounds to the acre are ordinarily sufficient. A rate of 3 to 6 pounds will suffice for smaller-seeded species such as crested wheatgrass. When the seed is of low viability, as is often the case with western wheatgrass, the rate of sowing should be increased accordingly.

Time of Seeding

There are three periods usually recommended for planting grass crops in Colorado: Early fall (late August or early September), late fall, and early spring. The supply of moisture and abundance of weeds will to a great degree determine which period is best for any particular year. Early fall plantings may be advisable in the plains and foothills if sufficient moisture is available to allow the seedlings to become well established before heavy frosts. Late fall seedings are probably more certain in most of the foothills and higher mountains. Fall plantings should be delayed late enough to prevent germination until spring. The time of late seeding will vary from about the first of October to just before the ground freezes. Spring seedings of most species should be made as soon as the soil can be worked. Blue grama grass, a summer-growing plant, is an exception for which seeding can well be delayed until late April or early May.

Nurse Crops

In general the use of nurse crops is not recommended with grass seedings in semi-arid regions. The supposed beneficial effects of the nurse crop are usually more than counterbalanced by the competition offered to the grass. In certain instances where erosion is severe, some rapidly growing cover crop planted thinly or in widely spaced rows may be valuable to protect the soil until the grass seedlings can produce an effective cover. Adapted varieties of the sorghums may be used as a cover crop. Whenever practicable, the cover crops should be cut as soon as they have served their purpose. Better still, the sorghums should be grown the previous season and the grasses planted in the stubble. Such a practice has been found to be the only practical method of obtaining satisfactory stands of native grasses from seedlings in certain sections of the Great Plains.

Management of Young Stands of Grass Seedlings

The tender seedlings should be given every possible consideration during the first growing season. Heavy infestations of weeds may often be controlled by proper mowing. The time and manner of mowing should be regulated so that as many weeds as possible will be eradicated and so that the grass seedlings will be the least injured. Savage and Smith (9) recommend two clippings with a mower the first year to reduce weed competition. Besides reducing the competition from weeds, mowing prevents the weeds from blowing away. The remaining weed stubble is effective in the control of wind erosion and

thereby aids in better establishment of the young grasses. After a stand of grass becomes established, judicious management of the pasture eventually will allow the grasses to control the area and therefore prevent weeds from gaining a foothold.

Stands of seedlings should be protected from grazing during the first year. However, some rapidly developing species such as slender wheatgrass and sweet clover may be lightly grazed late in the first season if the year has been favorable. Thereafter, moderate grazing or deferred and rotation grazing will give highest forage yields and prolong the productivity of the pasture.

Recommended Species

Practical recommendations of forage species to be used in reseeding range lands must necessarily take into account the availability of seed. Several promising native species are purposely disregarded here because seed is not commercially available at reasonable prices or because satisfactory methods of seeding have not been demonstrated for Colorado conditions.

Some grasses that have proven valuable for seeding range lands are crested wheatgrass, slender wheatgrass, western wheatgrass, and smooth brome. Blue grama and buffalo grass are excellent when seed can be obtained. Yellow sweet clover appears to be the most promising legume.

Selection of a suitable species is dependent upon the character of the site to be planted. Slender wheatgrass and smooth brome have done well in reseeding trials on high mountain ranges and on other favorable situations, such as irrigated pastures. Sometimes these two, especially smooth brome, may be used to advantage in the foothills. Crested wheatgrass and western wheatgrass are adapted to the lower mountain ranges. Past trials indicate that the success of crested wheatgrass is questionable on the plains of eastern Colorado. In such regions where hot summers prevail, blue grama is the best-adapted species. Western wheatgrass is especially useful on heavy soils in swales and is highly resistant to alkali. Where soil fertility has been decreased by erosion and where there is sufficient moisture, yellow sweet clover can be used to advantage.

Mixtures of adapted species increase the chances of getting a successful stand. An earlier crop combined with a long-lived stand can also best be realized through seeding suitable mixtures.

The foregoing recommendations apply in a general way to artificial reseeding. However, more detailed information concerning several prominent forage plants as to their growth requirements, proper time and rate to sow them, and their value to livestock is given.

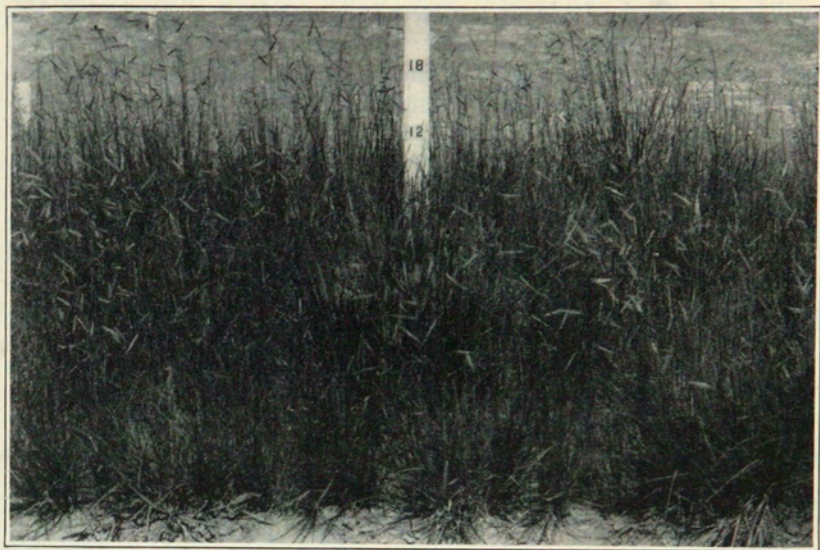


Figure 1.—Blue grama is the finest grass of plains and foothills.

Blue Grama Grass

Blue grama grass (*Bouteloua gracilis*) has a wide distribution in western United States and is a prominent native grass of the plains and foothills of Colorado. It is one of the most important forage species in the Great Plains region. With recent developments in methods of harvesting and with seed becoming available commercially, this species undoubtedly warrants serious consideration in a range reseeding program.

Growth Habits

The growth habits and general appearance of blue grama vary considerably in different parts of its range. In the northern Great Plains under favorable moisture conditions it tends to form a continuous sod; but farther south, as in Colorado, it is more likely to occur in patches or large tufts. It does not reproduce by stolons or rhizomes, but the plants do spread by tillering. Generally under range conditions its seed habits are weak, and its invasion into denuded areas or abandoned cropland areas is extremely slow.

