Bulletin No. 318 - Pitting and Other Treatments on Native Range

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Pitting
And Other Treatments
On
Native Range

By O. K. Barnes
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Agronomist, U. S. Soil Conservation Service, Research Division

INTRODUCTION

THE extensive acreage of native range in Wyoming suggests the possibility of significant increases in economic returns if a way could be found to make even small increases in grass production.

Moisture deficiency is the chief factor limiting range-forage production. To some extent, moisture shortages are due to losses of precipitation in run-off during intense storms that exceed the absorption capacity of the range. Purpose of this study, begun in 1939, was to find a practical and economical method of preventing water losses through run-off and thereby increase range-forage production. The approach used in this study was to apply mechanical treatments that would provide furrows or some type of basin to catch and hold water.

In the initial stage of this study, the first consideration was water retention. However, results soon indicated also that the tillage effect of some treatments on the range stimulated or renovated the plants with the result that a marked increase in forage followed, even though extra water was not held in the furrows or basins. Further studies have shown that closely spaced furrows or basins provide the most effective combination. This intimate type of treatment produces the renovation effect, and the numerous small basins hold the water from most storms.

During the past several years, all the work on mechanical treatments has been based on pitting the range. This has been carried on to learn of the life and long-time effects of pitting. The second aim has been to determine the extent of adaptation of this treatment to other range types, and its long-time value as a range-improvement practice.

ACKNOWLEDGMENT

The author wishes to acknowledge helpful suggestions and guidance in this study from A. L. Nelson, formerly Superintendent of the Archer Field Station, R. L. Lang and A. A. Beetle, associate agronomists, and the late Frederic E. Clements. Also many people in the Soil Conservation Service gave assistance to this work.

This study has been a joint project of the Research Division of the Soil Conservation Service, Federal Bureau of Plant Industry, and the Wyoming Agricultural Experiment Station.

-2-
REVIEW OF LITERATURE

From review of literature it appears that little work was done in the field of mechanical treatments on range land before the drought years of the 1930's. At that time various government agencies, particularly the Soil Conservation Service, carried out some field trials using contour furrows. Results from these furrowing trials were good enough to encourage treatment of rather extensive acreages of range land from Texas to Montana during 1937 and 1938.

Some of the reports on these trials and experiences follow:

Fred C. Newport reporting in Soil Conservation in January 1937,* on contour furrowing on the High Plains of Texas, stated that while the furrowing tests had not been in progress long enough at that time to point to any particular method as being superior, indications were that such treatments conserved sufficient amounts of water to make noticeable increases in plant growth.

Whitfield and Fly† reported in 1939 that contour furrowing on Southern Great Plains range increased forage production and brought about a striking change in plant composition.

Arnold S. Dahl‡ reported in 1937 that contour furrows on pasture land in the Cornbelt increased plant growth along the furrows, extended the period that the vegetation remained green, but left in question whether over-all pasture production was significantly increased.

Anderson and Swanson,+++ using a pitting machine adapted from the Wyoming studies, reported in 1949 that pitting conserved sufficient moisture to establish several species of lovegrass (Eragrostis) on some of their Arizona desert lands.

Early research in Wyoming on various mechanical treatments on range land was reported in 1945 by Barnes and Nelson.†† At that time it was shown that closely spaced, small furrows or similar structures were effective in increasing range-forage production and in improving the variety of grass species in the cover.


DESCRIPTION OF THE AREA

The Archer Field Station is located in Southeastern Wyoming, 10 miles east of Cheyenne. Elevation at this location is approximately 6,000 feet.
Topography and vegetation of the range land used for these studies are typical of the shortgrass range of the Central Great Plains. The land is level to undulating; most of it is relatively level.

**SOIL**

The major soil type which occupies gently sloping to rather level land is described as follows: the surface 3 inches is brown to dark brown, loose, porous, mellow, non-calcareous, fine, sandy loam having no discernible structural features. Organic-matter content of this layer is moderately high. Immediately below, the same color prevails, but the soil is characterized by faintly developed prismatic structure, and its texture is noticeably heavier, being a clay loam. Lime is not evident, and the organic matter may be somewhat lower than the surface layer. The upper subsoil occurs abruptly at about 7 inches, is distinctly brown, coarse granular, silty clay, having a prismatic primary structure. Lime is not evident to a depth of 13 inches, which is the lower limit of this layer. Numerous insect casts occur throughout this depth. Below 13 inches, and extending to about 18 inches, a very sandy clay soil prevails which is moderately high in lime content and faintly prismatic in structure. When moist, a secondary granular structure is faintly visible. The lime is more or less well distributed throughout. This layer blends gradually with the more or less loose, single-grain, sandy, parent soil material which extends to a depth greater than 36 inches.

The characteristics of this soil type favor good plant growth. The surface and subsoil, although fairly heavy, are penetrable by water, air, and plant roots. The subsoil has a high water-holding capacity but absorbs moisture rather slowly, thus permitting some loss by surface run-off.

