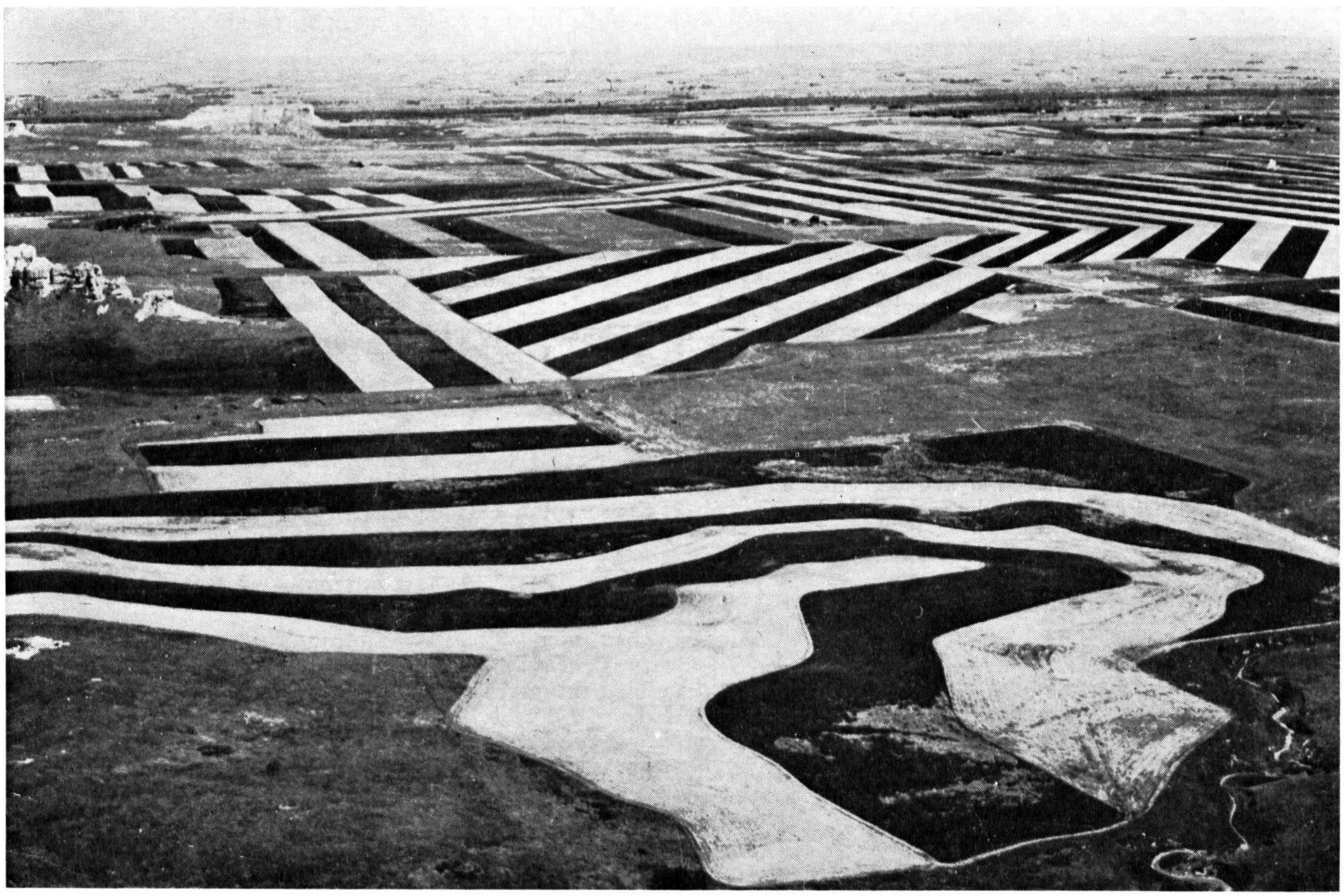
Series 1957, No. 14 Issued March 1962

SOIL SURVEY

Kimball County, Nebraska



UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
in cooperation with
UNIVERSITY OF NEBRASKA
Conservation and Survey Division

HOW TO USE THE SOIL SURVEY REPORT

THIS SURVEY of Kimball County will serve several groups of readers, particularly farmers and ranchers who want information that will help them plan the kind of use and management that will protect their soils and provide high yields. The survey describes the soils, shows their location on a map, and tells what they will do under different kinds of management.

Find your farm or ranch on the map

In using this report, start with the soil map, which consists of sheets bound in the back of this report. These sheets, if laid together, make a large photographic map of the county. You can see fields, roads, streams, and many other landmarks on this map. In fact the county appears on the map as it does from an airplane.

Use the Index to Map Sheets to find your farm or ranch on the soil map. This is a small map of the county on which numbered rectangles have been drawn to show where each sheet of the soil map is located.

After locating the rectangle that contains your land, note the number of the rectangle and turn to the map sheet with that number. Now locate your land on this sheet. The solid lines are boundaries of soils. Each boundary has a symbol indicating the kind of soil. All areas marked with the same symbol are the same kind of soils, wherever they appear on the map. To learn the name of the soil for each of the different symbols, look at the map legend that is with the map sheets. For example, if the symbol Ke appears in a delineation on your land, the legend tells you it is Keith loam, 0 to 1 percent slopes. Keith loam, 0 to 1 percent slopes, and all other soils mapped are described in the subsection "Descriptions of Soils."

Make a farm or ranch plan

For the soils on your farm or ranch, compare your yields with those in tables 2 and 3 and your farming or ranching practices with those suggested in this report. Look at your fields for signs of runoff and erosion, and at your range to see if your grasses are as good as they might be. Then decide whether or not you need to change your methods. The choice, of course, must be yours. This survey will aid you in planning new methods, but it is not a plan of management for your farm or ranch or any other in the county.

If you find you need help in planning improvements in your farming or ranching, consult the local technicians of the Soil Conservation Service or the county agricultural agent. Members of the staff of your State experiment station and others familiar with conditions in your county will also be glad to help you.

Finding information

This report has special sections for different groups, as well as sections that may be of value to all.

Farmers and ranchers and those who work with them will want to learn about the soils in the subsection "Descriptions of Soils," and then turn to the section "Use and Management of Soils" and read what is said about managing the soils when they are used for different purposes. Tables 2 and 3 tell how much a farmer can expect to harvest on dry-farmed soils and on irrigated soils.

Engineers will want to refer to the subsection "Engineering Applications." A table in that section shows characteristics of the soils that affect engineering.

Soil scientists and others interested in the scientific aspect of soils will find information about how the soils were formed and how they are classified in the section "Formation and Classification of Soils."

Students, teachers, and other users will find information about the soils and their management in the various parts of the report, depending on their particular interest.

Newcomers in Kimball County will be interested in the section "General Soil Map," which describes the broad pattern of the soils and where they occur. They may also wish to read the section "General Nature of Kimball County."

At the back of this report is a "Guide for Mapping Units" that will guide you to practically everything in this report that is written about each soil. In this guide the map symbols for the soils are listed in alphabetic order. This list gives the page on which each soil is described and the capability unit, range site, and woodland site in which it has been placed.

* * * * *

This soil survey was made as a part of the technical assistance furnished by the Soil Conservation Service to the Kimball County Soil Conservation District. Fieldwork was completed in 1957, and unless otherwise stated, all statements in this report refer to conditions in the county at that time.

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Contents

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SOIL SURVEY OF KIMBALL COUNTY, NEBRASKA

SURVEY BY LAWRENCE F. CLOCKER, ENIS ALLDREDGE, DENNIS L. BROWN, CHARLES C. COTTER, KENNETH GOOD, AND MAX A. SHERWOOD, SOIL SCIENTISTS, SOIL CONSERVATION SERVICE

REPORT BY RICHARD K. JACKSON, SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE UNIVERSITY OF NEBRASKA CONSERVATION AND SURVEY DIVISION

KIMBALL COUNTY is in the southwestern corner of Nebraska (fig. 1). The county is bordered by Wyoming on the west and by Colorado on the south. The area of the county is about 953 square miles. Kimball is the principal town and the county seat.

The county is on the high plains of the Great Plains physiographic province. These plains are moderately rolling and are cut by the valley of Lodgepole Creek, which extends in an east-west direction across the center of the county.

Kimball County is practically treeless. The native vegetation consists mainly of short and mid grasses. Ranching used to be the dominant enterprise, but most of the ranches have been broken up. Much of the land in the county is now used for cultivated crops, mainly winter wheat.

General Soil Map

As one travels over a county, it is fairly easy to see differences in the landscape. There are many obvious differences in the shape, steepness, and length of slopes; in the course, depth, and speed of the streams; in the width of the bordering valleys; in kinds of wild plants; and in the kinds of agriculture. With these more obvious differences, there are also less easily noticed differences in the patterns of soils. The soils differ with the other parts of the environment.

By drawing lines around the different patterns of soils on a small map, one may obtain a general map of the soils. Such a map shows the patterns of soils. Each kind of pattern is called a soil association, or general soil area.

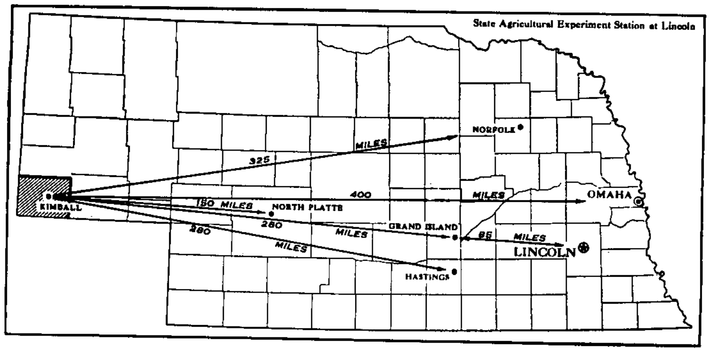

Figure 1.—**Location of Kimball County in Nebraska.**

A general soil map is useful to those who want a general idea of the soils, who want to compare different parts of a county, or who want to locate large areas suitable for some particular kind of farming or other broad land use. It does not show accurately the kinds of soils on a single farm or small tract.

The seven general soil areas, or kinds of soil patterns, in Kimball County are shown on the colored map at the back of this report. The areas are named for the major soil series in them, but soils of other series may be present in any of the areas. Also, the major soil series of one area may occur in other general soil areas. The seven general soil areas in this county are:

1. Rosebud association.
2. Rosebud-Canyon association.
3. Altvan-Rosebud-Dix association.
4. Rock land-Canyon-Rosebud association.
5. Bridgeport-Tripp association.
6. Canyon-Vebar association.
7. Keith-Rosebud association.

Rosebud Association

This association is in the northern, central, and southern parts of the county. It is mainly on high tablelands. In the northern part of the county are ridges and knobs of limy gravel with gentle slopes and flats below. Some steeper areas are along the drainageways (fig. 2). In the southern part of the county are broad uplands that appear nearly level but are gently undulating (fig. 3).

Rosebud soils are dominant in this association, but there are also shallow Canyon soils and Goshen, Keith, and Tripp soils. Deep Rosebud soils are at the higher elevations, and the Canyon soils are below them on steeper slopes. On the broad flats and gentle slopes are Goshen, moderately deep Rosebud, and Keith soils. Tripp soils are along the main drainageways.

In the southern part of the county, most of the association consists of Rosebud soils. Small areas of Goshen soils are in depressions and along some drainageways. Shallow Canyon soils lie along part of the edge of the tableland.

