I think many range technicians would agree that the identification and attainment of proper grazing use has been, is now, and will be in the future our most urgent problem in rangeland utilization by domestic livestock and big game animals. Despite supporting evidence from research studies and from an increasing number of individual ranch enterprises, we still have a long way to go in attaining universal application of this concept. Some of the things that will need doing to gain increasing acceptance of this practice include:

a. Additional research that will identify what constitutes proper grazing use for additional kinds of rangeland, and for different seasons of use and different stages of plant growth.

b. Devising more effective ways of demonstrating the application of this practice to rangeland users in a manner that will convince them of its merits and benefits on their particular range operations.

**Realistically Coming To Grips With Rangeland Economics**

We urgently need additional convincing evidence that what we call good range management pays (Fig. 2). This evidence is needed in terms of the ranch enterprise as a whole rather than simply in terms of a single pasture or a single practice such as seeding or brush control. For maximum utility such evidence should go further than simply budgeting the enterprise—it should identify the kind and condition of rangeland involved and the nature and degree of grazing use in effect during the period of record.

I'm sure that our profession believes that good range management pays. We are gradually accumulating substantiating evidence. Let's give a high priority to fortifying this evidence to a point at which the proof is obvious. This will certainly be an effective "helper" in opening the gate to the future.

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**Range Interseeding in Nebraska**

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In the Great Plains states many counties have thousands of acres of formerly cultivated lands producing very little forage because climax grasses have not become re-established. In many cases, often because of erosion hazard, it is impractical to resume cultivation, grow a non-competitive cover crop, and drill seed of the native grasses adapted to the site. On such lands the range interseeder provides a means of re-establishing climax grasses in spaced rows without the erosion hazard, the complete disruption of plant succession, or the inconvenience of complete cultivation. The range interseeder discussed here was designed for use in Nebraska, but the principles involved have a much wider application.

**Development**

The first pasture furrowing in the Great Plains was done for the primary purpose of range interseeding. H. L. Bentley, a field agent for the U. S. Department of Agriculture, gives an account of this work done at the old range experiment station near Abilene, Texas. Bentley (1899) states that furrows were plowed at 12-foot intervals, across the prevailing winds, on one of the station pastures. The purpose of these furrows was to catch grass seeds blown by the wind and prevent their being lost to the pasture. An additional objective was to catch storm waters and provide irrigation for the seedlings. This study was short lived, as were other range research projects started at that time. A half century later the primary purpose of pasture furrows was again to be the establishment of a suitable seedbed for grass seeds.

Furrowing of rangeland was used to a very limited extent before the drouth of the 1930's and the advent of a nationwide program of soil conservation. During the late 1930's, Soil Conservation Service technicians initiated the installation of many acres of furrows, generally on the contour, as a range improvement practice. The primary purpose of these furrows was to hold water and prevent soil loss on the land treated and to prevent deposition on lands below. It was found that furrows had to be placed at close intervals and that this destroyed much of the existing vegetation. To speed recovery on the furrowed area seedbox attachments were devised for some of these furrowing machines. One of these attachments is illustrated in Fig. 1 top 1. Results of this reseeding were disappointing because the method had several weaknesses. Furrows were not wide enough (3-6") to adequately reduce competition. The furrows were too deep (3-6") and seed or seedlings were often buried. Seed was not placed in the soil but was broadcast over the furrow. The selection of species was limited because the seedboxes would not handle fluffy seeds. Especially noteworthy is the fact that little consideration was given to the use of native grasses of locally adapted strains higher in the successional scale than the existing vegetation.

Following these unsuccessful
efforts, little further interest was shown in the development of a furrow seeder, or range interseeder, until the Plains States experienced another severe drought. Then, at nearly the same time, workers in three states started, independently, to devise a furrow seeder. Hervey (1960) reports that construction was started in 1953 at the Colorado Agricultural Experiment Station by R. D. Barmington. Peter N. Jensen, Range Conservationist, Soil Conservation Service, Dodge City, Kansas, started work on such a planter in 1954. The University of Wyoming Experiment Station started work at about the same time on the Wyoming range seeder which was first used in 1955.