The second important soil type occurring within the experimental area occupies sloping land. This soil type is described as follows: the topsoil averages 8 to 10 inches in depth and consists of brown, non-calcareous, porous, gravelly sandy loam. At some points the surface is quite gravelly. Generally there is enough fine material to give it loamy character. The underlying subsoil extends to 22 inches and is a brown, somewhat calcareous, gravelly sandy loam having a faintly prismatic-columnar structure with lime more or less well distributed throughout. On the north-facing slopes the layer is somewhat more maturely developed as evidenced by a horizon of lime enrichment. Soft limy splotches have also been observed in some profiles. Below 22 inches to 36 inches or deeper, a loose, porous, sandy, calcareous, parent soil material of grayish color prevails.

The characteristic of texture and structure are such that roots, water, and air readily penetrate this soil. The structural features thus enable not only ready absorption of water, but facilitate withdrawal of soil moisture by roots. However, this soil is somewhat lower in water-holding capacity.
than the major soil type. The sloping nature of this land allows considerable loss of rain water by surface run-off.

Approximately 60 percent of the land used for the experimental pastures was of the first soil type described and approximately 30 percent was of the second type, with the remainder in minor variations of these two types.*

**TOPOGRAPHY**

Topography of the experimental pastures varies from almost level (1 to 2 percent) to slopes of 8 percent. The pastures used in this study lay in a row about a mile long by approximately 0.3 of a mile wide. A draw with good shortgrass cover runs through the approximate center of this strip, which was subdivided into nine pastures for the study. The pastures have almost identical topography. Each experimental pasture has approximately 57 percent level land, 29 percent sloping land, and 14 percent within the draw. Comparability between pastures is exceptional for range land in this region.

**VEGETATION**

The vegetation is quite typical of the Great Plains area. On the flat lands the dominant grass is blue grama (*Bouteloua gracilis*) (H.B.K.) Lag. Mixed with the blue grama in varying proportions is buffalograss (*Buchloë dactyloides*) (Nutt.) Engelm., which is the co-dominant. Western wheatgrass (*Agropyron smithii*) Rydb., needleandthreadgrass (*Stipa comata*) Thrin. and Rupr., Sandberg bluegrass (*Poa secunda*) Presl., and junegrass (*Koeleria cristata*) (L.) Pers. are found in scattered stands with the above-named dominants.

The main perennial forb on this flat land is false mallow (*Sphaeralcea coccinea*) (Nutt.) Rybd. Various annuals are usually present; most common are plains plantain (*Plantago purshii*) R.S., annual peppergrass (*Lepidium apetalum*) A. Gray, and beggars tick (*Lappula redowskii var. occidentalis*) Wats.

Two semi-shrubs, pasture sage (*Artemisia frigida*) Willd, and aromatic sage (*Artemisia glauca*) Pallas., are frequently found.

On the slopes the vegetative type is usually quite different from the level land. Here the vegetation takes on a midgrass aspect. Although blue grama and buffalograss are present, they have yielded their dominance to western wheatgrass, needleandthreadgrass, and Sandberg bluegrass. The annual forbs are usually quite sparse and the perennials are found more frequently. The semishrubs are the same here as on the level land.

Vegetation as described for this level land will be referred to in the remainder of this report as the shortgrass type, and vegetation for the slopes will be referred to as the midgrass type.

*The soils description of the experimental area was prepared by Harold Bindschadler, Wyoming State Soil Scientist for the Soil Conservation Service.
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**TABLE 1—Precipitation in Inches at Archer Substation, 1913-51, by Months**

**Notes:**
- 4.81 in. fell Aug. 25-29.
PRECIPI TATION

During the 13 years included in this study, a new high and a new low record in precipitation was established. The first year of the study (1939) had the lowest recorded rainfall since the Archer Station was started in 1913. In 1941, 1942, and 1949 the Station received the highest total rainfall ever recorded there. The other 9 years included 2 years slightly below the 1913-1938 average and 6 years of approximately normal precipitation. Average for the 13 years was 15.96 inches, a little over 1 inch above the previous 26-year average.

Table 1 gives the monthly precipitation records collected at the Station during the period of this study and the 26-year average beginning in 1913.

FIG. 1—The eccentric one-way disc. When used for pitting range land, the regular discs—nos. 2, 4, 6, etc. in this picture—are removed, leaving only the off-center disc every 16 inches

DESCRIPTION OF IMPLEMENTS AND TREATMENTS USED

EC CENTRIC ONE-WAY DISC

This implement was developed in 1936 at the Archer Field Station for summer-fallow pit tillage, partially covering field trash.