Most of this association is cultivated. Only small areas of shallow soils and areas around farmsteads have been left in native grass. Wheat is the principal crop, but some sorghum, millet, and safflower are also grown.

Where these soils are not protected by a growing crop or by crop residue, wind erosion is a hazard. Water erosion is a hazard on the sloping soils. Yields of both

Figure 2.—**Landscape north of Kimball. Keith loam in foreground; deep Rosebud loams and Canyon loams in background.**

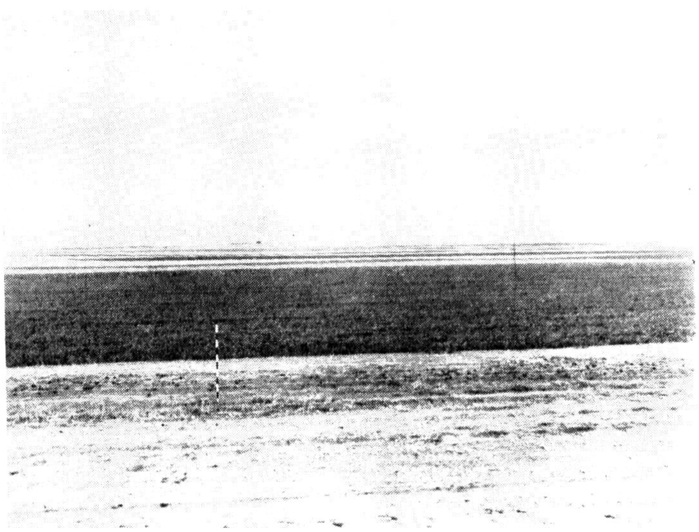

Figure 3.—**High tableland south of Kimball. Moderately deep Rosebud loams in the foreground. Small areas of deep Rosebud loams and Canyon loams are in the background.**

cultivated crops and grass are limited mainly by a scarcity of moisture.

Rosebud-Canyon Association

Most of this association is north and south of Lodgepole Creek. The largest areas are along the many dry creeks south of Lodgepole Creek. Here the small creeks are usually dry, but they overflow after heavy rains. The valley sides are sloping to steep, and, in most places, a ledge of caliche is exposed along the top of the valley sides. North of Lodgepole Creek are gravelly areas and areas of caliche.

Rosebud soils are the principal soils in this association, but Canyon soils and other soils also occur (fig. 4). In the southern part of the association, the Canyon soils occur where the caliche is exposed. Smaller areas of

Figure 4.—**Rosebud-Canyon association south of Lodgepole Creek. A deep Rosebud loam is in foreground; a moderately deep Rosebud loam is near the man, part way up the slope; and a Canyon loam is at the top of the slope.**

Tripp and Bridgeport soils are along the streams. In the northern part of the county are areas of gravel as well as of caliche. Rosebud soils are the most extensive soils in this part of the association (fig. 5), but Canyon, Altvan, and Dix soils also occur in the upland. Bridgeport and Tripp soils lie along some of the streams.

In the southern part of the association, wheat is the principal crop, but sorghum and millet are also grown. More grass is grown in the area north of Lodgepole Creek, but some of the deeper soils are farmed. In areas that

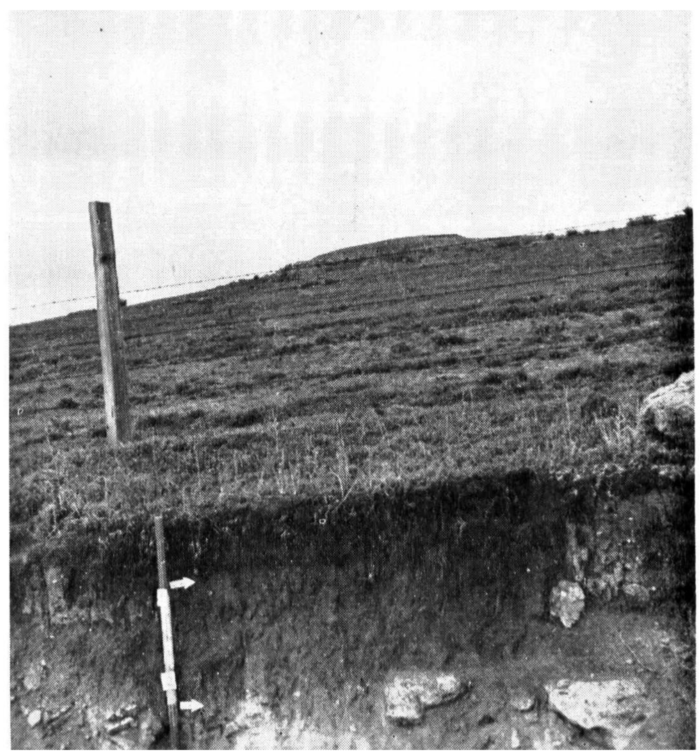

Figure 5.—**Rosebud-Canyon association near Bushnell. A moderately deep Rosebud loam is in the foreground, and a Canyon loam is on the knob in the background.**

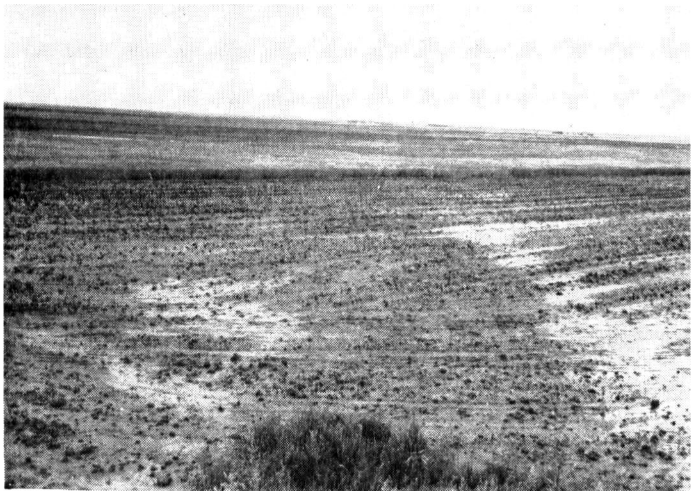

Figure 6.—**Altvan-Rosebud-Dix association. Stripcropping (wheat and fallow) north of Bushnell. Most of the acreage is in Altvan soils.**

are bare, many rills and small gullies form after rains. Controlling erosion and conserving moisture are the main problems of management.

Altvan-Rosebud-Dix Association

The Altvan-Rosebud-Dix association lies north of Lodgepole Creek in a belt that extends across the county. This area is gently sloping to steep. It is crossed by drainageways that run southeastward and empty into Lodgepole Creek.

Altvan soils are dominant, but Rosebud and Dix soils, as well as other soils, also occur in this association. The loamy Altvan soils and Rosebud soils are on the nearly level to gently sloping parts of uplands (fig. 6). The shallow Dix soils and Gravelly land occur on the sloping to steep areas, especially those areas that border drainageways. Goshen and Tripp soils are on the bottom lands along the streams. The pattern of soils is shown in figure 7.

Most of the association is cropped. Wheat is the principal crop. The steep slopes and some rocky spots are still in native grass. Wind is the main hazard in areas that have been cultivated. A scarcity of moisture limits yields; practices to conserve moisture should be used.

Rock Land-Canyon-Rosebud Association

This association is in the roughest parts of Kimball County. The main areas are along the western part of the valley of Lodgepole Creek, along Sidney Draw in the southeastern part of the county, and in Rocky Hollow in the northeastern part.

This association consists mainly of Rock land, Canyon soils, and Rosebud soils. The Canyon soils and Rock land are on steep slopes (fig. 8). Rosebud soils are on the gentle slopes between steep breaks, and along the drainageways are Bridgeport soils.

The steep, rocky slopes in this association are in grass, which is grazed. Some small areas of Rosebud soils are cultivated. Areas of this association southwest of Bushnell are in scattered stands of pine.

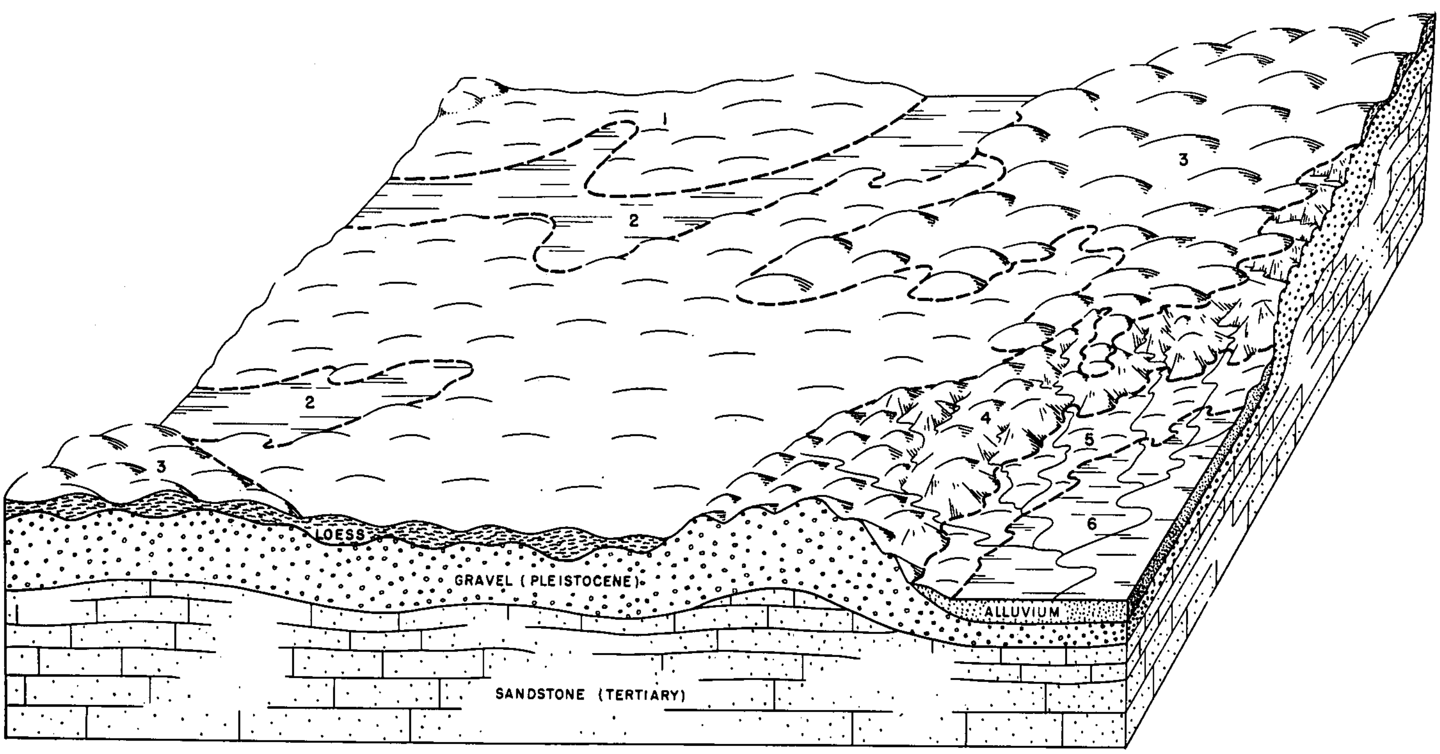

Figure 7.—**Typical soil pattern in the Altvan-Rosebud-Dix association: (1) deep Altvan loams; (2) Goshen loams; (3) moderately deep Altvan loams; (4) Gravelly land; (5) Bridgeport loams; and (6) Tripp loams.**

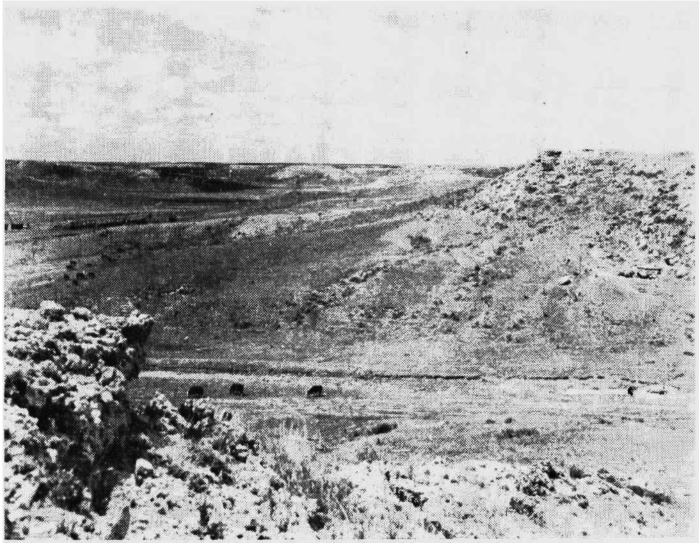

Figure 8.—Rock land-Canyon-Rosebud association in Rocky Hollow. Canyon soils and Rock land are on the steep slopes, and Rosebud soils are on the gentle slopes.