Blue grama makes some growth in May and June. In July and August, with more favorable temperatures and moisture conditions, it grows rapidly and often matures in 60 to 70 days. Because of its slow growth in May and June, it does not supply

much early feed. It is exceptionally drought-resistant and has the ability to become dormant during drought periods which may occur in the growing season. Subsequently, with the occurrence of summer rains, it resumes growth.

Site Requirements

Blue grama has a wide habitat. In Colorado it grows on the dry eastern plains and foothills and up into the woodland and ponderosa pine zones in the mountains. It grows on soils varying from sandy to heavy clays.

Forage Value

Blue grama is splendid forage for all classes of livestock. It is highly palatable throughout the year. The unharvested forage cures well on the ground and furnishes nutritious pasturage for the fall and winter.

Establishment of Artificially Sown Stands

CULTURAL METHODS.—The usual precautions of good seed-bed preparation apply particularly to blue grama. The very fine seed require a mellow, firm soil. A drill with a grass-seeding attachment or a suitable agitator is one of the best methods of planting. A mixture of sand helps force the light seeds through a common grain drill but causes some wear on the drill. Broadcast seedings may be covered by crisscrossing the land with an empty drill set at shallow depths, by using a disk-harrow with the disks set straight, or with a close-set surface packer, or by using sheep to trample the seed into the soil.

Native grass stands have been improved by broadcasting hay of blue grama which was cut at about the time of seed maturity. Trampling by livestock helps to work the seed into the soil. Fallow ground or prepared seedbed may similarly be sown, especially if the hay is pressed into the ground by a pointed-wheeled packer.

RATE AND DEPTH OF SEEDING.—The seed of blue grama are very small and light and must not be too deeply covered. When the seedbed has a good cover of vegetative litter or when the seeding is done in a heavy grain stubble, planting 7 to 10 pounds per acre at depths varying from one-half to three-fourths inch is recommended. Without the protection of some vegetative mulch, the seed should be covered more deeply, but not to exceed 1 inch.

TIME OF SEEDING.—Since it is a warm weather species, it is not necessary to plant blue grama early in the spring. In the Great Plains region of Colorado it may be sown to advantage about the middle of April or early May. At this time temperatures are more favorable for growth and very favorable precipitation usually occurs. Successful seedings have been made, however, in late fall and early spring.

Source of Seed

In recent years bluegrass strippers have been improved and adapted for harvesting blue grama. Individuals are reporting seed supplies for sale, and undoubtedly the seed will be available through commercial seed companies in the near future. Seed-bearing hay may be harvested cheaply from meadows, roadsides, or deferred pastures.

Slender Wheatgrass

Slender wheatgrass (*Agropyron pauciflorum*), also known as western rye grass, for many years had the distinction of being the only native grass to be used to any considerable extent under cultivation. Its value as a hay grass has long been recognized. At the present time crested wheatgrass and brome grass, and possibly western wheatgrass, blue grama grass, and buffalo grass, are receiving more attention than is slender wheatgrass as species suitable for range and pasture seeding in Colorado.

Results obtained by the Colorado Experiment Station indicate that slender wheatgrass is adapted for reseeding various mountainous and foothill areas in the State. Because of several outstanding characteristics, including its adaptability to high altitudes, its rapid development, good seeding habits, and forage value, it warrants consideration in any general reseeding program.

Growth Habits

Slender wheatgrass is a perennial bunchgrass with erect, slender to stout stems from 6 inches to 4 feet high. The flower heads are slender and from 2 to 8 inches long. It reproduces by seed and spreads by tillering, forming bunches up to 1 foot in diameter.

Slender wheatgrass begins growth fairly early in the spring, somewhat later than smooth brome and about 2 weeks later than crested wheatgrass. At elevations of 5,000 feet in Colorado, slender wheatgrass starts growth about the middle of March. It is one of the earliest of the wheatgrasses to mature seed, and

the herbage tends to become dry at about the same time. Only slight aftermath is produced in the fall.

The seedlings develop rapidly, allowing a light hay crop to be harvested the year of seeding if the season is favorable. An undesirable feature of this species is that it often dies out after 4 or 5 years unless provisions are made for reseeding. It is particularly well adapted to seeding in mixtures with more permanent grasses which may be slower in becoming well established.

Site Requirements

Although slender wheatgrass has extremely wide climatic adaptations, it is preeminently a grass of mountain areas in Colorado. In the latitudinal range of the northern half of Colorado, it makes its maximum growth above 8,000 feet altitude. It is not adapted to the eastern plains of Colorado. On the other hand it withstands low temperatures and is drought-resistant.

It is best adapted to light, well-drained, sandy soils, its preference in this regard being in marked contrast to western wheatgrass, which thrives best on clays and heavy loams of the gumbo type. Neither of these wheatgrasses tolerates prolonged saturation of the soil. Slender wheatgrass possesses a high degree of tolerance to soil salinity, although it is surpassed in this respect by western wheatgrass.

Forage Value

The forage is rated rather high as feed for livestock, particularly for cattle and horses. It is readily grazed by sheep up to about the time of flowering. At that time the leafage becomes somewhat harsh. In late summer sheep greatly relish the grain, which is highly nutritious.

Slender wheatgrass hay is usually slightly lower in protein and higher in fiber than is western wheatgrass, crested wheatgrass, and brome grass. The lower protein and higher fiber content is a reflection of the stemmy character of the species at maturity. It is quite important that hay of slender wheatgrass be cut at the proper time (when in flower). Delayed cutting results in coarse hay of low feeding value. There is also more danger of harmful amounts of ergot in hay that has gone past the flowering period.

In yields of hay, slender wheatgrass ranks favorably with brome grass and crested wheatgrass in the northern Great Plains region. Slender wheatgrass produces high yields for the first 3 or 4 years, but thereafter its productivity usually diminishes

rapidly. Over a 15-year period in the northern Great Plains region, the yields of slender wheatgrass were somewhat less than crested wheatgrass (10). Reitz (8) reports better yields of slender wheatgrass from row seedings than close-drilled seedings.