The eccentric disc is an ordinary one-way or Wheatland plow with every other disc off center. The eccentric discs are 2 inches larger in diameter than the other discs, with the gang-bolt hole 2 inches off center. The plow at this station is equipped with 18-inch discs. (See Fig. 1.)
To mount the eccentric discs properly on this one-way, it is suggested that one start from the rear of the gang bolt and proceed as follows:

1st disc—18 in.
2nd disc—20 in. Eccentric with long side up.
3rd disc—18 in.
4th disc—20 in. Eccentric with long side to the rear.
5th disc—18 in.
6th disc—20 in. Eccentric with long side down.
7th disc—18 in.
8th disc—20 in. Eccentric with long side to the front. Continue in this same rotation until all the discs are mounted.

The gang-bolt hole in every 20-inch disc is 2 inches off center. This forms an eccentric disc.

The principle can be applied to most disc implements with variations to meet the requirements of the implement.

This system of mounting the discs not only produces the desired pattern of pits but also gives even distribution of the draft on the implement.

The set-up is used for summer fallow. The same can be used for pitting sod land. However, the implement must be carefully regulated as to depth in order to prevent cutting the sod by the smaller discs. If considerable pitting is to be done it is advisable to remove the smaller discs and in their places put large washers to take up the width on the gang bolt. Also, by removing the smaller discs it is possible to make the pits 1 inch deeper.

This pitting operation leaves the surface resembling a waffle, with the pits about 16 inches apart. The actual volume or holding capacity of an area so pitted amounts to a rain of approximately 0.3 of an inch. This may be compared to large grooves spaced at 10-foot intervals, or small grooves at 2-foot intervals. Figure 1 shows the eccentric one-way disc, which was developed at Archer for summer-fallow work and later adapted to use on range land.

Since these pits are not connected, it is not necessary to place them on a level contour. Rather, the implement can be run on a course that appears to be approximately at right angles to the slope.

The range land used for study of this implement was treated solidly (Fig. 2). With an 8-foot disc, one man and tractor pitted 15 acres per day on these experimental areas. Here some little time was involved in getting around experimental plots that would ordinarily not be necessary. On sod land the implement requires much less power than it does on cultivated land.
GROOVER

This type of implement is a lister adaptation. In this study two sizes of shovels were used in the early work. During later years only one size was continued and that was a shovel making a furrow 5 inches wide. Horizontal spacing intervals of the furrow of from 2 to 30 feet were studied earlier, but in the work reported here only the 2-foot spacing is included. With the close type of spacing, such as the 2-foot intervals, a blade was used to spread and distribute the loose soil thrown up. The shovels were attached to the blade, which was set about an inch above the surface so that the shovel went in about 4 inches.

FIG. 2—Freshly pitted range. Within a few weeks the loose soil and debris thrown between pits weather down, leaving the space between the pits well covered with vegetation.

EXPERIMENTAL PROCEDURE

PASTURES

In 1939 a 124-acre piece of range land was subdivided into nine pastures. Six of these were 15 acres each, three were 11½ acres each. In spring 1939 the 15-acre pastures were set up to study the value of furrowing with a large groover and a plow, the furrows being at 30- to 50-foot horizontal intervals. Two pastures were furrowed with the plow, two with the groover, and two left untreated as a check. Late in summer 1939, when
time permitted, the 11 1/4-acre pastures were set up to study the pitting treatment and the small grooves at 2-foot intervals. This took two pastures. The third was non-treated for a check.

The study of this wide-spacing interval of the plowed and grooved furrows was carried on through 1941. By that time all indications were that such treatment was having no significant influence on the range production. Consequently, some of these pastures were put to use in another study referred to below.

In 1942 two of the 15-acre pastures that had had the wide spacing of the plow and groover furrows were pitted with the eccentric disc in order to check further on the results obtained from the pitting treatment applied in 1939. The two non-treated check pastures included with the original six pastures were continued as such for checking the results from these newly pitted pastures.

The pastures started in 1939 are herein referred to as “Group I” pastures and those pitted in 1942 as “Group II” pastures.

The pitting on the Group II pastures was performed in the latter part of April 1942. They recovered so well from the treatment that it was not necessary to pamper them in any way. Grazing started about six weeks after pitting.

GRAZING

Grazing on all pastures has been conducted during the spring, summer, and early fall. The Group I pastures were first grazed as part of this study in 1940, although the area was grazed after treatment in 1939, but the pastures were not fenced separately. Before establishment of these studies, this range land had been part of a 320-acre pasture. Past use of the individual pastures had been uniform.

Sheep have been used for all these grazing studies. Thus it was possible to confine these studies to relatively small pastures and so allow selection of pastures comparable in original vegetation and topography, in order to make comparisons of treated range with non-treated range land. At the same time, enough animals could be used per pasture to avoid undue effects from individual animal variations.