Bridgeport-Tripp Association

This association is in the valley of Lodgepole Creek and occupies practically all of the valley that is in Kimball County (fig. 9). Loamy Bridgeport soils, Tripp soils, and Parshall soils are in large areas; loamy Cheyenne soils, Sandy alluvial land, and other soils and land types are in smaller areas. Dwyer soils occur on hummocks, and Riverwash and types of alluvial land occur along Lodgepole Creek.

Most of this association is cropped. A part of the acreage in Bridgeport soils, and most of the acreage in Tripp, Parshall, and Havre soils, is irrigated (fig. 10). The water is obtained from Lodgepole Creek or from wells dug into the beds of gravel that underlie the surface. Irrigated soils in the valley of Lodgepole Creek are used for alfalfa, corn, potatoes, beans, small grains, and feed crops. Wheat is the principal nonirrigated crop.

Canyon-Vebar Association

This association is in the west-central part of the county in only one area. It consists mainly of shallow and moderately deep soils and outcrops of rock.

The Canyon soils and the Vebar soils are dominant (fig. 11), but also in the association are Rosebud, Bayard, and Parshall soils. The Canyon soils are shallow, and the Vebar soils are moderately deep. The Rosebud soils are on the gentle slopes, and the Bayard soils are at the base of steep slopes. Along the drainageways are small areas of Parshall soils.

Most of this association is in rangeland of native grass. Wheat is the main crop on some of the deeper, gently sloping soils, but many fields that were once cultivated have been returned to grass.

Keith-Rosebud Association

This association is in the northeastern corner of the county. It consists of tableland and areas that slope from the top of the tableland to the steams.

Keith and Rosebud soils are the principal soils, but there are also areas of Goshen, Altvan, Canyon, Tripp,

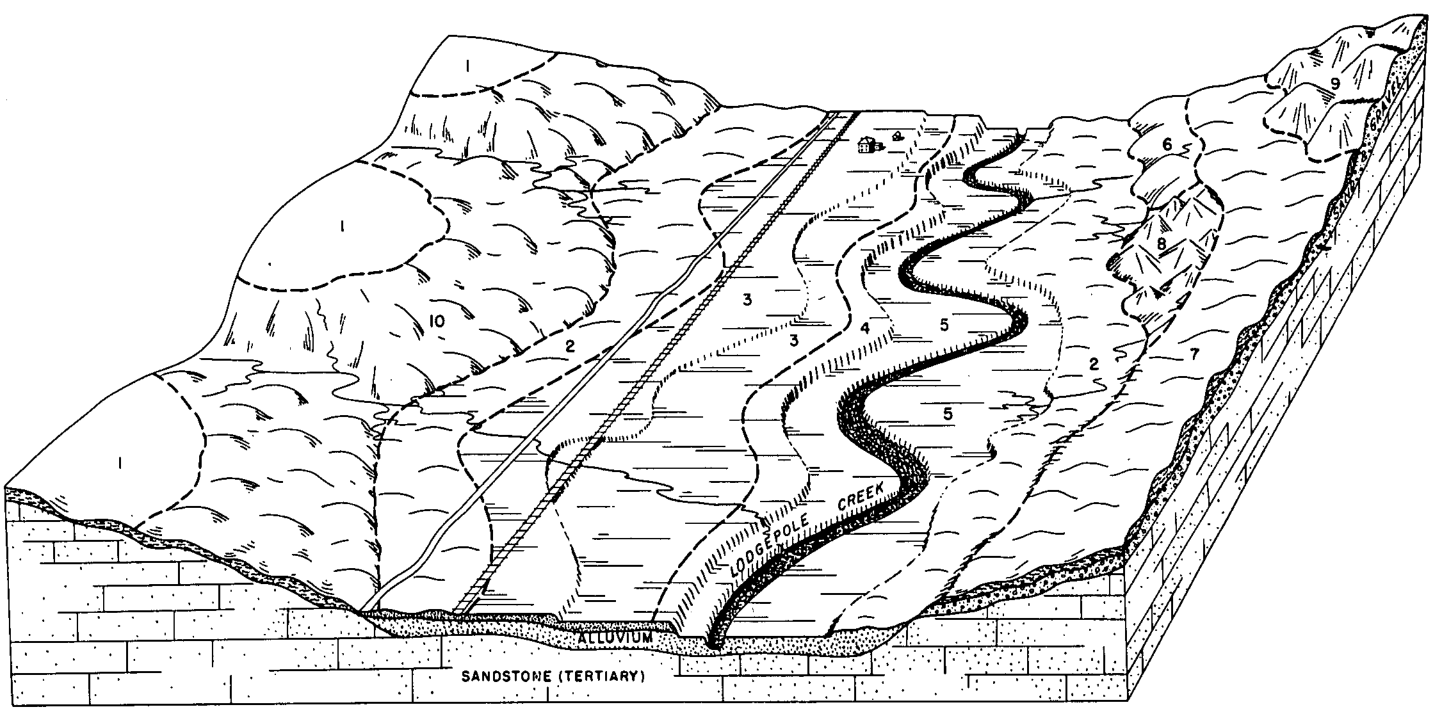

Figure 9.—Pattern of soils in valley of Lodgepole Creek: (1) Rosebud loams; (2) Bridgeport loams; (3) Tripp loams; (4) Parshall sandy loams; (5) Havre silt loam; (6) Vebar sandy loams; (7) Altvan loams; (8) Canyon complexes; (9) Gravelly land; and (10) Canyon-Rosebud loams.

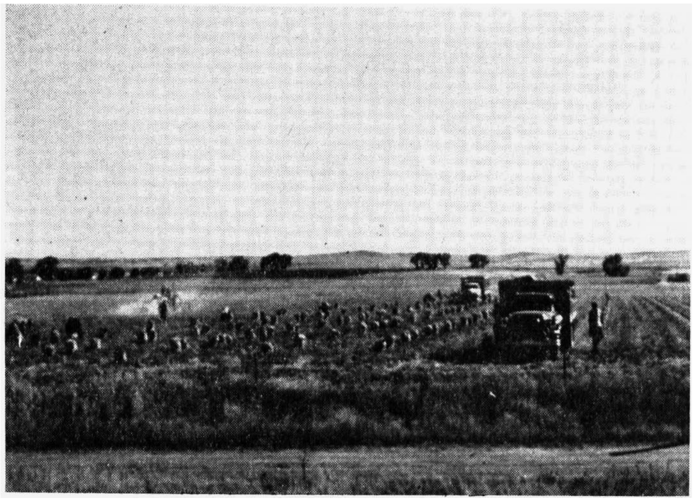

***Figure 10.*—Harvesting irrigated potatoes in the valley of Lodgepole Creek. A Tripp loam is in the foreground, and the Parshall and Bridgeport soils are in the background near the trees.**

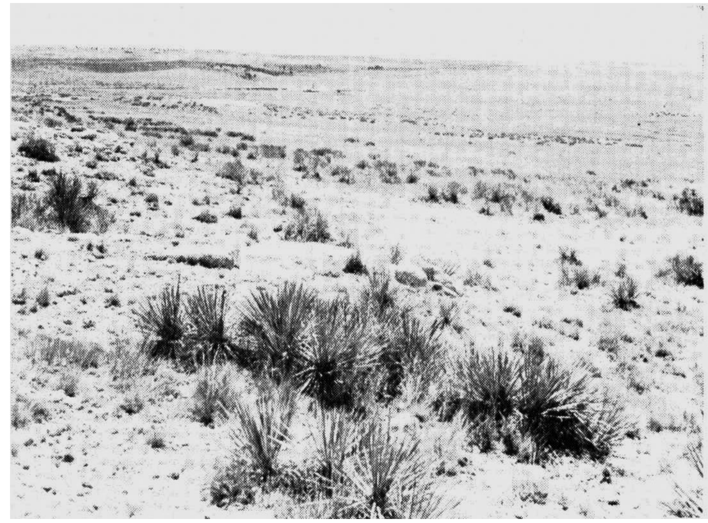

***Figure 11.*—Canyon-Vebar association. The soils in yucca are Canyon loams. Vebar sandy loams are in the lower lying areas.**

and Bridgeport soils. The loamy Keith soils are on the upland ridges and flats that are covered with loess, or silty windblown material. Goshen soils are in swales and depressions in the flat areas on uplands. They have a silty surface soil and a clayey subsoil.

Below the upper part of the tableland are Keith and Rosebud soils. The loamy Rosebud soils and the Altvan soils are on moderately sandy material that was covered by loess before the loess was removed by wind erosion. Goshen soils are in narrow drainageways. In places along the steeper side of the drains are small areas of shallow Canyon soils (fig. 12). Tripp and Bridgeport soils are on the stream terraces.

Most of this soil association is cultivated. Wheat is the principal crop. Because rainfall is slightly greater in this area than it is in the rest of the county, crop yields are slightly higher. But if yields are to be high, moisture must be conserved. Wind erosion is a hazard on this association, and the sloping soils are subject to water erosion.