Establishment of Stands

CULTURAL METHODS.—The seed of slender wheatgrass is not especially large, and it requires rather good conditions for successful germination and establishment. The use of nurse crops is not recommended with this species because it develops quite rapidly and a nurse crop offers serious competition to the grass. Because of the bunch habit of growth and relatively short life of slender wheatgrass, it is most useful in a mixture with sod-forming species or legumes. It has a distinct place in such mixtures in that it makes prompt and rapid growth after planting, thus giving early returns from the seeding.

TIME OF SEEDING.—Depending upon the soil moisture available, slender wheatgrass may be sown early or late in the fall or in early spring. Young seedlings are subject to winter-killing and hence fall plantings should be sufficiently early to allow the seedlings to become well established before heavy frosts or else delayed late enough to prevent germination until spring. From the middle of August to about the first of September is probably best for early fall plantings. Late fall seeding ordinarily should not be done before mid-October. Spring seedings should be made as early as the soil can be worked.

RATE AND DEPTH OF SEEDING.—Rates of sowing depend upon the character of the planting site and the method of seeding. Heaviest seeding rates are justified on the most productive sites. For average, non-irrigated range lands the following rates are recommended: For drilled rows 28 to 35 inches apart, 4 to 6 pounds per acre; for close-drilled rows, 6 to 9 pounds; and for broadcast sowings, 8 to 12 pounds. Since slender wheatgrass is readily handled by an ordinary grain drill, this implement can be used to advantage in many instances.

Recommended depths of seeding slender wheatgrass vary from one-half to 1½ inches. Good results have been obtained by the Colorado Experiment Station from planting depths of from one-half to 1 inch in unirrigated soil.

Management of Newly Sown Areas

As with all grasses, the tender seedlings should be protected from grazing animals until the grass is well established. Damage

due to trampling when the ground is wet and soft is more serious with bunchgrasses such as slender wheatgrass than with sod-forming species. The seedlings of slender wheatgrass develop more rapidly than those of smooth brome grass or crested wheatgrass, and in favorable years a light seed crop may be harvested late in the first season.

Although slender wheatgrass is rather short-lived, it does produce seed consistently. Therefore a system of deferred and rotation grazing is recommended to maintain and improve newly seeded stands.

Western Wheatgrass

Western wheatgrass (*Agropyron smithii*), also known as Colorado bluestem or bluejoint, is a native perennial grass of wide distribution. It occurs throughout the United States with the exception of the eastern and southern coastal regions. In Colorado it is important throughout the plains and mountain regions both as a pasture and meadow grass. Its altitudinal range extends to at least 8,500 feet.

In the Great Plains region of eastern Colorado it grows with blue grama grass and buffalo grass. It is generally considered less palatable but often more productive than the two shortgrasses. It is also not so resistant to grazing and has decreased in abundance under continued heavy grazing during the past century. However, this species has several desirable qualities which make it promising for range reseeding.

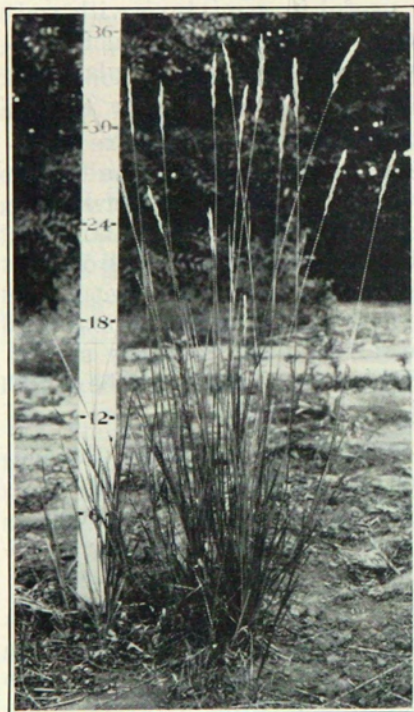


Figure 2.— Western wheatgrass, showing characteristic growth. Note new plant from rootstock near white stake.

Growth Habits

Western wheatgrass is an erect, rigid perennial, growing from 1 to 4 feet tall. The waxy covering of the stems and leaves gives them a bluish appearance. An outstanding characteristic

of this grass is the rapidity with which its vigorous underground rootstocks invade bare soil and form an open sod. It is thus particularly aggressive in many areas in reclaiming abandoned fields. The seed crop, however, is uncertain and in some years fails entirely. It is among the first grasses to become green in the spring, and most of its growth is made throughout the spring months and early summer. Additional growth occurs again in the fall if moisture is available. In northern Colorado its seed is usually matured in late July or early August.

Western wheatgrass does survive drought very well but produces very little forage in critically dry spells.

Site Requirements

Western wheatgrass is particularly well adapted to heavy clay soils of the gumbo type. Natural, pure stands are found only on such areas. It frequents swales, valley bottoms, and higher bench lands. A significant feature of the species is its relatively high tolerance for alkali. In this respect it surpasses most all the grasses found in the region. Field tests of the Soil Conservation Service demonstrate the value of the grass in revegetation work, such as in sodding terrace outlets and channels, and for stream and reservoir banks as a protection against wave action.

Forage Value

Western wheatgrass furnishes an excellent crop of palatable feed for cattle but is less palatable to sheep. It is particularly useful as winter pasture because it cures well on the ground, retaining much of its palatability and nutritious quality. When cut at about the blooming stage it produces hay of excellent quality. In nutritive value the hay ranks on a par with the better native hays. Black and Mathews (1) who conducted hay feeding trials with cattle in the northern central Plains region found western wheatgrass and alfalfa of about equal value for winter feed.

Establishment of Artificially Sown Stands

CULTURAL METHODS.—The ability of the species to spread rapidly by underground rootstocks makes it especially suitable for reseeding abandoned lands. Natural spread may be depended upon to fill in the spaces between wide rows or strip sowings. On land previously farmed but uncultivated for 2 or 3 years, fair results may be expected from drilling in the seed without further preparation of the seedbed. Careful attention should be given to the quality of the seed and to the sowing operations.

Cleaned seed can be readily used in a common grain drill. This method of planting is recommended wherever the use of a drill is practicable. Otherwise the optional seeding methods already discussed may be expected to give fair results.

TIME OF SEEDING.—Western wheatgrass makes its best growth during the cool weather of spring and fall. Therefore it should be sown in early or late fall or early spring, depending upon soil moisture conditions.

In the foothills and mountains, late fall sowing is preferable to spring sowing. The seed should be sown in late October or early November before the soil freezes. Then the seed lies dormant throughout the winter and germinates in the spring as soon as climatic conditions are favorable. In the Plains region where wind erosion is prevalent, spring sowing is less hazardous.