Records maintained on the station flock of sheep have made it possible to select the required groups of ewes and lambs each year comparable in age and weight, so that each pasture had approximately the same number of each age ewe and lamb and the same total weight at beginning of each grazing season.
The average of at least two and usually three consecutive daily weighings was used for initial and final weights. Each animal was also weighed at 2- or 3-week intervals during the grazing season, except that since 1948 only two to three weighings were made between initial and final weighing. All pastures within a group were stocked at the same time in the spring. Stocking rates were reduced on any or all pastures when forage conditions justified reduction, or in some instances increased to keep up with forage production. Between years the number of lambs to ewes has varied from 120 to 125 percent, depending upon number of acceptable animals with single lambs.

**UTILIZATION STUDIES**

Frequent inspections of the pastures were made to determine forage condition during the season. Three measures in addition to observations were used to determine utilization and feed conditions during the grazing season: (1) clipping the vegetation for comparative yield data between treatments, (2) height measurements of the major grass species, and (3) gains of the ewes and lambs as determined by periodic weighing. In determining utilization by clipping, 6 plots, each 4-square feet in area, were selected at random on the shortgrass vegetative type on each pasture. For utilization by height measurements, the three most important species—blue grama, buffalograss, and western wheatgrass—were measured on 20 plots 1 square foot in size, selected at random on the shortgrass vegetative type on each pasture. Leaf-height measurements were made for these species. For blue grama and buffalograss this was an average of numerous measurements of all leaves whether they had been eaten or not. For western wheatgrass all plants in the plot were counted. The number showing evidence of use and those showing no use were counted separately. Average height of each condition was recorded. A weighted average represents the average height of western wheatgrass left at end of season or at any given time during a season.

Factors beyond control sometimes slightly reduced the length of the grazing season over that which would have been ideal from standpoint of this comparative study. However, when this happened, any under-utilization of the forage is reflected in the clippings for determining the amount of carryover vegetation at end of grazing season.

**VEGETATIVE STUDIES**

All vegetative studies on the pastures as well as the small plots were made on basis of basal cover—that is, the actual ground cover at approximately ground level. In most cases cover and composition were read on transects. Each transect was 1 decimeter wide by 100 decimeters long.
frame 1 decimeter wide by 10 decimeters long was used. A separate frame
of 1 square decimeter, divided into 1/16ths, was used to place over the
large frame to assist in estimating basal covers. The actual cover was read
and recorded in 1/16th of a square decimeter. Plants of species such as
western wheatgrass and annual forbs were counted and the total count con-
verted to percentage of cover. For example, it generally required about 400
western wheatgrass culms to fill completely 1 square decimeter where the
culms are measured at the base. Thus 400 western wheatgrass culms in
100 square decimeters would equal a basal cover of one percent.

SOIL MOISTURE

Soil samples for moisture determination have been taken in large
numbers during the period of this study. Because of the gravelly nature
of the soil on parts of the experimental area, much variation appeared in
the soil-moisture data. To cover such variations properly, a large number
of samples was necessary per plot. With as many plots and pastures as
this study included, it was physically impossible to obtain enough sampling
for all plots and on all dates to make soil-moisture data as reliable and
accurate as the data on forage production. Forage is a more sensitive mea-
sure of amount of moisture present for any treatment or set of conditions.
Therefore, in general, forage yields can be taken as a relative measure of the
amount of moisture available and conserved by any particular treatment.

TIME OF TREATING

While no comparative data have been collected as to time of year to
apply these mechanical treatments, it appears that early spring is probably
best. Pitting done in late March or early April looks better and seems to
do better than work performed during the summer. At this station, pitting
on range land has been done satisfactorily in spring when cultivated fields
were too wet to get into.

EXPERIMENTAL RESULTS

All indications from this study are to the effect that mechanical treat-
ments, to be effective in improving range land in this region, must be of
a closely spaced type—that is, in the nature of renovating, such as produced
by pitting or by small grooves at 2-foot intervals. In some years and with
certain types of furrows such as made by plow or large groover, a spacing
as wide as 10 feet has shown a significant effect on forage production.
However, in earlier studies at the station it was found that the average yield
over a 5-year period showed that any spacing interval greater than 5 feet
had no significant influence on forage production.

The effect of the closely spaced type of mechanical treatments on
native range can be summarized as follows:
1. It systematically thins the cover and at the same time leaves a basin for retaining water. The tillage seems to renovate and stimulate the range vegetation.

2. With less competition there is more moisture and plant food per remaining plant, which tends toward an immediate response in increased volume per plant. Less shortgrass competition during the season gives the midgrasses, principally western wheatgrass, a chance to produce and spread. This increase provides a condition which holds snows in the winter and results in more soil moisture for early spring growth as well as improved forage production for the year; and, being cool-season species, they utilize moisture that may be lost to the warm-season shortgrasses. Properly utilized midgrasses provide more vegetative carryover from one year to another than shortgrasses, and with this increased accumulation of organic matter there is improved moisture conservation and forage production. The surface mulch accumulated in four years on the pitted and grooved pastures was 2.8 times greater than on the check pasture.