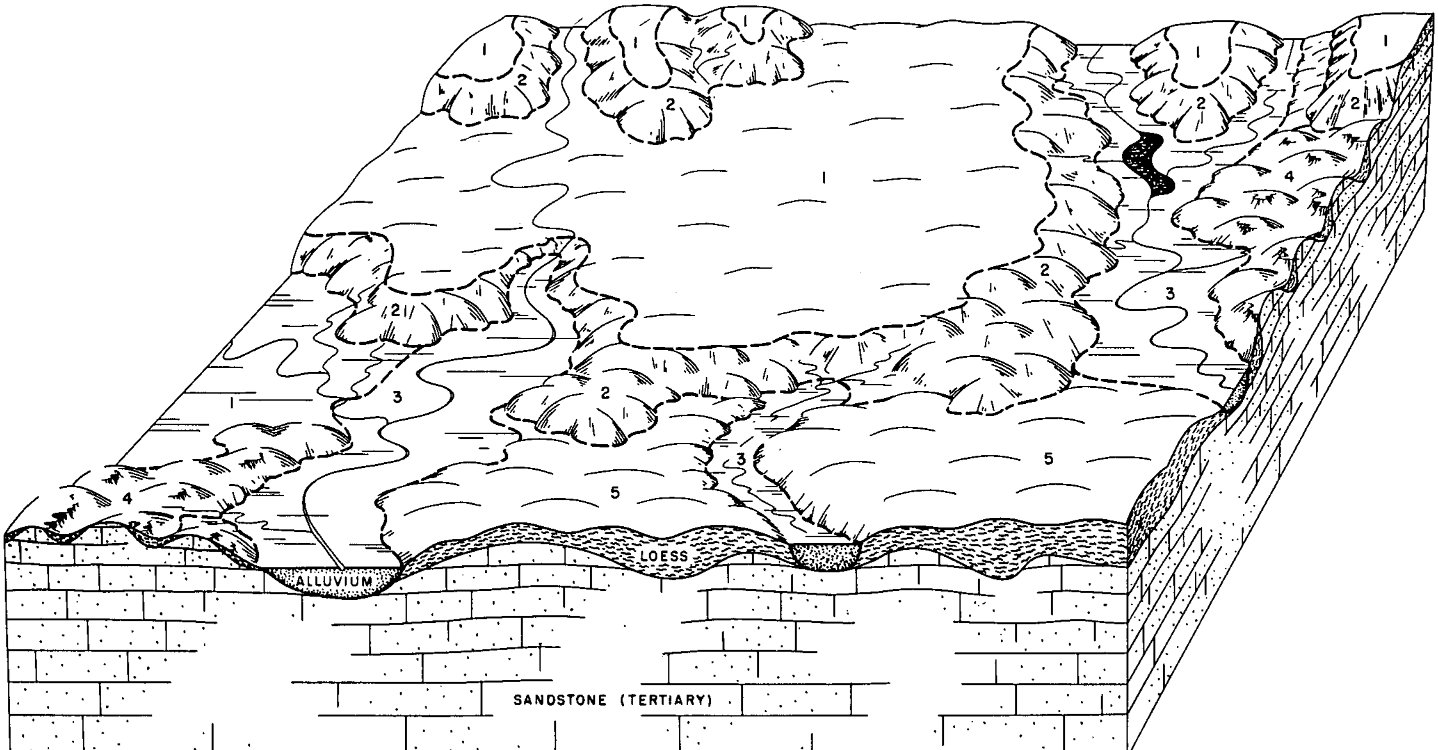

***Figure 12.*—Soil pattern of the Keith-Rosebud soil association: (1) deep Rosebud loams; (2) Canyon-Rosebud loams; (3) Goshen loams; (4) moderately deep Rosebud loams; and (5) Keith loams.**

Soils of Kimball County

This section was written for those who wish information about the single soils, or mapping units, in the county. It first discusses the effects of erosion in the county and then describes the soil series, or groups of soils, and the single soils.

Effects of Erosion

In Kimball County and elsewhere on the high plains, the high winds that occur during droughts cause widespread movement of soil. Because plant growth is slow in dry periods, little protection is provided by vegetation.

When the soil blows, small, low hummocks and drifts form in some places on the smooth, nearly level and gently sloping cultivated fields. The soil material in these drifts will blow away again unless the drifts are smoothed and tilled in such a way that the surface is rough and resistant to blowing. Soil also accumulates in road ditches and along fences. In some places it fills the ditches and covers the fences. In some fields the surface soil is removed.

On the more undulating parts of tablelands, the tops of ridges and knolls are more susceptible to blowing than are the adjacent nearly level areas. The soil on the more exposed areas tends to blow more often, and, consequently, some of it has been removed and deposited on smoother areas nearby.

Rangeland may be damaged by wind erosion both where the grass is sparse and where it is thick and tall. If the grass is not thick enough to protect the soil, some of the soil is blown away. In some places where the grass is thick and tall, soil accumulates in a layer. Although this layer is only one-eighth inch thick in some places, it forms an effective crust that is almost impervious to water. Runoff and water erosion increase, and the grasses lose moisture that is greatly needed. In some areas, the native vegetation is damaged or even destroyed. Then less desirable grasses and annual weeds invade the pasture.

The least noticed yet most damaging effect of wind erosion probably is the removal of organic matter, silt, and clay from the soil. The finer soil particles are picked up by the wind and carried many miles. Some are blown out of the county. In one year soil may be blown from a particular field, but in another year the same field may have soil added. The loss of soil depends largely on the amount of vegetative cover, the cloddiness or roughness of the surface, and on the practices of erosion control used.

Though wind erosion is very apparent in Kimball County when it occurs, it is difficult to map soil losses that are the result of soil blowing. Eroded soils, therefore, are shown on the soil map as separate mapping units only where the erosion has modified some important soil characteristic that is significant to use and management. Small severely eroded areas in mapping units are shown by a symbol on the soil map.

Soil is lost from some fields through water erosion. In some areas, a thin sheet of soil is removed. On some slopes, small rills form, and if erosion is not controlled, these rills deepen into gullies that may interfere with cultivation. Gullies that appear to be permanent are shown on the soil map by a symbol.

Descriptions of Soils

The soil scientists who made this survey traveled through the county and, at intervals, examined the soils and recorded facts about them. This subsection was written mainly from the facts that the soil scientists recorded.

In examining the soils, the scientists brought up soil material with a spade, an auger, or a power soil sampler. They compared the different layers, or horizons, which collectively are called the soil profile. They separated the different kinds of soils from each other and drew lines on aerial photographs around areas of each soil. From these aerial photographs, cartographers drew the soil map at the back of this report. The approximate acreage and proportionate extent of the soils in the county are listed in table 1.

In describing the soils, the author first describes the soil series, or group of soils, and then describes the single soils in this county that are in the series. It is to be assumed that all the soils in one series have essentially the same kind of profile. The differences, if any, are explained in the descriptions of the single soils or are indicated in the soil names.

Profiles of the soils that make up a series are much alike except for differences in the texture of the surface soil. The name of a place near the area where the soils in a series were first mapped is used to name the series. This place name is the first part of the name of all the soils in a series, and the texture of the surface soil is another part. The series name together with the textural name are used to name the soil type, which is a subdivision of the series. Many soil types are divided further, according to slope, erosion, or some other factor that affects management, into soil phases. A single soil shown on the soil map may be a soil type or a soil phase. For example, the mapping unit Havre silt loam is a soil type that has not been subdivided, whereas Chappell sandy loam, 1 to 3 percent slopes, is a phase of a soil type.

In the descriptions of the single soils, a set of symbols in parentheses follows the soil name. These symbols identify the soil on the soil map. The capability units, the range sites, and the woodland sites are named at the end of each soil description and are discussed in the section "Use and Management of Soils."

In describing the soils, the scientist assigns letter symbols to the various layers in a profile. These letter symbols have special meanings that concern soil scientists and others who make studies of soils. Most readers will need to remember only that all letter symbols beginning with "A" designate surface layers; those beginning with "B," subsoil; and those beginning with "C," parent material or substratum.

The profile descriptions in this report are divided into "surface soil," "subsurface soil," "subsoil," and "substratum," where those terms apply. *Surface soil* is that part of the soil ordinarily moved in tillage, or its equivalent in uncultivated soil. It is not more than 8 inches thick. *Subsurface soil* is that part of the A horizon below the surface soil *Subsoil* is the B horizon in soils with distinct profiles. In soils with weak profiles, it is the soil below the surface soil in which roots normally grow.

The color of a soil is described in words, such as yellowish brown, and is indicated by a symbol for hue, value, and chroma, such as 10YR 5/4. These symbols, called

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Area	Extent
	Acres	*Percent*
Altvan fine sandy loam, deep, 1 to 3 percent slopes	280	(1)
Altvan loam, deep, 0 to 1 percent slopes	9, 353	1. 5
Altvan loam, deep, 1 to 3 percent slopes	23, 310	3. 8
Altvan loam, deep, 3 to 5 percent slopes	8, 085	1. 3
Altvan loam, deep, 5 to 9 percent slopes	1, 663	. 3
Altvan loam, moderately deep, 1 to 3 percent slopes	4, 499	. 7
Altvan loam, moderately deep, 3 to 5 percent slopes	11, 632	1. 9
Altvan loam, moderately deep, 5 to 9 percent slopes	12, 775	2. 1
Bayard fine sandy loam, 1 to 5 percent slopes	2, 167	. 4
Bridgeport loam, 1 to 3 percent slopes	10, 671	1. 7
Bridgeport loam, 3 to 5 percent slopes	1, 729	. 3
Canyon loam, 0 to 5 percent slopes	14, 758	2. 4
Canyon loam, 0 to 5 percent slopes, eroded	4, 153	. 7
Canyon-Rosebud loams, 5 to 9 percent slopes	40, 419	6. 6
Canyon-Rosebud loams, 5 to 9 percent slopes, eroded	2, 057	. 3
Canyon loam, 9 to 20 percent slopes	5, 420	. 9
Canyon sandy loam, 0 to 5 percent slopes	165	(1)
Canyon-Vebar sandy loams, 5 to 9 percent slopes	6, 858	1. 1
Canyon sandy loam, 9 to 20 percent slopes	1, 858	. 3
Canyon complex, 0 to 9 percent slopes	866	. 1
Canyon complex, 9 to 20 percent slopes	29, 762	4. 9
Chappell sandy loam, 1 to 3 percent slopes	741	. 1
Chappell sandy loam, 3 to 5 percent slopes	1, 186	. 2
Chappell sandy loam, 5 to 9 percent slopes	1, 564	. 3
Cheyenne loam, 0 to 1 percent slopes	1, 106	. 2
Cheyenne loam, 1 to 3 percent slopes	1, 018	. 2
Dix loams, 3 to 9 percent slopes	11, 073	1. 8
Dix complex, 9 to 20 percent slopes	4, 312	. 7
Dwyer loamy sand	789	. 1
Glendive fine sandy loam	656	. 1
Goshen loam, 0 to 1 percent slopes	12, 936	2. 1
Goshen loam, 1 to 3 percent slopes	2, 450	. 4
Gravelly land	6, 157	1. 0
Havre silt loam	649	. 1
Keith loam, 0 to 1 percent slopes	8, 353	1. 4
Keith loam, 1 to 3 percent slopes	9, 798	1. 6
Keith loam, 3 to 5 percent slopes	2, 165	. 4
Loamy alluvial land	1, 560	. 3
Parshall sandy loam, deep, 0 to 1 percent slopes	2, 468	0. 4
Parshall sandy loam, deep, 1 to 5 percent slopes	2, 265	. 4
Parshall sandy loam, deep, 5 to 9 percent slopes	232	(1)
Parshall sandy loam, moderately deep, 0 to 1 percent slopes	977	. 2
Parshall sandy loam, moderately deep, 1 to 5 percent slopes	995	. 2
Riverwash	524	. 1
Rock land	6, 799	1. 1
Rosebud loam, deep, 0 to 1 percent slopes	40, 462	6. 6
Rosebud loam, deep, 1 to 3 percent slopes	61, 982	10. 2
Rosebud loam, deep, 3 to 5 percent slopes	18, 578	3. 0
Rosebud loam, deep, 5 to 9 percent slopes	15, 423	2. 5
Rosebud loam, 9 to 15 percent slopes	5, 463	. 9
Rosebud loam, moderately deep, 0 to 1 percent slopes	23, 280	3. 8
Rosebud loam, moderately deep, 1 to 3 percent slopes	49, 233	8. 1
Rosebud loam, moderately deep, 3 to 5 percent slopes	27, 410	4. 5
Rosebud loam, moderately deep, 5 to 9 percent slopes	31, 060	5. 1
Sandy alluvial land	8, 488	1. 4
Scott silt loam	1, 869	. 3
Tripp fine sandy loam, 0 to 1 percent slopes	1, 357	. 2
Tripp fine sandy loam, 1 to 3 percent slopes	1, 165	. 2
Tripp fine sandy loam, 3 to 5 percent slopes	308	. 1
Tripp loam, 0 to 1 percent slopes	21, 212	3. 5
Tripp loam, 1 to 3 percent slopes	6, 428	1. 1
Tripp loam, 3 to 5 percent slopes	632	. 1
Tripp loam, 5 to 9 percent slopes	209	(1)
Vebar sandy loam, 0 to 3 percent slopes	5, 156	. 8
Vebar sandy loam, 3 to 5 percent slopes	4, 694	. 8
Vebar sandy loam, 5 to 9 percent slopes	7, 953	1. 3
Vebar sandy loam, 9 to 15 percent slopes	2, 654	. 4
Wet alluvial land	941	. 2
Water	363	. 1
Intermittent water	310	. 1
Mines and pits	37	(1)
Total	609, 920	100. 0

[1] Less than 0.1 percent.