RATE AND DEPTH OF SEEDING.—Many germination tests show that the seed of western wheatgrass in most years is of low viability. It is therefore suggested that the rate of sowing be regulated by the germination percentage of the seed. Information obtained from field sowings shows that a seeding rate of 5 to 8 pounds of good seed per acre is satisfactory if sowings are made in rows 28 to 35 inches apart suitable for cultivation. A rate of 9 to 15 pounds per acre is necessary if the seed is close-drilled or broadcast. These rates should be increased if the viability of the seed is less than 25 percent.

Successful seedings have been made at depths varying from one-half inch to a maximum of 2 inches. The shallower depths are preferable if the seedbed is quite firm and the danger of excessive drying before germination is not great.

Management of Young Stands

The newly seeded area must be fully protected from grazing for at least the first season to allow the seedlings to become established and begin to spread. If grazing is deferred again the second year until midsummer, the grass will have made its full growth. Western wheatgrass is adapted to winter grazing, and such use is most favorable to the young stand. Once established it withstands consistent grazing by livestock.

Available Seed Supply

Seed of western wheatgrass and price quotations may be obtained from many reliable seed companies. In years of better rainfall farmers and ranchmen may collect their own seed from local areas. It can be harvested like wheat with a combine or binder.

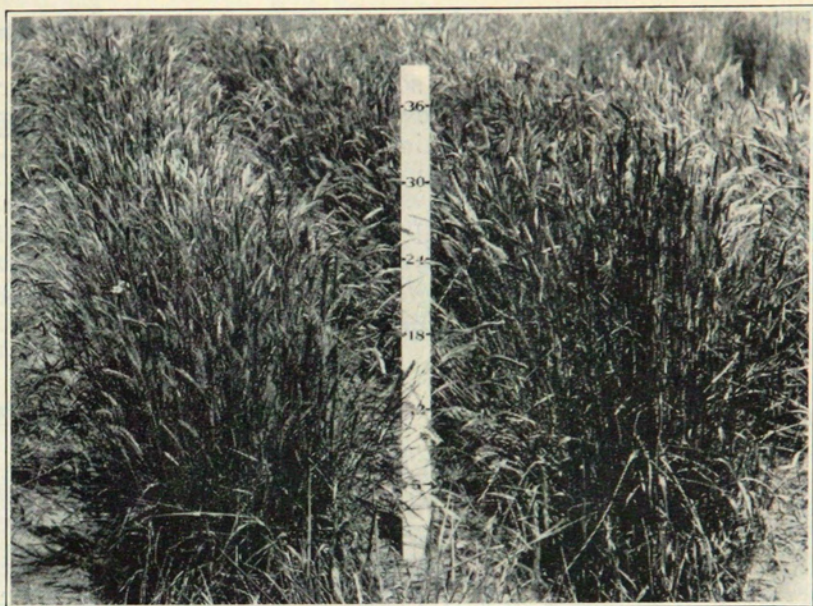


Figure 3.—Crested wheatgrass is promising for reseeding in foothills and intermediate mountainous elevations.

Crested Wheatgrass

Crested wheatgrass (*Agropyron cristatum*) is native to the Steppes of Russia and western Siberia, a region noted for its extremes in temperature and inadequate rainfall. The grass was introduced into the United States by the Department of Agriculture as early as 1898 and in recent years has received much attention because of its excellent performance under dry-land conditions in northern states. Results in several sections of Colorado (3, 5) indicate that crested wheatgrass is one of the more promising species for range reseeding in the State.

A strain known as "Fairway" (2) has been developed in Canada primarily for a turf or lawn grass. It has fine leafy stems somewhat shorter than the regular "commercial" variety and tends to form a turf rather than tufts of growth. At Fort Collins the commercial strain has yielded slightly more forage than Fairway. The two strains are probably equally adapted for seeding range lands.

Growth Habits

Crested wheatgrass is a long-lived perennial grass. It is of bunchgrass type but tillers profusely. The flared spikelets or seed

clusters that give the seed head a crested appearance are responsible for its name. Since it is a cool-climate species, it starts growth early in the spring, in some years even 2 weeks earlier than some native grasses. Growth is rapid during the spring months when moisture conditions are usually favorable. At Fort Collins it matures seed from mid-July to the first of August while the foliage is still green. Following seed maturity, it remains in a dormant state until early fall. It then makes considerable regrowth if favorable moisture and temperature conditions prevail. Because of vigorous seeding habits, it reseeds itself exceptionally well. Once permanently established, it tolerates fairly heavy grazing.

Site Requirements

Crested wheatgrass is typically a dry-land grass, though it does respond to irrigation satisfactorily. It is adapted to a wide range of soil conditions, good results having been obtained from seedings in both light sandy loams and heavy clay soils. Best results are obtained on soils of medium texture. Crested wheatgrass is reported to be slightly tolerant of alkali.

Although this grass is extremely cold-resistant, it has not been particularly outstanding in high mountain plantings. The species is better adapted to the lower foothills of the Eastern Slope. It is successfully grown in northern Colorado at elevations of from 5,000 feet to about 8,000 feet. It has been reported growing successfully above Montrose in the pinyon-juniper woodland type of country at 7,300 feet elevation. An excellent stand of Fairway strain has been reported growing near Pagosa Springs in southwest Colorado at an elevation of 8,000 feet. Observations in the Great Plains of Colorado indicate that crested wheatgrass is not well suited for the hot, dry conditions that prevail in that area.

Forage Value

The value of crested wheatgrass forage equals that of most native grasses. The fine stems and abundant leafage growth are relished by all classes of livestock. Chemical analyses of the grass show that it equals or is better in nutritive value than slender wheatgrass, smooth brome, and the better native range grasses. Crested wheatgrass is valuable as a hay crop in cool climates where moisture is limited. In tests in Canada (2) and the northern Great Plains states (10), forage yields of crested wheatgrass equalled or surpassed those of smooth brome and slender wheatgrass. Reitz (8) in Montana reports that crested

wheatgrass if used for hay should be cut shortly after heading or just after blooming but before seeds have formed.

Seed Production

Growing crested wheatgrass for seed has been a lucrative enterprise in many localities. The prospects of a continued ready market and favorable price offer inducements for growing it as a seed crop. Yields of about 200 to 300 pounds per acre may be expected under favorable conditions on dry lands. In addition to the seed crop a considerable amount of forage can be realized from such operations.