3. When torrential rains occur during summer, the pits or grooves hold back the water (Fig. 3), while the consistently greater amount of grass residues accumulating from year to year with increase in midgrasses materially aids moisture conservation. A $\frac{1}{2}$- to 1-inch covering of the pits

FIG. 3—During torrential rains, pits hold back excess water
TABLE 2—Ten-year Grazing and Utilization Record on Native Range
Pitted in 1942, Compared with Non-pitted Range*

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<td>34.6</td>
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<td>442</td>
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<td>42.9</td>
<td>62.3</td>
<td>56.9</td>
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<td>38.5</td>
<td>36.0</td>
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<td>95</td>
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<td>54.9</td>
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<td>166</td>
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<td>70</td>
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<td>29.2</td>
<td>57.3</td>
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<td>Inc.</td>
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<tr>
<td>1948</td>
<td>68</td>
<td>49</td>
<td>33.3</td>
<td>25.2</td>
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<td>29.9</td>
<td>49.1</td>
<td>49.0</td>
<td>640</td>
<td>315</td>
</tr>
<tr>
<td>1950</td>
<td>50</td>
<td>37</td>
<td>29.0</td>
<td>24.9</td>
<td>46.9</td>
<td>49.1</td>
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<td>1951</td>
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<td>45</td>
<td>38.0</td>
<td>29.0</td>
<td>49.0</td>
<td>48.0</td>
<td>Inc.</td>
<td>Inc.</td>
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<tr>
<td>Av.</td>
<td>75</td>
<td>56</td>
<td>38.4</td>
<td>29.0</td>
<td>49.3</td>
<td>48.3</td>
<td>416</td>
<td>268</td>
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</table>

*Figures for Group II pastures represent average of two pastures per treatment.

provided by well-compacted stems and leaves, collected over the past year or more, has improved penetration and reduced evaporation.

Infiltration studies made on two locations where pitting and no pitting could be compared showed that pitting nearly doubled the rate at which the simulated rainfall entered the soil.

Wider spacing of the mechanical treatments or furrows has had little influence on total production of the treated area. Although the larger and wider-spaced furrows may hold excess water, distribution is limited to a small portion of the area so treated.

PASTURES

Results of mechanical treatments are reported from two groups of native pastures. Group I includes two types of treatment and a check pasture. This group was started in summer 1939. Group II includes duplicate pitted pastures and duplicate non-treated check pastures. The pitting on these pastures was done in spring 1942. Conditions were more favorable for proper installation of the treatment on Group II pastures than when Group I pastures were started.

Table 2 summarizes the grazing record for the Group II pastures from 1942 through 1951.

The 10-year average shows that the pitted pastures supported 75 sheep days of grazing per acre and that the check pastures supported 56 sheep days of grazing per acre. This is a 34 percent advantage in grazing capacity in favor of pitting. The amount of grass left at end of grazing season shows that, even with the heavier stocking rate, the pitted pastures had an
annual average carryover of 416 pounds per acre, while the check pastures had 268 pounds per acre left each year.

Stocking rates during the 10 years varied from 57 percent heavier stocking on the pitted pastures in 1945 down to the same rate in 1942, the year the pitting was done. In each year except 1942, the pitted pastures had from 19 to 104 percent greater carryover of perennial grass than did the check pastures.

The reason for greater carryover of grass with heavier stocking rate is primarily that the greater amounts of western wheatgrass were brought about by the pitting treatment. Sheep graze mainly on blue grama during summer and fall. Wheatgrass and other midgrasses are not utilized to any extent until blue grama is fairly well removed. The system employed in this study for determining when to remove the animals for the year was based on leaf height of blue grama. When use had brought the average height of this species down to about one inch, the animals were removed for the season. This degree of use on blue grama does not force much use of western wheatgrass except in spring. On pastures where this species has been thickened up there will be heavier carryover at the time the sheep are removed.

The data in Table 2 on lamb gains on a per-head basis show little difference between those made on the pitted and the check pastures. This is to be expected when ample feed is available at all times. However, gains made on a per-acre basis show an average of 9 pounds more in favor of the pitted pastures. This is in direct proportion to the stocking-rate difference. With more sheep carried per acre on the pitted pastures and with similar gains per head, the result is a proportionately higher gain per acre.

The pitted pastures produced more lamb each year, ranging from 4 to 13 pounds per acre. Over the 10-year period the total advantage of pitting amounted to 90 pounds of lamb per pitted acre.