Munsell notations, are used by soil scientists to designate the color of a soil precisely. They are described in the "Soil Survey Manual" (*9*).[1] For the profiles described in this report, color names and color symbols are given for both dry and moist soils.

The *structure* of a soil horizon depends on the way the individual soil particles are arranged in larger grains, or aggregates, and on the amount of pore space between the grains. The structure of the soil is described by names that indicate the distinctness, the size, and the shape of the aggregates. For example, a horizon with *weak, fine, blocky structure* has structure that is not distinct and is made up of small aggregates that have a blocky shape.

Consistence is described by terms that indicate how well the soil particles stick toegther or how easily the soil material can be molded or broken. Consistence may be given for a horizon when it is dry, moist, or wet. In this report, terms of consistence are generally given for layers when they are moist and when they are dry; for example, the subsoil in the typical profile of Parshall sandy loam is *very friable when moist, soft when dry.*

The boundaries between horizons are described to indicate their thickness and shape. The terms for thickness are (1) *abrupt*, if less than 1 inch thick; (2) *clear*, if about 1 to 2½ inches thick; (3) *gradual*, if 2½ to 5 inches thick; and (4) *diffuse*, if more than 5 inches thick. The shape of a boundary is described as *smooth, wavy, irregular*, or *broken.*

Some of the foregoing soil terms and others are defined in the Glossary of this report, and all are described in the "Soil Survey Manual" (*9*).

Altvan series

In the Altvan series are deep and moderately deep loamy soils on uplands. These soils have developed in loamy material that contains some silty material in the upper part.

The surface soil of these soils is grayish-brown loam. It has a weak, blocky structure that may break to weak, very fine granules under cultivation. This layer is about

[1] Italic numbers in parentheses refer to Literature Cited, page 72.

592765—62——2

neutral in reaction. It contains coarse gravel in places. It is friable when moist and is easily tilled. The surface soil combined with the subsurface soil is 6 to 12 inches thick.

The subsoil extends to a depth between 20 and 40 inches or more. It is brown to grayish-brown clay loam that, in some places, contains coarse sand and gravel. Weak, coarse prisms that break into weak blocks make up the structure. The reaction is normally neutral, but the lower part of the subsoil contains lime in some places. The subsoil is firm when moist and hard when dry. Gravel and coarse sandy material are at a depth ranging from 20 to 40 inches.

The Altvan soils are more sandy than the Keith soils and are underlain by sand and gravel at a shallower depth. They are more sandy and less limy than the Rosebud soils.

The Altvan soils developed under short and mid grasses, mainly blue grama, western wheatgrass, needle-and-thread, and threadleaf sedge. These soils are well drained. Runoff is slow to moderate, and permeability is moderate.

Typical profile: A moderately deep phase of Altvan loam in a cultivated field (*location* 500 feet north and 100 feet east of the SW. corner of sec. 29, T. 16 N., R. 57 W.):

Surface soil—
A_{1p} 0 to 6 inches, grayish-brown (10YR 5/2) loam; very dark grayish brown (10YR 3/2) when moist; weak, very fine, granular structure; friable when moist, soft when dry; about neutral reaction; abrupt, smooth boundary.

Subsurface soil—
A_{12} 6 to 10 inches, grayish-brown (10YR 5/2) loam; very dark grayish brown (10YR 3/2) when moist; weak, medium, subangular blocky structure; friable when moist, soft when dry; neutral; clear, smooth boundary.

Subsoil—
B_1 10 to 15 inches, brown (10YR 5/3) heavy loam; dark brown (10YR 3/3) when moist; weak, medium prisms breaking to weak, medium, subangular blocky structure; firm when moist, hard when dry; patchy clay skins on faces of peds; numerous fine pores; neutral; clear, smooth boundary.

B_2 15 to 24 inches, light brownish-gray (10YR 6/2) clay loam; dark grayish brown (10YR 4/2) when moist; weak, coarse prisms breaking to moderate, medium, blocky structure; firm when moist, hard when dry; nearly continuous clay skins on ped faces; numerous fine pores; neutral; clear, wavy boundary.

Substratum—
C_{ca} 24 to 30 inches, very pale brown (10YR 7/3) loam; pale brown (10YR 6/3) when moist; weak, coarse, subangular blocky structure; firm when moist, soft when dry; medium and fine granitic and quartz pebbles make up about 15 percent of horizon; lower sides of pebbles are coated with lime; lime in root channels and on faces of peds; gradual, wavy boundary.

D 30 to 48 inches +, pale-brown (10YR 6/3) gravelly coarse sandy loam or loamy sand; brown (10YR 5/3) when moist; structureless; calcareous.

The texture of the surface soil ranges from fine sandy loam to loam. The depth to gravel ranges from 20 to 50 inches. Where the soils are shallow over gravel, most of the fine material is in the solum and the accumulation of carbonate is in the gravel. Where the soils are deep, there is a B_{ca} horizon in the profile and the C_{ca} horizon is above the gravel. The texture in the B horizon is loam or clay loam in most places.

Altvan fine sandy loam, deep, 1 to 3 percent slopes (AfAW).—This soil has a slightly sandier surface soil than that in the profile described as typical of the Altvan series. The depth to gravel is more than 36 inches. Although wheat is the principal crop, this soil is suited to all crops grown in the county. If this soil is cultivated, controlling erosion and conserving moisture are the main problems of management. Capability unit IIIe-3 (dryland); Sandy range site; Sandy woodland site.

Altvan loam, deep, 0 to 1 percent slopes (Aa).—This soil is underlain by gravel at a depth of more than 36 inches (fig. 13). It is suited to all crops grown in the county.

***Figure 13.*—Profile of Altvan loam, deep, 0 to 1 percent slopes.**

Wheat is the principal dryland crop. If this soil is cultivated, controlling erosion and conserving moisture are the main problems of management. Capability unit IIIc-1 (dryland); Silty range site; Silty to Clayey woodland site. In the Keith-Rosebud association (see General Soil Map), this soil is in capability unit IIc-1 (dryland) because of the more favorable climatic conditions.

Altvan loam, deep, 1 to 3 percent slopes (AaAW).—Much of this soil is in cultivated crops. Conserving moisture and controlling erosion are the main problems of management. Capability unit IIIe-1 (dryland); Silty range site; Silty to Clayey woodland site. This soil is in capability unit IIe-1 (dryland) in the Keith-Rosebud association because of the more favorable climatic conditions.

Altvan loam, deep, 3 to 5 percent slopes (AaBW).—Most of this soil is cultivated. Wheat is the principal dryland crop. The main problems of management are conserving moisture and controlling erosion. Capability unit IIIe-1 (dryland); Silty range site; Silty to Clayey woodland site.

Altvan loam, deep, 5 to 9 percent slopes (AaCW).—This soil is slightly thinner in the surface soil than the soil described as typical of the Altvan series. Because of its strong slopes, this soil is not well suited to row crops. Wheat is the principal dryland crop. Capability unit IVe-1 (dryland); Silty range site; Silty to Clayey woodland site.

Altvan loam, moderately deep, 1 to 3 percent slopes (3AAW).—The profile of this soil is like the one described as typical of the Altvan series (fig. 14). Because it is underlain by gravel and coarse sand at a depth less than 36 inches, this soil is somewhat droughty. Yields of crops may be less than normal in dry years. Conserving moisture and controlling erosion are the main problems of management. Capability unit IIIe-1 (dryland); Silty range site; Silty to Clayey woodland site.

Altvan loam, moderately deep, 3 to 5 percent slopes (3ABW).—This soil is somewhat droughty. It is underlain by gravel and coarse sand at a depth less than 36 inches. Conserving moisture and controlling erosion are the main problems of management. Capability unit IVe-1 (dryland); Silty range site; Silty to Clayey woodland site.

Altvan loam, moderately deep, 5 to 9 percent slopes (3ACW).—Because of its strong slopes, this soil is best suited to grass or trees. If moisture is conserved and erosion is controlled, small grains can be grown. Capability unit IVe-1 (dryland); Silty range site; Silty to Clayey woodland site.

Bayard series

The Bayard series consists of deep, limy, moderately sandy soils. These soils occur near the base of slopes, on fans, and in drainageways.

The surface soil is grayish-colored fine sandy loam with weak, fine and very fine, granular structure. It is slightly calcareous and very friable to friable. The surface soil combined with the subsurface soil is about 12 inches thick.

The subsoil is grayish-brown, very friable, fine sandy loam with weak, medium, blocky structure. It is calcareous and, in most places, contains a few limy rock fragments. It is 8 to 12 inches thick.

The parent material is massive, calcareous loamy fine sand and is lighter colored than the subsoil. It normally contains some limy fragments of rock and, in some places, is stratified with coarse sand and gravel.

The Bayard soils are in positions similar to those of the Bridgeport soils but are more sandy and less stable. Bayard soils contain more silt and clay than the Dwyer soils. They are less clayey than the Vebar soils, in which a B horizon has developed.

The Bayard soils formed under tall and short grasses, dominantly blue grama. They are well drained. Runoff is slow to moderate, and permeability is moderately rapid.

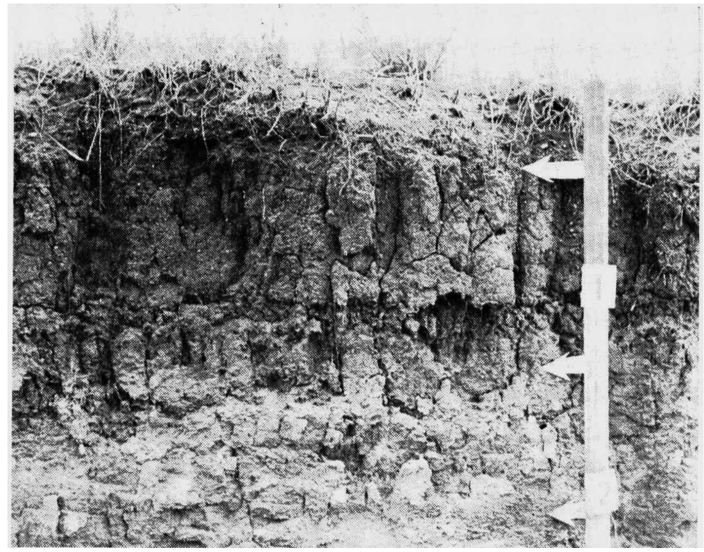

***Figure 14.*—Profile of Altvan loam, moderately deep, 1 to 3 percent slopes.**

Typical profile: A Bayard fine sandy loam in native grass (*location* 450 feet south and 1,050 feet west of the E¼ corner of sec. 9, T. 14 N., R. 58 W.):

Surface soil and subsurface soil—

A_{11} 0 to 3 inches, gray (10YR 5/1) fine sandy loam; very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; very friable when moist, loose when dry; abundant grass roots; slightly calcareous; abrupt boundary.