Of these three developments, only the work done in Kansas has had any direct influence on the Nebraska range interseeder. The Wyoming range seeder, as reported by Becker, McNanee, and Lang (1956), and Becker, Lang, and Rauzi (1957), is a modified till-planter which was used to introduce exotic grasses and legumes into native range. The experimental planter developed in Colorado is described by Barmington (1957) as a lister-type planter. The last model of this machine is equipped with 10-inch lister bottoms and it has a 26-inch row spacing. There has been no commercial production of this machine, and it has not been brought into use outside of the test area.

The work initiated in southwestern Kansas by Jensen had important influences on the development of the range interseeder, Fig. 1 top r. Jensen equipped a two-row lister with cotton hoppers to handle fluffy seeds, and legume-type seed boxes to handle fine free-flowing seeds. Seed was dropped in the furrow made by the lister and covered by two narrow shovels. A press wheel helped to cover and firm the soil over the seed. As work progressed with this machine, the lister share was modified to make a specific kind of furrow. The furrow desired was not over two inches deep, with a minimum top width of eight inches. This was an important change in concept as the primary purpose became the construction of a furrow best suited for the establishment of grass seedlings rather than one designed primarily to retain water.

The drouth which began in southwestern Kansas in 1952 emphasized the need for a method of re-establishing climax grasses on lands not suited to tillage. The type of furrow seeding done with the Jensen machine became an accepted practice in the Agricultural Conservation Program and in the newly created Great Plains States year. The work done by Jensen and the Wyoming seeder had a profound influence on the development of the range interseeder.
Plains Conservation Program

Seeding contractors wanted to cover more acres per hour and they assembled much larger machines, Fig. 1 bot. 1. Many thousands of acres of sandhill rangeland in southwestern Kansas have been seeded with these machines since 1958.

In 1958, Murray Cox, Plant Materials Technician, Soil Conservation Service, Scottsbluff, Nebraska, studied the machines and results of the work in Kansas and at Wyoming University. He then assembled a machine for field evaluation in Soil Conservation Districts in Nebraska. This machine is much like the original Jensen machine except that it is equipped with double-disk furrow openers and depth bands to give precise placement of the seed. This interseeder is essentially a tractor-mounted lister equipped with double-disk planting units and legume-type seed boxes in addition to the cotton hoppers. This machine can be operated as a two-, three-, or four-row unit. Row spacing can be varied by adjusting the planting units on the toolbar. This machine, Fig. 1, bot. r., more nearly meets the objectives of range interseeding in Nebraska than does any of the other machines.

Status of Range Interseeding in Nebraska

Before evaluating the status of range interseeding, it is important that the purpose and limitations of this method be understood. The purpose of range interseeding is to re-establish native grasses in spaced rows on lands where the erosion hazard is too great, or where for other reasons it is impractical to establish a cover crop. This method of seeding is not intended as a substitute for drilling in non-competitive stubble, but it is a method for use on lands where complete seedbed preparation is impractical. Under optimum conditions, range in poor condition class or cultivated land can, by the full seeding method, be converted into range in the good or excellent condition class within three to five years. With the interseeder, the optimum result in this same length of time is the establishment of spaced rows of grass that will raise the overall range condition class to fair or good. Several more years of careful management are necessary to raise the condition to good or excellent. However, when compared with the many years of careful grazing management required to permit natural entry of climax grasses on such land, the alternative of interseeding gains favorable attention.

There are now 21 range interseeders in Nebraska. All of these machines are built essentially like the original machine designed by Cox. Some are tractor-mounted and some are tractor-drawn, and all machines are either two-row or three-row units. Some modifications have been made in type of planting

![Figure 2. Top—Poor pasture, southwestern Nebraska, as it appeared soon after seeding with range interseeder, 1959. Bottom—Same pasture October 1962, three years after interseeding.](image-url)
unit or seed hopper, but there has been no change in the basic planting principles. All of the range interseeders in Nebraska are in Sandhill counties or in counties that include Sandhill outliers.

Range interseeding was accomplished on 505 acres of Nebraska rangeland in 1959. The present rate of interseeding is about 5,500 acres per year, and the total acreage now seeded in Nebraska by this method is 17,835 acres. Of this total acreage, 93 percent is either on the Sand or Sandy range site.