Table 3 shows the plant cover and composition for the pitted and the check pastures in 1949. Studies made earlier in the life of these pastures

| Table 3—Percentage of Basal Plant Cover on Pitted and on Non-pitted Shortgrass Range* |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
|                                  | Pitted range    | Non-pitted range |
| Blue grama and buffalograss      | 18.36 percent   | 18.28 percent   |
| Western wheatgrass              | 0.70            | 0.14            |
| All other perennial grass†      | 1.27            | 0.64            |
| Total                           | 20.33           | 19.06           |
| Count of weeds per square meter | 8               | 14              |

*Includes sandberg bluegrass, needleandthreadgrass, junegrass, and two species of dryland sedges.
*Readings made in 1949 on Group II pastures.
showed that, by the second year after pitting, the amount of western wheatgrass was several times greater than the amount found on the adjoining check pastures; also that the cover of grasses other than blue grama and buffalo-grass is about two times greater on the pitted pastures. These grasses include Sandberg bluegrass, needleandthreadgrass, Junegrass, and two species of dryland sedges. It appears desirable to have a relatively high proportion of these species in the shortgrass range for several reasons. These species make their growth earlier in spring than do blue grama and buffalo-grass. This allows better utilization of seasonal moisture. Also, these species furnish spring feed and afford variety in the forage. Furthermore, these species when properly utilized provide more stubble to hold snow and provide more mulch and organic matter to the soil than will the shortgrasses blue grama and buffalograss. (See Figs. 4 and 5.)

Plant studies made in 1949 indicate that the pits have been fairly well revegetated, as the total plant cover is about the same on the pitted and the check pastures. Readings in 1947 indicated that only limited re-vegetation had taken place at that time. Thus it appears that considerable revegetation occurred between 1947 and 1949. Pitting cuts out approximately one-third of the original cover, and the evidence shows that this cover difference remains for a considerable period of time.

As shown in Table 3 there is little difference in amount of weed growth on the pitted and the check pastures. Such has been true in all experiences with pitting or similar treatments. This would indicate that one-third reduction in normal cover of shortgrass range still leaves a sufficient number of plants to compete normally with weeds.

Tables 4 and 5 summarize the 10 years of grazing on Group I pastures. Treatments used on this group of pastures were applied in summer 1939 in the midst of the driest season on record. As a result, the ground was too hard to apply the treatments properly, and it is believed that full benefit of the treatments was not obtained.

Experimental grazing on these pastures was discontinued at end of the 1949 season. This provides a 10-year record from these pastures. The record shows practically no difference in grazing capacity and animal gains on the pitted pasture and on the one grooved at 2-foot intervals. Difference was noted between the treated pastures and the check. The treated pastures carried an average of 22 percent more sheep per acre than did the check pasture. The amount of grass left at end of each season averaged just slightly higher on the treated pastures.

As shown in Table 5, there was small difference in lamb gain per head on these pastures. The pitted pasture had the lowest gain and the grooved pasture the highest gain per head. This difference is too small to be clearly associated with treatment. The lamb gain on a per-acre basis
shows the expected difference in line with the higher stocking rate on the treated pastures. This difference amounted to 6.1 pounds per acre per year more from the pitted pasture, and 8.2 pounds more from the grooved pasture, than was produced on the check pasture.

FIG. 4—The pasture shown in the top picture illustrates the appearance of the non-treated check pastures at end of grazing season. The lower view shows the pitted pasture the same season and shows the difference in amount of stubble left because more western wheatgrass is present.
FIG. 5—These pictures show the effect of having midgrass stubble left during the winter to hold snow in place. Both pictures were taken the same day. The upper view is on the non-treated check pastures and the lower view is a pitted pasture.
Table 6 summarizes the plant studies made on these pastures in 1949, 11 years after the treatments were applied. This study showed that the treated pastures still had nearly twice the amount of western wheatgrass found on the check pasture. The cover of perennial grasses other than blue grama, buffalograss, and western wheatgrass was found to be about the same on the pitted and the check pasture but slightly higher on the grooved pasture. Earlier studies of plant cover showed that the treated pastures supported a higher percentage of all grasses other than blue grama and buffalograss. Thus the 1949 readings show trend back to blue grama and buffalograss.

As shown in Table 6, the total plant cover is somewhat higher on the check pasture than on the treated pastures. From this it is apparent that revegetation of the pits and grooves has been slower than was the case with the previous group of pastures.

FIELD TRIALS

In 1945 a testing program was started by the Soil Conservation Service in various parts of Wyoming for purpose of learning about response of different range types to the pitting operation. During the following three years over 50 different sites on range land in Soil Conservation Districts were pitted. Tests were put on soils ranging from sandy to heavy clay and on vegetative types ranging from shortgrass range to wheatgrass bottoms, sagebrush-wheatgrass, and desert shrub types.