Establishment of Stands

CULTURAL METHODS.—Because of the exceptionally good seeding habits of crested wheatgrass, it is adapted to strip seeding. By depending upon natural reseeding to fill in between the seeded strips, the grower materially reduces the original cost of planting. This method is sometimes practical where soil blowing makes it desirable to leave strips of weeds or other cover to control erosion. Thus the low cost per acre may make such seeding practical on low-value lands.

TIME OF SEEDING.—Crested wheatgrass should be sown either late in the fall (October 15 or later, but before the soil freezes) or in the spring as early as possible. Young seedlings are not damaged by spring frosts, but winter-killing is serious when the seedlings germinate late in the fall and are not well established before winter.

RATE AND DEPTH OF SEEDING.—Field tests indicate that very good results may be obtained by sowing seed at one-half inch depth. However, more consistent results were obtained at the Colorado Experiment Station by sowing at depths of three-fourths to 1 inch. Moisture and temperature conditions are better at these depths than nearer the surface. The seedlings are more easily injured by heat than by cold.

Four to 6 pounds of seed per acre are recommended for 7-inch to 14-inch drill rows. A heavier rate, 6 to 8 pounds, is required for broadcast sowings. Satisfactory stands for seed production may be obtained by sowing 3 pounds per acre in rows approximately 3 feet apart.

Management of Newly Sown Areas

Mowing to reduce weed competition may often be justified on new seedings. No grazing should be allowed the first year.

A small crop of seed may be produced the first season, provided the area was seeded the previous fall.

On seed production areas more-vigorous and faster-growing plants are assured if the plants are thinned to 6 inches apart in the rows. Two or more cultivations are desirable to keep down the weeds the first year, but after the grass stand becomes well established it can easily compete with invading weeds; therefore further cultivation is unnecessary. Three years may be required for the grass to gain control of weeds, even in good seedings. Therefore hope for a successful stand need not be abandoned because the grass fails to show prominently for 2 or 3 years.

Crested wheatgrass is exceptionally long-lived, and with moderate care a good stand may be maintained indefinitely.

Smooth Brome Grass

Smooth brome grass (*Bromus inermis*), also known as Hungarian brome, Austrian brome, brome grass, and awnless brome, is native to Eurasia. It was introduced into the United States about 1884 and soon became popular as a hay and pasture crop, especially in northern and semi-arid areas. It is undoubtedly one of the most valuable cultivated forage grasses for the Rocky Mountain region.

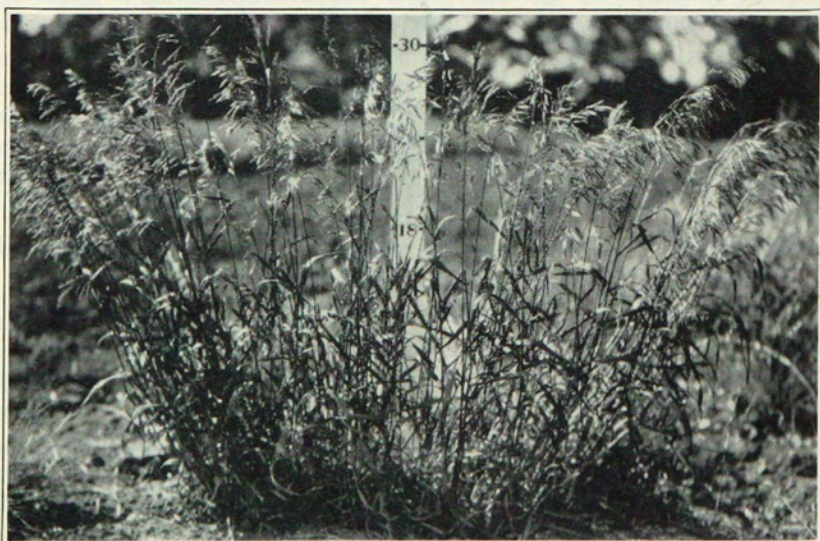


Figure 4.—Smooth brome grass is an excellent species for reseeding.

Growth Habits

Smooth brome grass is a hardy, vigorous, long-lived perennial which spreads by underground rootstocks. In good soil it spreads fairly rapidly, and the stand normally thickens in a few years. However, thick stands of brome grass tend to become sod-bound, especially where the supply of moisture is fairly good. This condition has often been attributed to the density of the root growth, but there is evidence which indicates that the real trouble is nitrogen deficiency. Some correcting measures are: Application of fertilizer, planting a legume with the grass, or opening up the sod by cultivation to stimulate nitrification.

Smooth brome begins growth early in the spring, usually about a week later than crested wheatgrass. In the earlier part of the season its growth rate is slower than that of crested wheatgrass but it does have a more prolonged growth period. If the moisture supply permits, it remains green all summer, although growth lapses somewhat during the hot, dry midseason. The seed habits of brome are good, a viable crop being produced nearly every year.

Site Requirements

Smooth brome is not very exacting in soil requirements and can be grown satisfactorily on most soil types. Best yields are obtained on the heavier soils, as the clay loams, which hold moisture well, but it produces fair yields even on light sandy soils when sufficient moisture is available. Although smooth brome is primarily a cool-climate grass, it is adapted to a wide altitudinal range. Successful stands have been established as high as 9,000 feet altitude in Colorado, and the grass also does well at the western edge of the Plains if the proper moisture and soil conditions prevail. It is able to survive very well under adverse moisture conditions. Results at Fort Collins indicate that it is as drought resistant as crested wheatgrass.

Forage Value

The forage of smooth brome compares favorably in nutrients, palatability, and yield with that of any cultivated grass. Its potential yielding capacity is greater than that of crested wheatgrass, but crested wheatgrass may outyield it when rainfall is limited. Forage yields as high as $3\frac{3}{4}$ tons per acre have been reported under ideal climatic conditions. Because of its vigorous sodding habit, brome withstands heavy grazing and trampling. The combination of good qualities possessed by smooth brome makes it a most desirable pasture grass where conditions favor its use.

Establishment of Stands

CULTURAL METHODS.—The usual recommendations for seedbed preparation and methods of planting apply to smooth brome. A common grain drill with an agitator will handle the seed satisfactorily. Smooth brome is well adapted to strip sowing because it spreads vegetatively by underground rootstocks as well as by seed. Likewise it will tend to fill in the spaces between wide drill rows. Vegetative spread of the new plants is slow, however, for the first year or two.