A_{12} 3 to 12 inches, grayish-brown (10YR 5/2) light fine sandy loam; very dark grayish brown (10YR 3/2) when moist; weak, fine and very fine, granular structure; friable when moist, soft and loose when dry; grass roots common; slightly calcareous; clear boundary.

Transition layer—

AC 12 to 22 inches, grayish-brown (10YR 5/2) light fine sandy loam or loamy fine sand; very dark grayish brown (10YR 3/2) when moist; weak, medium, subangular blocky structure; very friable when moist, soft to loose when dry; few grass roots; few limy rock fragments of gravel size; calcareous; strong effervescence; gradual boundary.

Substratum—

C_1 22 to 40 inches, light brownish-gray (10YR 6/2) loamy fine sand; dark grayish brown (10YR 4/2) when moist; massive (structureless) to weak, subangular blocky structure; very friable when moist, soft when dry; a few rock fragments and siliceous gravel; calcareous; violent effervescence; gradual boundary.

C_2 40 to 60 inches, very pale brown (10YR 7/3) loamy fine sand; pale brown (10YR 6/3) when moist; massive (structureless); very friable when moist, soft and loose when dry; many small fragments of Tertiary rock that washed from higher slopes; calcareous; violent effervescence.

Below the A horizon are coarse and moderately coarse textured materials stratified in thick layers. Bayard soils are soft and loose and lack genetic horizons below the A_1 horizon. They are calcareous at or near the surface in many places, but they may be leached to a depth between 1 and 2 feet where the parent materials are low in lime.

Only one soil in the Bayard series is mapped in Kimball County.

Bayard fine sandy loam, 1 to 5 percent slopes (BfBW).—If this soil is not protected, the surface soil blows away. This soil is suited to grass and to cultivated crops. Wheat is the principal dryland crop. Yields of other crops can be increased by irrigation. Conserving moisture and controlling erosion are the main problems of management. Capability units IIIe–3 (dryland) and IIIe–3 (irrigated); Sandy range site; Sandy woodland site.

Bridgeport series

In the Bridgeport series are deep, well-drained, calcareous loamy soils. These soils occur at the base of slopes and on alluvial fans in broad valleys.

The surface soil is dark grayish-brown, calcareous loam. It has weak, blocky or weak, granular structure. The surface soil combined with the subsurface soil ranges from 8 to 14 inches in thickness.

The parent material directly underlies the A horizon, for a B horizon has not developed. The parent material is grayish-brown to brown loamy material that is massive or has weak, blocky structure. At the base of slopes, the parent material is recently deposited colluvium and alluvium; in the broad valleys, it is alluvial material in fans. The parent material contains a high proportion of silt that washed from uplands mantled by loess. In many areas some sandier materials are included. The parent material and the soils are coarsely stratified. They may contain thin lenses or strata of fine sandy loam and a few to a thin sprinkling of rounded siliceous pebbles and angular calcareous fragments of rock.

The Bridgeport soils are about as dark colored as the Goshen soils. They are limy higher in the profile than the Goshen soils and are coarser textured in the subsoil. The Bridgeport soils are weaker in structure of the subsoil than the Tripp soils and generally are less deeply leached of lime. They do not have a well-defined C_{ca} horizon like that in the Tripp soils.

The Bridgeport soils developed under mid and short grasses, chiefly gramas, buffalograss, and a scattering of western wheatgrass. These soils have good surface runoff and good internal drainage. The content of phosphorus is low. Crop yields, especially in irrigated areas, can be increased by applying fertilizer. Add the fertilizer according to the needs of crops and the results of soil tests.

Typical profile: A Bridgeport loam in a cultivated field (*location* 900 feet north and 43 feet east of the SW. corner, sec. 35, T. 15 N., R. 55 W.):

Surface soil—

A_{1p} 0 to 7 inches, dark grayish-brown (10YR 4/2) loam; very dark grayish brown (10YR 3/2) when moist; weak, very fine, granular structure; very friable when moist, soft when dry; calcareous; slight effervescence; abrupt boundary.

Subsurface soil—

A_{12} 7 to 13 inches, dark grayish-brown (10YR 4/2) loam or silt loam; very dark grayish brown (10YR 3/2) when moist; weak, coarse, subangular blocky and weak, very fine, granular structure; very friable when moist, soft when dry; calcareous; slight effervescence; clear boundary.

Substratum—

C_1 13 to 28 inches, light brownish-gray (10YR 6/2) silt loam; dark grayish brown (10YR 4/2) when moist; weak, coarse, prismatic and weak, coarse, blocky structure; friable when moist, soft when dry; a few patches of thin clay skins on some ped faces; calcareous; moderate effervescence; clear boundary.

C_2 28 to 41 inches, light brownish-gray (10YR 6/2) light loam or fine sandy loam; dark grayish brown (10YR 4/2) when moist; massive (structureless); very friable when moist, soft when dry; few to common, small, calcareous fragments of Tertiary rock; violent effervescence; clear boundary.

C_3 41 to 46 inches, grayish-brown (10YR 5/2) loam or very fine sandy loam; very dark grayish brown (10YR 3/2) when moist; weak, medium, subangular blocky structure; friable when moist, soft when dry; few small fragments of rock; calcareous; some threads of lime in pores and channels; thin films on ped faces; violent effervescence; gradual, wavy boundary.

C_4 46 to 60 inches, pale-brown (10YR 6/3) heavy loam; brown (10YR 4/3) when moist; massive (structureless); friable when moist, soft when dry; calcareous; violent effervescence.

These soils vary in thickness, arrangement, and texture of the sedimentary layers and in thickness of the dark upper horizons.

Bridgeport loam, 1 to 3 percent slopes (BhA).—Most of this soil is cultivated. Wheat is the principal dryland crop. Some of the other crops grown are irrigated. Conserving moisture and controlling erosion are the main problems of management. Capability units IIIe–1 (dryland) and IIe–1 (irrigated); Silty range site; Silty to Clayey woodland site. Because of more favorable climatic conditions, this soil is in capability unit IIe–1 (dryland) in the Keith-Rosebud association.

Bridgeport loam, 3 to 5 percent slopes (BhB).—Most of this soil is cultivated. Wheat is the principal dryland crop. Conserving moisture and controlling erosion are the main problems of management. Capability units IIIe–1 (dryland) and IIIe–1 (irrigated); Silty range site; Silty to Clayey woodland site.

Canyon series

The Canyon series consists of very shallow and shallow loamy soils that overlie sandstone and limestone. These soils occur on high flats and along the sides of stream valleys where bedrock crops out or is near the surface.

The thin, grayish-brown surface soil is loamy and calcareous. It has a weak, granular structure. The subsurface soil is weak, blocky in structure and, in some places, contains more clay than the surface soil.

The parent material (C horizon) is slightly lighter colored than the surface soil. It is massive, limy loam that contains pieces of rock broken from the material below. It begins at a depth between 8 and 24 inches and is underlain by limy sandstone or caliche (fig. 15). The hard rock crops out in some places. In some areas, the stony substratum prevents deep penetration of water; in others, it is porous enough for water to penetrate easily.

The Canyon soils are about the same thickness as the Dix soils. They are less sandy than the Dix soils, which are underlain by gravel.

These soils developed under thin stands of grasses, mainly blue grama, side-oats grama, western wheatgrass, and needle-and-thread. They are well drained.

Typical profile: A Canyon sandy loam in a cultivated field (*location* 300 feet east and 140 feet north of the S¼ corner of sec. 27, T. 13 N., R. 56 W.):

Surface soil—

A_{1p} 0 to 4 inches, grayish-brown (10YR 5/2) sandy loam; dark brown (10YR 3/3) when moist; weak, fine, granular structure; soft when dry, very friable when moist; calcareous; strong effervescence; abrupt, smooth boundary.

Subsurface soil—

AC 4 to 9 inches, light brownish-gray (10YR 6/2) loam; dark grayish brown (10YR 4/2) when moist; weak, medium and coarse, subangular blocky structure; soft when dry, very friable when moist; strongly calcareous; violent effervescence; clear, smooth boundary.

Substratum—

C 9 to 16 inches, light brownish-gray (10YR 6/2) loam; brown (10YR 5/3) when moist; massive (structureless); slightly hard when dry, very friable when moist; strongly calcareous; violent effervescence; abrupt, wavy boundary.

D, 16 to 22 inches, pinkish-gray (7.5YR 7/2) to light-brown (7.5YR 6/4) moist, partially weathered Tertiary material consisting of many fragments of limestone in a sandy loam to loam matrix.

Fragments of limestone make up from 5 to 10 percent of the soil profile. The horizons vary in thickness. The depth to the D horizon ranges from 8 to 20 inches. In some places, the AC horizon is silt loam or silty clay loam and has a strong, blocky structure.

Canyon loam, 0 to 5 percent slopes (CcBW).—Because this soil is shallow over rock, it is best suited to grass. Capability unit VIs–4 (dryland); Shallow range site; Shallow woodland site.

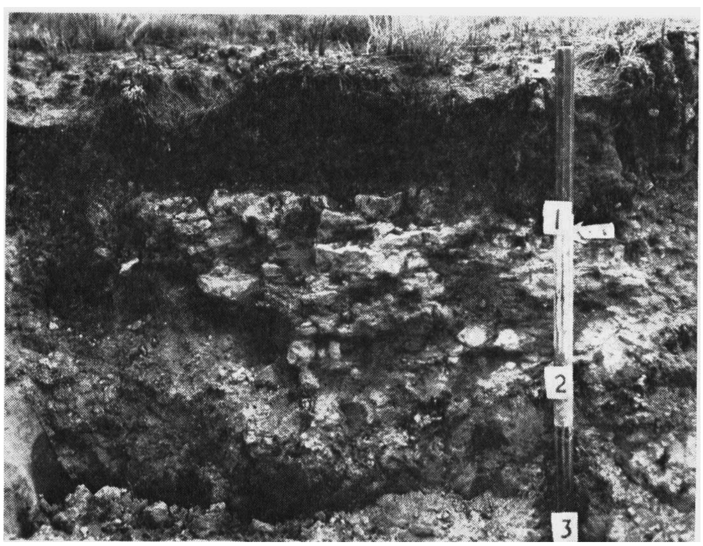

Figure 15.—**Profile of a Canyon sandy loam.**

Canyon loam, 0 to 5 percent slopes, eroded (CcB3).—Where it has been cultivated or overgrazed, this soil is severely eroded. Most of the surface soil has been removed. This soil is best suited to grass, but good stands may be difficult to establish. Capability unit VIs–4 (dryland); Shallow range site; Shallow woodland site.

Canyon loam, 9 to 20 percent slopes (CcD).—This soil is underlain by rock at a depth of about 12 inches. It is interspersed with many outcropping ledges and with small to large areas of nearly barren rock. These areas may be as much as an acre in size. Because it is shallow and rocky, this soil is best suited to grass. Capability unit VIs–4 (dryland); Shallow range site; Shallow woodland site.

Canyon sandy loam, 0 to 5 percent slopes (CnBW).—This soil contains more sand through the profile than the Canyon loams and is slightly shallower to bedrock. It is best suited to grass. Capability unit VIs–4 (dryland); Shallow range site; Shallow woodland site.