TABLE 4—Summary of Grazing Use and Utilization on Treated and on Non-treated Range, 1940-1949*

<table>
<thead>
<tr>
<th>Year†</th>
<th>Pitted</th>
<th>Grooved‡</th>
<th>Check</th>
<th>Pitted</th>
<th>Grooved</th>
<th>Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>1940</td>
<td>53</td>
<td>53</td>
<td>53</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1941</td>
<td>104</td>
<td>104</td>
<td>104</td>
<td>317</td>
<td>239</td>
<td>74</td>
</tr>
<tr>
<td>1942</td>
<td>91</td>
<td>91</td>
<td>87</td>
<td>489</td>
<td>434</td>
<td>379</td>
</tr>
<tr>
<td>1943</td>
<td>82</td>
<td>82</td>
<td>60</td>
<td>276</td>
<td>331</td>
<td>140</td>
</tr>
<tr>
<td>1944</td>
<td>89</td>
<td>89</td>
<td>62</td>
<td>241</td>
<td>260</td>
<td>235</td>
</tr>
<tr>
<td>1945</td>
<td>84</td>
<td>81</td>
<td>61</td>
<td>331</td>
<td>536</td>
<td>295</td>
</tr>
<tr>
<td>1945</td>
<td>59</td>
<td>59</td>
<td>52</td>
<td>172</td>
<td>221</td>
<td>132</td>
</tr>
<tr>
<td>1947</td>
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<td>89</td>
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<td>—</td>
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<td>—</td>
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<td>63</td>
<td>47</td>
<td>158</td>
<td>283</td>
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<td>68</td>
<td>53</td>
<td>193</td>
<td>338</td>
<td>286</td>
</tr>
<tr>
<td>Av.</td>
<td>78</td>
<td>78</td>
<td>64</td>
<td>272</td>
<td>330</td>
<td>217</td>
</tr>
</tbody>
</table>

*Group 1 pastures.
†These treatments were applied in the summer of 1939.
‡This treatment consisted of a small groove 5 inches wide by 4 inches deep and applied to the range at intervals of 2 feet.
TABLE 5—Summary of Lamb Gains from Treated and from Non-treated Range, 1940-1949*

<table>
<thead>
<tr>
<th>Year†</th>
<th>Pitted</th>
<th>Grooved‡</th>
<th>Check</th>
<th>Pitted</th>
<th>Grooved</th>
<th>Check</th>
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<tr>
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<td>34.1</td>
<td>65.7</td>
<td>66.6</td>
<td>63.9</td>
</tr>
<tr>
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<td>44.5</td>
<td>54.9</td>
<td>64.0</td>
<td>57.4</td>
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<td>66.3</td>
<td>56.1</td>
<td>67.6</td>
<td>71.5</td>
<td>61.0</td>
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<tr>
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<td>46.1</td>
<td>34.2</td>
<td>57.1</td>
<td>55.1</td>
<td>60.4</td>
</tr>
<tr>
<td>1944</td>
<td>33.8</td>
<td>30.9</td>
<td>24.6</td>
<td>38.0</td>
<td>34.8</td>
<td>36.9</td>
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<td>1945</td>
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<td>44.0</td>
<td>31.4</td>
<td>46.4</td>
<td>58.0</td>
<td>57.8</td>
</tr>
<tr>
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<td>28.8</td>
<td>21.9</td>
<td>49.9</td>
<td>54.1</td>
<td>49.3</td>
</tr>
<tr>
<td>1947</td>
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<td>40.1</td>
<td>29.8</td>
<td>52.1</td>
<td>53.5</td>
<td>55.5</td>
</tr>
<tr>
<td>1948</td>
<td>29.6</td>
<td>30.2</td>
<td>22.3</td>
<td>43.6</td>
<td>44.5</td>
<td>41.9</td>
</tr>
<tr>
<td>1949</td>
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<td>35.9</td>
<td>26.5</td>
<td>44.1</td>
<td>47.7</td>
<td>45.4</td>
</tr>
<tr>
<td>Av.</td>
<td>38.6</td>
<td>40.7</td>
<td>32.5</td>
<td>51.9</td>
<td>55.5</td>
<td>53.0</td>
</tr>
</tbody>
</table>

*Group I pastures.
†These treatments were applied in the summer of 1939.
‡This treatment consisted of a small groove 5 inches wide by 4 inches deep and applied to the range at intervals of 2 feet.

Observations were made on most of these trials and on some, yield measurements and plant studies were made. In general it was found that pitting on any mixed shortgrass range increased forage production by 25 to 100 percent. This result appears to hold on any soil where shortgrass range cover occurs. Pitting appears to have little influence on production of pure stands of wheatgrass, sagebrush-wheatgrass types, and desert shrub type of vegetation.

On practically all these field trials, grass seeding was done in connection with the pitting operation (Fig. 6). In most instances crested wheatgrass was used for the seeding at rate of 2 to 4 pounds per acre. In this operation the seed was placed in the pit where competition from other plants would be least and where moisture would tend to accumulate.