Planting a mixture of alfalfa or yellow sweet clover with smooth brome will alleviate or correct its tendency to become sod-bound in pure stands.

TIME OF SEEDING.—Depending on the available moisture, smooth brome may be sown in early or late fall, or in early spring. However, in the foothills and higher mountains fall sowing has proved better than spring sowing.

RATE AND DEPTH OF SEEDING.—The seeding rate should be altered somewhat according to the methods of sowing. The lightest rate may be used with widely spaced rows (up to 3 feet), where 5 to 8 pounds of good seed per acre are adequate. For close drills the rate should be increased to 8 to 12 pounds. Broadcast sowing requires the heaviest rate of seeding, 9 to 15 pounds per acre, for satisfactory stands. When seeding is to be done only on strips or on plowed contour furrows, a heavy rate of sowing (15 to 20 pounds per acre) is justified on the small area actually seeded.

The seed should be covered at least 1 inch in ordinary soils. This may be increased to a maximum of 1½ inches in very loose or sandy soils.

Management of Young Stands

Smooth brome is rather slow in becoming established and should not be grazed the first summer following planting. Early spring grazing should always be avoided. Smooth brome is better adapted to midsummer grazing than is crested wheatgrass or western wheatgrass because it remains green and continues to make slight growth even in periods of high summer temperatures when the other two species have become more or less dormant.

Legumes

A suitable legume in a pasture mixture increases both the yield and the nutritive value of the forage. Stagnant or sod-bound stands of grass can be renovated and the yield of the grass itself, to say nothing of the additional high-protein forage,

materially increased by establishing a legume in them. For restoring the productivity of stagnated grass stands, sweet clover was found to be superior to manure in Wyoming (6). The so-called sod-bound condition of certain old grass stands is usually induced by nitrogen deficiency. The accelerated fixation of nitrogen effected by legumes largely prevents or corrects this condition and helps maintain a thrifty stand of grass.

Sweet Clover

Sweet clover has been used successfully in dry-land pastures throughout the Great Plains area and is recommended for that region. Likewise this species has been found to be the most successful legume for dry-land pastures in other sections of Colorado. However, it has been only moderately successful in reseeding mountain ranges, although trials in such areas have been very limited to date.

Sweet clover, particularly the yellow variety, has many admirable qualities for a forage crop. Although yellow sweet clover and white sweet clover are both desirable, the former seems to be superior for pastures, especially on dry sites. It is less stemmy and more leafy than the white variety. Stands of yellow sweet clover persist longer than the white variety, because the former has a spreading growth habit which allows for seed production even under fairly heavy grazing. Both varieties are biennials and depend upon seed for reproduction. They are drought-resistant and seldom winter-kill. McKee (4) reports that in dry years sweet clover makes satisfactory yields.

Young sweet clover stands develop rapidly, and in an average year a light hay or pasturage crop may be harvested the first fall after planting. In the second season the yield is heaviest, and thereafter the stand tends to die out. In most of the investigations on sweet clover in which it has been reported to die out after the third or fourth years, the crop has been mowed rather than grazed. Because of sweet clover's prolific seeding habits, fairly adequate stands can be maintained for several years if the area is properly grazed. The percentage of legumes in a pasture need not be high to have considerable influence on nitrogen relationships and yield of forage.

Site Requirements

Sweet clover has a wide climatic adaptation and is grown throughout the United States and much of Canada.

One of its chief virtues is the wide range of soil conditions on which it will grow. The principal soil requirement is an adequate supply of lime, which is present in most Colorado soils.

Sweet clover endures considerable alkali and can be grown successfully where the alkali concentration prevents good growth of grain crops, alfalfa, and most grasses. Little preference is shown for particular soil types, such as clays, loams, or sandy loams, provided there is sufficient moisture to establish and maintain the plants. An outstanding characteristic of sweet clover is its ability to thrive on poor soil. Stands have been found growing vigorously on almost barren hillsides, and plants commonly grow well along roadsides where the topsoil has been entirely removed. In areas of very poor soil, sweet clover persists year after year, while on good soil it tends to be replaced by other plants after 3 or 4 years. Sweet clover does not hold its own in competition with other vegetation on good soils, whereas it does very well on the poorer sites where plant competition is not so great. This is especially true where drought conditions exist. Proper grazing management which will insure reseeding is necessary to maintain a stand of sweet clover on the more favorable sites.

Forage Value

The forage of sweet clover is consistently reported to be about equal to alfalfa in feeding value, provided it is harvested at the right time. It is equally well adapted as a pasture crop or as a hay crop. Livestock which are unaccustomed to grazing sweet clover readily acquire an appetite for the plant, although they may not like it at first. They not only relish the taste of sweet clover but find it highly nutritious and thrive on it. The forage is rich in calcium and nitrogen and has good laxative qualities. McKee (4) reports that sweet clover pastures should be grazed early and closely throughout the growing season to get the most value for livestock. Osland of the Colorado Experiment Station substantiates this statement. Many livestockmen report considerable trouble from bloating where livestock graze sweet clover pastures. Therefore it is advisable to be cautious in the use of such pastures.

Establishment of Artificially Sown Stands

SEEDBED.—The recommendations for careful seedbed preparations given for grasses apply equally well to sweet clover. Since the seed are very small, it is essential that the seedbed be firm and mellow.

CULTURAL METHODS.—The best method of planting sweet clover is to use a grain drill with a grass-seeding attachment. When sweet clover is sown in mixture with grasses, the grass seed should be placed in the grain compartment and the clover

kept separate in the grass seeder. If the two types of seed are mixed, frequent stirring is necessary to prevent the smaller and heavier clover seed from settling to the bottom. When other methods of seeding are used, care should be taken to cover the seed and firm the soil. Fallowed land provides the best seedbed. Seeding sweet clover in thin grass stands has been done successfully, although this procedure is too uncertain to be generally recommended.

DEPTH AND RATE OF SEEDING.—The small seed of sweet clover must not be planted too deeply. In heavy soils, one-half to 1 inch is the recommended depth. This might be increased to 1½ inches where the soil is sandy. The recommended rate of seeding a pure stand of sweet clover in the dry lands of Colorado is 8 to 10 pounds per acre. In mixtures with grasses, from 1 to 4 pounds of sweet clover per acre may be included, making it from 10 to 30 percent of the mixture by weight.