The plant materials field evaluation plantings in Soil Conservation Districts have been an important factor in the growing acceptance of this practice. The results of these plantings convinced Soil Conservation Service technicians, seedsmen, and landowners that this method of seeding has merit. People familiar with the Dundy County pasture, as it appeared at the time of interseeding, are impressed with the improvement accomplished in three years, (Figure 2). Farther east and in the northern part of the state, in Holt County, is an excellent example of a three-year-old interseeding now being grazed by cattle. Figure 3 shows this pasture as it appeared at the end of 1962 grazing season.

The range interseeding method is admirably suited for re-introducing climax dominant grasses in order to hasten natural succession. Dominants can spread from spaced rows on lands where no other seedbed preparation has been attempted. In December 1961, a survey was made of 46 such interseedings made in Nebraska since 1958. The grass stands on 74 percent of these were rated good or excellent, 15 percent were rated fair, and only 11 percent were rated poor. This success ratio is practically identical to the success ratio of full seedings made during the same period with a grass drill on prepared seedbeds. Grass stands on 172 drill seedings were rated as 12 percent poor, 15 percent fair, and 73 percent good or excellent. The high success ratio of range interseeding has given this method the status of an accepted practice.

Conclusions From Five Years Observation

RANGE SITE—The range interseeding machine, as well as the method, is best adapted to Sand and Sandy range sites. Interseeding on Silty sites, though more difficult to accomplish, has been nearly as successful. Unless soil moisture conditions are very favorable, it is difficult to properly plant on clayey and clay soils. If wet, these soils tend to stick on the depth bands and prevent the furrow opener from functioning properly. If dry and hard, the furrow opener fails to penetrate. An advantage of this method of seeding, on most sites, is that all vegetative cover and weed seed on and in the surface soil is pushed away from the drilled seed. This feature, on soils subject to crusting, places the seed in an area that is more apt to crust than if it were protected by a mulch cover. Some interseedings on Clayey and Clay sites have been lost because a crust formed on the soil surface and prevented emergence of the seedlings.

RANGE CONDITIONS—This method is best suited to go-back fields or other ranges in poor condition. If remnants of the climax dominant grasses are sufficiently distributed so that resting alone will bring about range recovery in a reasonable time, then there is no justification for range interseeding. Observations as well as ecologic theory indicate that range interseedings can succeed and persist on ranges only if the between row cover is lower successionally than the seeded ecotypes. For example, on a Sandy site in the 20-inch precipitation zone, seeding little bluestem (Andropogon scoparius) in perennial weeds or blue grama (Bouteloua gracilis) will succeed; whereas, when little bluestem is seeded into a natural stand of little bluestem, the seedlings will fail to survive. This is not a method to use on barren sandy fields or blow-outs because blowing sand is likely to bury or expose the seed or seedlings.

FURROW TYPE—The best
furrow has straight sides, a flat bottom, a top width of eight to ten inches, and a depth of two to three inches. Such a furrow can be made with a 14-inch lister bottom when it is functioning properly. The furrow made with a 10-inch lister bottom is too narrow for good results. Furrows that are too shallow, less than two-inches, will generally result in skips in the row. The too-shallow furrow does not kill all of the perennial competitors, nor does it push all of the annual weed seed out of the furrow. Furrows that are too deep result in the seed or seedlings being too deeply covered by action of wind or water. A lister bottom that rides on the point presents a serious problem because the operator, in attempting to make the furrow wide enough, will make it too deep. Figure 4 illustrates the proper type of furrow for this purpose.

FURROW SPACING — Furrows spaced 40 inches apart appear to give best results. They provide sufficient space for the displaced soil to fall between the furrows. Attempts have been made to use narrower row spacing so that the seeded grasses can more quickly cover the area between the rows. Generally a narrower row spacing results in excessive ridging of soil between the furrows or in the sacrifice of furrow width.

SEED PLACEMENT — The double-disk furrow opener with depth bands set at 3/4-inch will result in seed placement at various depths to a 3/4-inch maximum. This is a desirable safety feature as seed placed at varying depths does not all germinate at the same time. Some seed on the ground surface behind the packing wheel is no cause for concern. If much seed is not covered, it may be necessary to drag a chain behind the packer wheel to get better coverage.