TABLE 6—Percentage of Basal Plant Cover on Treated and on Non-treated Range Ten Years after Treating*

<table>
<thead>
<tr>
<th>Pitted pasture</th>
<th>Grooved 2-ft. interval</th>
<th>Non-treated check pasture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue grama and buffalograss</td>
<td>11.68%</td>
<td>12.45</td>
</tr>
<tr>
<td>Western wheatgrass</td>
<td>.42</td>
<td>.33</td>
</tr>
<tr>
<td>All other perennial grass†</td>
<td>.84</td>
<td>1.19</td>
</tr>
<tr>
<td>Total</td>
<td>12.94</td>
<td>13.97</td>
</tr>
<tr>
<td>Count of weeds per square meter</td>
<td>9</td>
<td>12</td>
</tr>
</tbody>
</table>

*Readings made in 1949 on Group I pastures.
†Includes: Sandberg bluegrass, needleandthreadgrass, junegrass, and two species of dryland sedges.
FIG. 6—The disc with seed box attached was used for seeding grass in conjunction with the pitting operation. Rake teeth were welded on the discs to produce creases in the pit, as shown in the lower view, for the grass seed to fall into.
On most sites this effort to seed and establish a grass in the range has been unsuccessful. On some ranges with sparse cover of sagebrush and wheatgrass, the pitting seeding operation has resulted in establishment of relatively good stands of crested wheatgrass. For such areas this method of improving the range through seeding other grasses will merit further study. On shortgrass range the seeded grasses generally emerged and grew until early summer, when moisture becomes a critical factor. Then the seedlings would die. It appears that, whenever any appreciable amount of native vegetation is left, there is little opportunity for seedling establishment.

**COST OF TREATMENTS**

It was not possible to make a study of costs in connection with this study. However, information is available on time required to pit given acreages which could be the basis for estimating costs under different conditions.

Pitting is by far the cheapest, most effective treatment used in this study in terms of time and effort required per acre. Pitting can be done with small tractors and at speeds of 5 or 6 miles per hour. Thus, with a 10-foot disc, approximately 5 acres can be pitted per hour.

Ranchers using the pitting treatment have estimated the cost at from 50 cents to one dollar per acre. On basis of only labor costs and tractor-operating expense, the per-acre cost would be somewhat lower.

**SUMMARY**

Objective of this study was to find a mechanical treatment that could be used to increase range production quickly and economically and to determine the extent of any increases and the life of such treatments.

A series of small plots included in an earlier study for comparing a plow, a groover, and a killifer with furrows at 5-, 10-, 20-, and 30-foot intervals as to effectiveness in moisture conservation and improvement in vegetative cover and production shows the following results for the 5-year period: the 5-foot spacing interval was the only spacing that significantly increased forage production for the 5-year period. Both the plow and the groover with the 5-foot furrow interval resulted in significant increases in forage production. No significant difference appeared between these two implements. The killifer failed to increase production at any furrow interval.

Effect of the closely spaced type of mechanical treatment on the range cover has apparently been general stimulation of the vegetation. Thinning the cover has apparently made more moisture and plant food available per remaining plant, and these plants have exceeded in most instances the production on non-treated range. The tillage and thinning has brought about increase in western wheatgrass and other desirable species at expense of
the blue grama grass. Increase of these species has increased total forage production, increased the food available in early spring, improved the ability of the range to hold and retain moisture, and improved the quality of the range feed through greater volume of a variety of grass species.

Effect on the original composition of the cover seems to vary with the spacing of treatment. The wider the interval between the treatments, the less the effect on the cover as a whole. Generally, it appears that on short-grass range any treatment that is spaced wider than 4 to 5 feet will not have a striking influence on the over-all vegetative composition.

Pitting has been the most economical of all the successful treatments tested. Grooving at 2-foot intervals or similar treatments can be expected to accomplish similar results to pitting, but at higher cost.

Pitting serves to hold run-off during heavy rains. The actual holding capacity of the pits is about 1000 cubic feet per acre or the equivalent of 3/10’s of an inch of rain. On some limited tests, pitting was found to increase the infiltration capacity of the range by over 50 percent.

Pitting shortgrass range has increased grazing capacity about one-third and has resulted in an average of 9 pounds more lamb per acre each year over the 10-year period. Even with the heavier stocking rate, pitting pastures had a 70 percent greater carryover of perennial grass than did the check pastures. On another and earlier group of treated pastures, pitted and grooving supported 22 percent more grazing and 6 and 8 pounds more lamb per acre, along with 30 and 50 percent more grass left at end of season.

Ten years after pitting was installed, the pastures were still supporting more grazing, and the change in plant composition was persisting.

Field trials of pitting on different soils and vegetative types indicate that this treatment can be expected to improve any shortgrass type of range. The increase resulting from pitting may or may not be as great as the increase obtained in this study. Climatic conditions, application of the treatment, and other factors seem to influence plant response. In the field trials over the state, results indicate some sites with greater response than obtained in this study, and others with smaller increase. However, in no instance did pitting reduce forage production. Pitting on other range types failed to show any appreciable increase in forage production.

Pitting and seeding grass into the pits holds some promise as a reseeding method on sparsely covered sagebrush and desert sites. This operation applied to shortgrass range types failed to establish any appreciable amount of the introduced grass.