TIME OF SEEDING.—Early spring is the time generally recommended for planting sweet clover. In Colorado this is from early March to mid-April. There is little objection to extending the seeding period into May if necessary. Some investigators maintain that weed eradication is more important in the establishment of a stand than is early seeding. McKee (4) reports that on dry-land areas in Montana early spring sowings have been most satisfactory.

Management of Young Stands

When heavy stands of weeds get started ahead of the clover, they should be mowed with the mower sickle set high enough to miss the young clover plants. It is better not to mow the weeds if in doing so the clover will also be cut.

A light crop of hay or pasturage may be harvested from a new stand of sweet clover late in the fall. Thereafter, if grazed judiciously, it may be used throughout the season from spring until late fall.

Seeding Mixtures for Unirrigated Pastures

For permanent pastures, seeding a mixture of grasses or grasses and legumes has several advantages over seeding a single species. In any planting site there are ordinarily variations in soil and moisture conditions. Likewise, rainfall and other seasonal conditions vary from year to year. A mixture of plants has a wider range of adaptability to meet these variations than a single species. Combining rapidly developing species with long-lived ones makes for more rapid and extended returns from

the seeding. As previously discussed, the inclusion of a legume not only adds protein to the pasturage but also stimulates the growth of grasses by adding nitrogen to the soil.

Pasture Mixture for High Mountains

For unirrigated pastures at medium to high altitudes (7,500-9,500 feet) where moisture conditions are more favorable, the following mixture is recommended if properly planted:

Species	Pounds per Acre
Smooth brome	7 to 10
Slender wheatgrass	3 to 5
Yellow sweetclover	1 to 2
	<hr/>
Total	11 to 17

The rate of seeding will be altered by the method of seeding used. For drilled rows the lighter seeding rates should be adequate, but for broadcasting, heavier rates are required. When seeding is done on plowed contour furrows, a good rule is to use double the recommended rates on the ground actually seeded. For example, if the seedbed along the contour furrows comprised one-fifth of the ground surface, the seeding rate for the total area would be 6 or 7 pounds per acre.

Smooth brome grass is long-lived and should ultimately dominate the stand. Slender wheatgrass develops rapidly and will give good yields during the first few years while the brome is becoming fully established. Yellow sweet clover is the only legume which can be recommended. The sweet clover is especially valuable on eroded sites where the soil nitrogen is likely to be depleted. Crested wheatgrass may be included in the mixture at elevations below 8,500 feet. The recommended rate of sowing per acre for that species is 3 to 5 pounds in the mixture.

Koonce (3) recommends the following mixture for the Western Slope of Colorado for an elevation of 7,600 feet:

Species	Pounds per Acre
Smooth brome	10
Orchard grass	8
Crested wheatgrass	8
Yellow sweet clover.....	4
	<hr/>
Total	30

Mixture for Lower Mountainous and Foothill Plains

Because of lighter rainfall at the lower elevations in the State, planting in these areas is more hazardous than at the higher elevations. Since a degree of speculation enters into

seedings of range and abandoned cropland, heavy rates of seeding are usually not justified. The following mixture is applicable to most dry-land situations that warrant planting (not below 5,000 feet) :

Species	Pounds per Acre
Crested wheatgrass	3 to 5
Smooth brome	2 to 4
Western wheatgrass	1 to 3
Yellow sweet clover.....	1 to 2
Total	7 to 14

As previously mentioned, the rate of sowing will depend somewhat on the method of seeding.

The mixture may be altered to fit specific conditions. For instance the proportion of western wheatgrass and sweet clover may be increased where the soil is very fine-textured (heavy clay) or slightly saline. It may be advisable to omit smooth brome and sweet clover entirely for seeding on very dry sites. The use of blue grama seed at the rate of 2 or 3 pounds per acre would increase the value of the summer pasture.

Mixtures for Eastern Plains

In the Plains region of eastern Colorado, the summers are characteristically hot and subject to drying winds. Blue grama



Figure 5.—Buffalo grass is one of the best grasses in the Great Plains, although, because of the scarcity of seed, it can be established only by transplanting sod.

and buffalo grass seem best able to endure the drought periods and at the same time to take advantage of any moisture that may occur during the summer. Western wheatgrass remains dormant during midsummer but grows rapidly in the spring and early summer and makes some regrowth again in the fall under favorable moisture and temperature conditions. It grows, therefore, when the short grasses are dormant and makes use of early and late moisture. The supply of buffalo grass seed is too limited to consider this species for reseeding. It can, however, be successfully established by transplanting sod squares. The following mixture is suggested for Colorado's eastern plains conditions:

Species	Pounds per Acre
Blue grama	4 to 6
Western wheatgrass	4 to 7
Total	8 to 13

Table 1 gives information concerning species, methods of seeding, and rates of seeding.

TABLE 1.—*Recommended rates of seeding in pounds per acre and remarks on grasses and mixtures.*

	Method of Sowing				Remarks
	Grain drill		Broadcast		
	7- to 14-inch rows	28- to 35-inch rows	Solid sowing	On contour furrows. Per acre of seedbed	
Crested wheatgrass	4-6	2-4	6-8	8-12	Extremely resistant to drought and cold. Especially adapted to mountains and foothills in Colorado.
Smooth brome	8-12	5-8	9-15	15-20	Very resistant to drought and cold. Does well from high ranges to plains if moisture is adequate.
Slender wheatgrass	6-9	4-6	8-12	12-18	Adapted to high altitudes or irrigated meadows.
Western wheatgrass	8-12	5-8	9-15	15-20	Especially good on heavy soil and slightly alkaline areas.
Blue grama	6-8	5-7	8-10	10-15	Extremely drought-resistant. Best on medium to light soils. Cures well on the ground. Plains and foothills.
High mountain mixture ...	13-15	11½-14	14-18	18-28	Adapted above 7,500 feet elevation.
Low mountain and foothill plains mixture	8-12	7-10	9-14	14-20	Recommended below 8,500 feet elevation.
Eastern plains mixture ...	8-13	7-10	10-13	13-20	For the Great Plains area of Colorado.

Summary

Artificial reseeding should be attempted only under favorable soil and climatic conditions.

The use of improved range management methods on many depleted range lands is the more practical solution to increase the yield of the native forage grasses.