SEED SELECTION — The kind and quality of seed planted is a vital factor in the success or failure of range interseeding. A proper mixture of climax dominant grasses that once occupied the site should be selected. These grasses can spread between the rows and make a full stand. Many climax dominant grasses are rhizomatous and these regularly are first to enter the undisturbed vegetation adjacent to the seeded furrow. Just as important as selection of species is the selection of variety, or strain, of the species used. The strain selected must be at home on the particular site on which it is seeded or it will not be an effective competitor with volunteer vegetation. This is still a limiting factor in some sections of Nebraska where seed of locally adapted climax grasses is not yet available. Quality of seed used (purity and germination) should be average or above. Mechanical difficulties of seeding are reduced if seed is of high quality with all leaves and stems removed. Seedling establishment is enhanced if the seed used is large, properly cured and processed, and of high germination.

MANAGEMENT — When locally adapted dominant grasses have been established, the range can be managed to encourage the processes of secondary plant succession. Periods of protection from grazing are essential. Stocking must be carefully regulated as livestock usually will graze the new seedlings before grazing the vegetation between the rows. The range manager must use the seeded grasses as the key plants in the determination of proper use until the seeded furrows have sufficient old growth of previous years to greatly reduce their attractiveness to livestock. Once fully established, 50 percent by weight of these key plants can be grazed. They will increase and the range condition will improve.

Summary

The range interseeder used for re-establishing climax dominant grasses on abandoned cropland, and other ranges in poor condition, has evolved from ideas recorded as far back as 1899. During the drought periods of the 1930's and 1950's, the needs for such an implement were emphasized and developments were evident. The range interseeder is basically a lister equipped with double-disk furrow opener planting unit, packer wheel, and seed hoppers capable of handling fluffy seed as well as fine seed.
The interseeding method is best suited to Sand or Sandy sites though it shows promise on Silty sites. Clay and Clayey sites are more difficult to properly plant because of problems of equipment operation and the hazards of soil crusting.

Range interseeding is an accepted range improvement practice in Nebraska, having been successfully used on 17,835 acres, principally on Sand and Sandy sites, since 1958.

Success of this method depends upon construction of a furrow that removes perennial and annual competition during the season of establishment, proper placement of the grass seed in the center of this furrow, selection of adapted ecotypes of climax dominant species that are of higher successional rank than the existing vegetation, and careful management of grazing to encourage the process of secondary plant succession after the seedlings have become established.

**LITERATURE CITED**


**Range Condition Classification of Bunchgrass Range at the Manitou Experimental Forest in Colorado**

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This paper indicates a method of judging range condition of grassland areas in the ponderosa pine forest of the Colorado Front Range based on relative herbage production of desirable forage species.

The loop method of Parker (1951) is now widely used in range management. Data obtained by the method include measurements of vegetation (cover index, composition, and vigor) and soils and erosion (bare ground and litter). Vigor is represented by leaf-height measurements of the major forage species. Guides for using these data for estimating range condition and trend in range condition on many plant types have been developed. However, improvement of these range condition guides is desirable.

At Manitou Experimental Forest near Woodland Park, Colorado, six experimental pastures of ponderosa pine (Pinus ponderosa)-bunchgrass range were grazed at different levels from 1942 until 1959. Because a wide range of conditions developed, loop-method data from these pastures were analyzed to determine which measurement would give the best index to range conditions, and what the weightings of each should be.

In 1954, 320 permanent loop transects were measured in the experimental pastures. Herbage yields were obtained by clipping plots adjacent to 26 of these transects located in the grassland type. In 1955, herbage yields and height growth of leaves of mountain muhly² were obtained on 76 transects adjacent to loop-method transects in the grassland type. Then, to test the procedure developed from the 1955 data, an entirely new set of 24 transects were measured and related herbage production data taken in 1959. Four transects were measured in the grassland type in each pasture.

**Conditions Sampled**

The range covered by these studies extends from what is believed to be the best condition obtainable for this area to conditions where desirable plants have been virtually eliminated, and replaced by stands dominated by fringed sagebrush and blue grama (Figure 1). Pine-bunchgrass ranges can deteriorate further, but such conditions were not available for study.

Herbage production of desirable forage plants on the transect areas varied from 50 pounds per acre to 989 pounds per acre in 1954, and from 15 to 631 pounds per acre in 1955. Positive observations on desirable plants, hereafter called hits³, varied from 0 to 40 per 100 observations.

¹Central headquarters maintained in cooperation with Colorado State University, Fort Collins, Colorado.

²Botanical names of plants appear later in a tabulation.

³A "hit" as used here is an observation of a species in a three-quarter-inch loop as used in the loop method described by Parker (1951).