Canyon sandy loam, 9 to 20 percent slopes (CnD).—This soil is underlain by rock at a depth of about 12 inches. Intermingled with the soil are many ledges and large areas of nearly barren rock. This soil is best suited to grass. Capability unit VIs–4 (dryland); Shallow range site; Shallow woodland site.

Canyon complex, 0 to 9 percent slopes (C–C).—This complex is made up of about 50 percent bare rock and 50 percent Canyon soils. The soils are underlain by rock at a depth less than 10 inches. This complex occurs in small nearly level to sloping areas in the southern part of the county. There is very little permanent vegetation. Capability unit VIIs–3 (dryland); Very Shallow range site; the soil is not suited to trees.

Canyon complex, 9 to 20 percent slopes (C–D).—This complex occurs mainly on steep breaks and the sides of canyons. About 70 percent of the complex is bare rock. About 30 percent consists of very shallow Canyon soils with sparse vegetation. Capability unit VIIs–3 (dryland); Very Shallow range site; the soil is not suited to trees.

Canyon-Rosebud loams, 5 to 9 percent slopes (CRC).—About 50 percent of this complex is Canyon loams, 40 percent is Rosebud loams, and 10 percent is outcrops of bare rock. The rock and the soils occur in such an intricate pattern that they cannot be mapped separately. Because the soils are shallow or are strongly sloping, this complex is not suited to cultivation. Capability unit VIs–4 (dryland); Shallow range site; Shallow woodland site.

Canyon-Rosebud loams, 5 to 9 percent slopes, eroded (CRC3).—This complex is similar to Canyon-Rosebud loams, 5 to 9 percent slopes, but much of the surface soil has been removed. If it is cultivated, yields are low and the hazard of erosion is severe. This complex is best suited to grass. Capability unit VIs–4 (dryland); Shallow range site; Shallow woodland site.

Canyon-Vebar sandy loams, 5 to 9 percent slopes (CVC).—About 50 percent of this complex is Canyon sandy loams, 40 percent is Vebar sandy loams, and 10 percent is outcrops of bare rock. The soils and rock occur in such an intricate pattern that they cannot be mapped separately. Some cultivated areas are severely eroded. Because the soils are shallow or are strongly sloping, this complex is not suited to cultivation. Capability unit VIs–4 (dryland); Shallow range site; Shallow woodland site.

Chappell series

In the Chappell series are moderately deep, moderately sandy soils on uplands. These soils are underlain by gravel at a depth between 20 and 36 inches. They occur on convex slopes and hilltops in the gravelly areas north of Lodgepole Creek and in scattered areas in other parts of the county.

The surface soil of these soils is grayish-brown sandy loam. In undisturbed areas, the upper part has a weak, granular structure and the lower part has a weak, coarse, blocky structure. In cultivated fields, the upper part of the surface soil is loose and single grained in most places. The cropland has had about half of the surface soil removed by erosion. In most places, the surface soil combined with the subsurface soil is about a foot thick.

The subsoil is grayish-brown sandy clay loam and has weak, coarse, blocky structure. It is about a foot thick.

The parent material is massive, calcareous sandy clay loam a few inches thick over beds of gravel and sand.

The Chappell soils are more sandy than the Altvan or the Keith soils. They have a more weakly developed B horizon than the Altvan soils.

The Chappell soils have developed under a cover of mid and short grasses, mainly blue grama, needle-and-thread, and threadleaf sedge. These soils are well drained. Internal drainage is rapid but not excessive. The material in the upper part of the profile holds moisture fairly well.

Typical profile: A Chappell sandy loam in a moderately eroded cultivated field (*location* 200 feet east and 1,000 feet south of the W¼ corner of sec. 18, T. 16 N., R. 56 W.):

Surface soil—
- A_{1p} 0 to 3 inches, grayish-brown (10YR 5/2) sandy loam; dark grayish brown (10YR 4/2) when moist; loose; single grain (structureless); noncalcareous; abrupt, smooth boundary.
- A_{12} 3 to 6 inches, dark grayish-brown (10YR 4/2) sandy loam; very dark grayish brown (10YR 3/2) when moist; weak, coarse, subangular blocky structure; friable when moist, soft when dry; noncalcareous; abrupt, smooth boundary.

Subsoil—
- B_2 6 to 18 inches, grayish-brown (10YR 5/2) heavy sandy loam; dark grayish brown (10YR 4/2) when moist; weak, coarse, subangular blocky structure; friable when moist, soft when dry; noncalcareous; gradual, wavy boundary.

Substratum—
- C 18 to 27 inches, pale-brown (10YR 6/3) fine sandy loam; brown (10YR 5/3) when moist; massive (structureless); calcareous; strong effervescence; gradual, wavy boundary.
- D 27 inches +, granitic gravel and sand; clay in upper few inches.

The surface soil and subsoil may be slightly calcareous. The content of gravel varies. Noncoherent gravel occurs at a depth ranging from 20 to 36 inches. The clay in the upper few inches of the D horizon slows internal drainage.

Chappell sandy loam, 1 to 3 percent slopes (ChAW).—Most of this soil is in crops. In the cultivated areas, the surface soil is similar to that in the profile described as typical of the Chappell series. In areas that are still in native grass, the surface soil is about 12 inches thick and is granular in the upper part. The gravelly substratum limits the moisture-holding capacity of this soil, and crop yields depend on the amount of rainfall. Yields range from fair to good. Capability unit IVe-3 (dryland); Sandy range site; Sandy woodland site.

Chappell sandy loam, 3 to 5 percent slopes (ChBW).—This soil is susceptible to erosion and has a moisture-holding capacity reduced by a gravelly substratum. The soil is, therefore, best suited to grass if it is dry-farmed. Crops can be grown under irrigation. The water ought to be applied in smaller and more frequent amounts than on deeper soils. Capability unit VIe-3 (dryland); Sandy range site; Sandy woodland site.

Chappell sandy loam, 5 to 9 percent slopes (ChC).—Because it is susceptible to severe erosion and has a moderate available moisture-holding capacity, this soil is best suited to grass. If it is irrigated, it is suited to close-growing crops. Capability unit VIe-3 (dryland); Sandy range site; Sandy woodland site.

Cheyenne series

In the Cheyenne series are moderately deep, dark grayish-brown loamy soils on high stream terraces.

The surface soil of these soils is dark grayish-brown, noncalcareous loam. Its structure is weak and granular in the upper part and weak and blocky in the lower part. The surface soil is about 8 inches thick.

The subsoil is brownish-colored loam about 18 inches thick. It has a blocky structure and thin coatings of clay on some faces of the blocks. It is noncalcareous.

The parent materials are mainly old alluvium that washed in when an ancient stream was higher than the present stream. In some places, the parent materials of the upper horizons are made up of local wash and windblown materials that have mixed with the alluvium.

These soils are underlain by a substratum of coarse sand and gravel at a depth of 20 to 40 inches. This material is weakly calcareous.

The Cheyenne soils are at lower elevations than the Altvan soils and developed in younger materials. They are less oxidized than the Altvan soils.

Cheyenne soils developed under short and mid grasses, mainly blue grama, buffalograss, upland sedges, and needlegrass. These soils are well drained. The permeability is moderate in the profile and rapid to very rapid in the underlying gravel.

Typical profile: A Cheyenne loam in a cultivated field (*location* 410 feet west and 250 feet south of the NE. corner of sec. 33, T. 15 N., R. 56 W.):

Surface soil—
- A_{1p1} 0 to 3 inches, dark grayish-brown (10YR 4/2) loam; very dark brown (10YR 2/2) when moist; weak, fine, granular structure; friable when moist, soft when dry; contains a few small pebbles; noncalcareous; abrupt boundary.
- A_{1p2} 3 to 8 inches, dark grayish-brown (10YR 4/2) loam; very dark grayish brown (10YR 3/2) when moist; weak, coarse, blocky and weak, fine, granular structure; friable when moist, slightly hard when dry; common fine pores and root channels; a few small siliceous and granitic pebbles; noncalcareous; abrupt boundary.

Subsoil—
- B_1 8 to 13 inches, dark grayish-brown (10YR 4/2) loam; very dark grayish brown (10YR 3/2) when moist; weak, coarse, prismatic and weak, medium, subangular blocky structure; friable when moist, slightly hard when dry; thin patches of clay coatings on some ped faces; pores and root channels common; a few small siliceous and granitic pebbles; noncalcareous; clear boundary.
- B_2 13 to 25 inches, brown (10YR 5/3) heavy loam; dark brown (10YR 3/3) when moist; weak, coarse prisms separating easily to moderate, medium and fine, blocky structure; friable when moist, hard when dry; patchy to nearly continuous thin clay coatings on most ped faces and in channels and pores; a few small siliceous and granitic pebbles; noncalcareous except where a thin crust of lime is on the lower side of a few pebbles in lower 2 inches; clear boundary.

Substratum—
- D_{ca} 25 to 36 inches, brown (10YR 5/3) very gravelly loamy sand; dark brown (10YR 3/3) when moist; loose; little coherence either dry or moist; weakly calcareous, including thin lime crusts on the gravel.

The depth to the gravelly substratum ranges from 20 to about 40 inches. The B horizon is loam or heavy loam in most places, but in some places it is light clay loam or sandy clay loam. The D horizon consists of stratified and cross-bedded coarse sands, gravelly sands, and gravelly loamy sands. In some places, a thin transitional horizon of sandy loam is between the B and D horizons.

Cheyenne loam, 0 to 1 percent slopes (Cy).—This soil is suited to all crops grown in the county. Wheat is the main dryland crop. Conserving moisture and controlling wind erosion are the main problems of management. This soil is well suited to irrigation. Capability units IIIc–1 (dryland) and IIs–5 (irrigated); Silty range site; Silty to Clayey woodland site.

Cheyenne loam, 1 to 3 percent slopes (CyA).—This soil is suited to all crops grown in the county. It can be irrigated successfully. Conserving moisture and controlling erosion are the main problems of management. Capability units IIIe–1 (dryland) and IIe–1 (irrigated); Silty range site; Silty to Clayey woodland site.

Dix series

The Dix series consists of shallow, excessively drained, loamy soils that developed on upland slopes over coarse sand and gravel. The material overlying the coarse substratum consists of a mixture of silt, fine sand, some clay, and gravel. The gravel makes up 10 to 50 percent of this material. It is remnants of early Pleistocene terraces and alluvial fans. The finer materials have been blown in from adjacent areas of silty and sandy soils and have been reworked by the wind.

The surface layer of these soils is grayish-brown loam. It has a weak, granular structure and is neutral in reaction. It is about 4 inches thick.

Directly underlying the thin surface layer is a B horizon of brown sandy loam. This horizon has a weak, blocky structure. It is about 6 inches thick. The substratum, or parent material, is brown loamy coarse sand that is neutral in reaction. It is underlain by coarse sand and gravel at a depth of 10 to 18 inches.

The Dix soils are more sandy and more shallow than the Altvan soils. Soil development is to about the same depth in the Dix soils as in the Canyon soils. The Dix soils are more sandy than the Canyon soils. They are underlain by sand and gravel, but the Canyon soils are underlain by limestone or sandstone.

The Dix soils have developed under short and mid grasses, mainly blue grama, threadleaf sedge, and needle-and-thread. Runoff is moderate. Permeability is moderate in the solum and rapid in the substratum.