Most range forage plants demand good soils for establishment and optimum growth. Therefore it is desirable to use considerable judgment in the selection of sites for reseeding. Many abandoned cropland areas, especially in the Great Plains, are potential seeding areas if it is possible to control soil blowing. In the foothill and higher mountain range regions, areas where existing vegetation may prevent the successful establishment of new seedling stands should be avoided.

Early spring sowing of forage species is recommended for the Great Plains region except for blue grama, which should be sown from the middle of April to early May. Late fall sowing is preferable to spring sowing in the foothills and higher mountains. However, spring sowings in the foothills are also recommended.

A well-prepared seedbed enhances the probability of success in reseeding. Eradication of weedy growth is extremely desirable except on wind-blown areas, where it is a good practice to leave strips of weeds to control blowing of soil. In the Great Plains it is recommended that sorghums and sudan grass be planted prior to grass seeding. In harvesting the forage of these two crops, a high stubble should be left to minimize soil blowing.

The best results are obtained when it is practicable to plant with a grain drill or any other similar drill. This method is better than broadcasting seed by hand. Where seed is broadcast, it should be covered by using a spike-toothed harrow or brush drag. Successful stands have been obtained where the seed has been trampled in by sheep. The proper depth to sow most grasses varies from three-fourths inch to 1½ inches. Grass seed should always be covered with soil for best results.

Every consideration should be given new grass stands. Where practicable, weed growth should be mowed at least once or twice the first year. As a general rule, livestock should not be allowed on newly seeded areas during the first year. However, the more rapid-growing species, slender wheatgrass and crested wheatgrass, may be lightly grazed late the first year if the new plants are well established.

The use of legumes, especially yellow sweet clover, is desirable in mixtures with grasses because it increases the yield and

nutritive value of the forage. Where conditions justify, a mixture of smooth brome and alfalfa is desirable.

Various mixtures of grasses are recommended for different sites and climates because forage plants vary in their rate of establishment.

In recommending the following forage plants for various sections of the State, the varied climate, topography, and soil have been taken into consideration:

GREAT PLAINS REGION.—Blue grama; western wheatgrass (more favorable sites; swales); buffalo grass (seed when obtainable; if not, sod squares); and yellow sweet clover.

HIGHER PLAINS WEST OF THE GREAT PLAINS REGION.—Blue grama, western wheatgrass, smooth brome, crested wheatgrass, and yellow sweet clover.

FOOTHILLS OF THE EASTERN SLOPE.—Blue grama, crested wheatgrass, slender wheatgrass, smooth brome, western wheatgrass, and yellow sweet clover.

MOUNTAINOUS AREAS.—Crested wheatgrass, slender wheatgrass, smooth brome, Kentucky blue grass, and the native bromes when seed is obtainable.

WESTERN SLOPE AREAS (on the better sites).—Crested wheatgrass, smooth brome, and western wheatgrass.

Literature Cited

- (1) BLACK, W. H., AND MATHEWS, O. R.
1930. Wintering Steers in the Northern Central Plains Section. U.S. Dept. Agr. Bul. 192. 13 pp., illus.
- (2) KIRK, L. E., STEVENSON, T. M., AND CLARKE, S. E.
1934. Crested Wheat Grass. Canada Dept. Agr. Pamphlet 157. 22 pp., illus.
- (3) KOONCE, DWIGHT
1937. High Altitude Studies on Dry-land Grasses and Clovers. Colo. Agr. Exp. Sta. Bul. 439. 16 pp., illus.
- (4) MCKEE, C.
1923. Growing and Using Sweet Clover in Montana. Mont. Agr. Exp. Sta. Cir. 118. 31 pp., illus.
- (5) MORRIS, M. S.
1935. Crested Wheat Grass for Dryland Pastures. Colo. Agr. Exp. Sta. Press Bul. 84. 7 pp., illus.

- (6) NELSON, A. L.
1933. Grasses, Alfalfa and Sweet Clover at the Archer Field Station. Wyo. Agr. Exp. Sta. Bul. 195. 46 pp., illus.
- (7) PALMER, L. J., AND NELSON, E. W.
1937. Range Resources of Colorado. Rocky Mtn. Forest and Range Exp. Sta. mimeo. Fort Collins, Colo.
- (8) REITZ, L. P., AND OTHERS
1936. Crested Wheatgrass in Montana: Comparisons with Slender Wheatgrass and Brome Grass. Mont. Agr. Exp. Sta. Bul. 323. 53 pp., illus.
- (9) SAVAGE, D. A., AND SMITH, JAMES E.
1940. Regrassing Cultivated Lands in the Southern Great Plains. The Cattleman. March, 1940.
- (10) WESTOVER, H. L., AND OTHERS
1932. Crested Wheatgrass as Compared with Bromegrass, Slender Wheatgrass, and Other Hay and Pasture Crops for the Northern Great Plains. U.S. Dept. Agr. Tech. Bul. 307. 36 pp., illus.

BULLETIN SERVICE

The following late publications of the Colorado Experiment Station are available without cost to Colorado citizens upon request:

Popular Bulletins

<i>Number</i>	<i>Title</i>
423	The Parshall Measuring Flume
427	Insect and Mite Pests of the Peach in Colorado
430	Oat Production in Colorado
434	Improving the Farm Wagon
435	North Park Cattle Production—An Economic Study
436	Fitting Sheep into Plains Farming Practices
440	Seal Coats for Bituminous Surfaces
442	Colorado Lawns
443	Home-Made Farm Equipment
444	Rural Households and Dependency
445	Improving Colorado Home Grounds
446	Growing Better Potatoes in Colorado
447	Black Stem Rust Control in Colorado
448	Lamb Diseases in Colorado Feedlots
449	Sorghums in Colorado
450	Alfalfa in Colorado
451	Landlord and Tenant Income in Colorado
452	Looped Wire for Concrete Reinforcement
453	Economics of Sugar Beet Production in Colorado
454	Potato and Tomato Psyllid
455	Colorado's Poisonous and Injurious Plants
456	Analysis of 50 Years' Weather Record
457	Educational Foundations for Rural Rehabilitation
458.	Orchard Management in Colorado

Press Bulletins

89	Some Injurious Plant Lice of the American Elm
91	Western Slope Lamb Feeding
93	Controlling the Squash Bug

**Colorado Experiment Station
Fort Collins, Colorado**