Typical profile: Dix loams, 3 to 9 percent slopes, in a pasture of native grass (*location* 0.25 mile south of the NW. corner of sec. 6, T. 15 N., R. 55 W.):

Surface soil and subsoil—

A_1 0 to 4 inches, grayish-brown (10YR 5/2) loam; very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; friable when moist, soft when dry; about neutral reaction; abrupt boundary.

B 4 to 9 inches, brown (7.5YR 4/2) sandy loam containing appreciable gravel; dark brown (7.5YR 3/2) when moist; moderate, medium, prismatic and weak, medium, subangular blocky structure; firm when moist, hard when dry, and sticky when wet; patchy clay coats and some dark stains on prism faces; neutral; clear boundary.

Substratum—

C 9 to 13 inches, brown (7.5YR 5/4) loamy coarse sand; brown (7.5YR 4/2) when moist; massive (structureless); coated grains of sand; friable when moist, slightly hard when dry; neutral; clear boundary.

D 13 to 20 inches +, brown (7.5YR 5/4) stratified coarse sand and gravel; brown (7.5YR 4/4) when moist; noncalcareous; 10 to 20 inches thick over calcareous gravelly sands.

In places all horizons are gravelly. The B horizon may be more yellowish brown than that described. A horizon of lime carbonate may occur in the gravelly D horizon, and broken sandstone may occur at a depth between 5 and 15 feet.

Dix loams, 3 to 9 percent slopes (DxC).—These soils have surface soils that range from loam to sandy loam (fig. 16). Because they are shallow over gravel, these

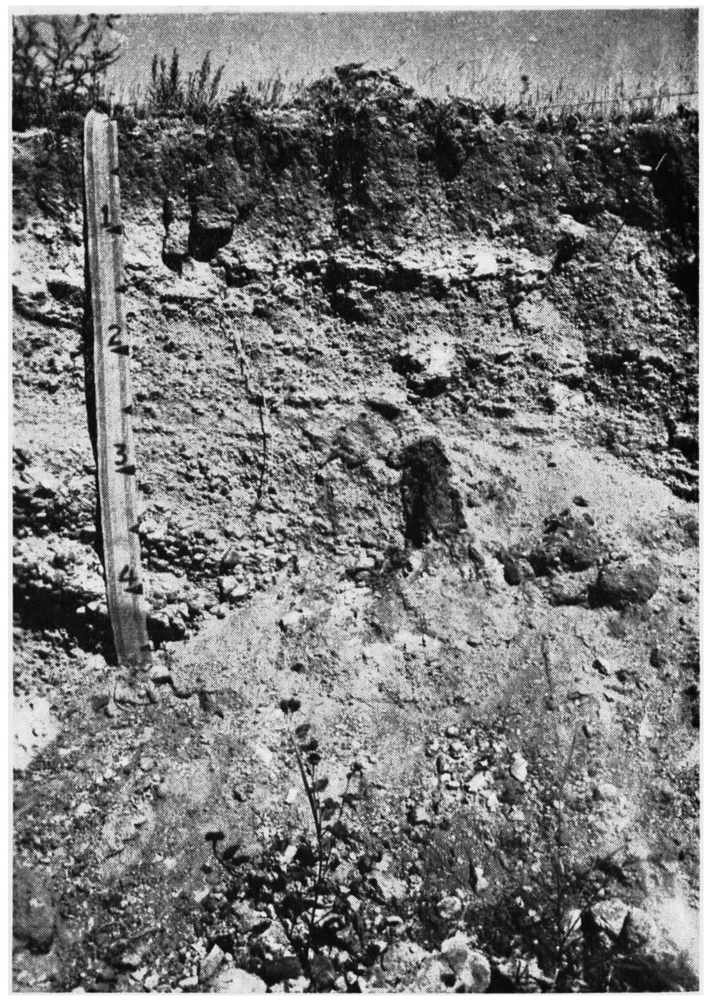

Figure 16.—**Profile of Dix loams, 3 to 9 percent slopes. The light-colored horizon is loosely cemented with lime at a depth ranging from 14 to 18 inches.**

soils are best suited to grass. Capability unit VIs–4 (dryland); Shallow range site; Shallow woodland site.

Dix complex, 9 to 20 percent slopes (DxD).—The soils in this complex have surface soils that range from loam to gravelly sandy loam. Gravel spots that have no soil development make up about 40 percent of this complex. The grass cover is moderate to sparse. This complex is not suited to cultivation. Capability unit VIs–4 (dryland); Shallow range site; Shallow woodland site.

Dwyer series

In the Dwyer series are light-colored, very sandy, limy soils. These soils are on the terraces and the valley sides of main streams, chiefly along Lodgepole Creek. They occur in hummocky areas and, in places, in dune-like areas.

The Dwyer soils have had very little soil development. The thin surface layer has been slightly darkened by organic matter. It is 3 or 4 inches thick. These soils are limy, but the lime may be at a depth of 3 feet in the sandiest areas.

Dwyer soils are more sandy than the Parshall soils and have more weakly developed horizons. Lime, however, is higher in the profile in the Dwyer soils than in the Parshall soils.

The Dwyer soils developed under mixed grass, mainly prairie sandreed, sand bluestem, little bluestem, and needle-and-thread. Permeability is rapid. Because the available water-holding capacity is low, these soils are droughty. They are very susceptible to wind erosion unless protected.

Typical profile: Dwyer loamy sand in a cultivated field (*location* 600 feet north of the W¼ corner of sec. 11, T. 14 N., R. 58 W.):

Surface layer—

A_p 0 to 3 inches, light brownish-gray (10YR 6/2) loamy sand; dark grayish brown (10YR 4/2) when moist; single grain (structureless); friable when moist, loose when dry; few, small, siliceous pebbles; calcareous; strong effervescence; abrupt boundary.

Substratum—

C_1 3 to 23 inches, pale-brown (10YR 6/3) loamy sand; brown (10YR 5/3) when moist; single grain (structureless); very friable when moist, loose when dry; contains a few pebbles; calcareous; violent effervescence; clear boundary.

C_2 23 to 48 inches, very pale brown (10YR 7/3) loamy fine sand; brown (10YR 5/3) when moist; single grain (structureless); friable when moist, loose when dry; a few more pebbles than in horizon above; calcareous; violent effervescence; clear boundary.

D 48 inches +, loose, calcareous sand-and-gravel alluvium.

The texture of the upper part of the profile ranges from loamy sand to sand. The gravelly layer (D horizon) may be absent or may be at a depth of 5 feet or more. In places below a depth of 4 or 5 feet, the soils are underlain by stratified alluvium and Tertiary bedrock.

Only one soil of the Dwyer series is mapped in Kimball County.

Dwyer loamy sand (Dy).—Most of this soil is on slopes less than 3 percent. Because it is sandy and is low in available water-holding capacity, this soil is best suited to sorghum. It does not hold enough moisture to make summer fallow practical. If irrigated by sprinklers, this soil is suited to close-growing crops. It is very susceptible to wind erosion. Capability unit IVe–5 (dryland); Sands range site; Sandy woodland site.

Glendive series

In the Glendive series are deep, loamy soils on bottom lands. The profiles of these soils are uniform in texture.

The surface soil has weak, granular to weak, blocky structure. It is very friable and easily tilled. The surface soil combined with the subsurface soil is about 10 inches thick.

No B horizon has developed. The substratum is light-colored alluvium of fine sandy loam texture. In some places layers of gravel or buried soils occur below a depth of 3 feet.

The Glendive soils have developed in more recently deposited materials than the Parshall soils and occupy lower, more frequently flooded positions.

The native vegetation consists mainly of needle-and-thread, prairie sandreed, western wheatgrass, and little bluestem. The soils are moderately well drained and and moderately permeable. Although these soils may be flooded by high water, the water table is normally below a depth of 8 feet.

Typical profile: Glendive fine sandy loam in a pasture of native grass (*location* 400 feet south of the NW. corner of sec. 26, T. 15 N., R. 55 W.):

Surface soil and subsurface soil—

A_1 0 to 3 inches, grayish-brown (10YR 5/2) fine sandy loam; very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; very friable when moist, soft when dry; noncalcareous; abrupt, smooth boundary.

A_{12} 3 to 9 inches, grayish-brown (10YR 5/2) fine sandy loam; dark grayish brown (10YR 4/2) when moist; weak, coarse, subangular blocky structure; very friable when moist, soft when dry; noncalcareous; smooth boundary.

Substratum—

C_1 9 to 24 inches, light brownish-gray (10YR 6/2) fine sandy loam; grayish brown (10YR 5/2) when moist; massive (structureless); very friable when moist, soft when dry; calcareous; violent effervescence; clear, smooth boundary.

C_2 24 to 34 inches, grayish-brown (10YR 5/2) fine sandy loam; very dark grayish brown (10YR 3/2) when moist; weak, medium, subangular blocky structure; friable when moist, slightly hard when dry; calcareous; strong effervescence; gradual, wavy boundary.

C_3 34 to 46 inches, pale-brown (10YR 6/3) fine sandy loam; brown (10YR 5/3) when moist; massive (structureless); friable when moist, soft when dry; calcareous; violent effervescence; gradual, wavy boundary.

C_4 46 to 54 inches +, very pale brown (10YR 7/3) sandy loam; brown (10YR 5/3) when moist; loose; single grain (structureless); calcareous; violent effervescence.

The surface soil ranges from light very fine sandy loam to sandy loam. Lime occurs at or near the surface. Gravel is at a depth of 36 to 60 inches or more. Buried soils occur in some places.

Glendive fine sandy loam (Gd).—This soil is nearly level. It is suited to all crops grown in the county but is likely to be flooded at times. Conserving moisture and controlling wind erosion are the main problems of management. Capability units IIIe–3 (dryland) and IIe–3 (irrigated); Sandy range site; Sandy woodland site.

Goshen series

In the Goshen series are deep, dark-colored soils on uplands. These soils are loam in texture to a depth of about 25 inches. At this depth and extending to the substratum, the texture is silty clay loam. These soils have developed in loessal material on uplands. They are in swales and depressions, on broad flats, and in silty alluvium in narrow drains. The silty alluvium was probably loess before it was transported by water. The Goshen soils receive runoff from adjoining areas.

The surface soil is dark-colored loam. It has a weak, granular to a weak, blocky structure and is noncalcareous and friable. The surface soil combined with the subsurface soil is 12 to 18 inches thick.

The subsoil is dark colored and contains more clay than the surface soil. It has a blocky structure and is noncalcareous. Roots penetrate the subsoil easily.

The loessal material extends to a depth of several feet. It is massive and friable and, in some places, contains lime and small bits of broken rock.

The Goshen soils normally occur on more gentle slopes than the Keith soils and have much thicker A and B horizons. Their loessal material extends to a greater depth than in the Keith soils. The Goshen soils are more silty than the Rosebud soils and have thicker horizons.

These soils developed under grass, mainly buffalograss, western wheatgrass, and gramas. They are well drained and are high in natural fertility. Because these soils receive moisture from other areas, crop yields are among the highest in the county. During wet periods, wheat may grow too fast and may lodge before it is harvested.

Typical profile: Goshen loam in a cultivated field (*location* 1,050 feet south and 120 feet east of the NW. corner of sec. 13, T. 16 N., R. 56 W.):

Surface soil—

A_{1p} 0 to 7 inches, grayish-brown (10YR 5/2) loam; very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; friable when moist, soft when dry; contains a few small rounded pebbles; noncalcareous; abrupt boundary.

Subsurface soil—

A_{12} 7 to 18 inches, very dark grayish-brown (10YR 3/2) loam; very dark brown (10YR 2/2) when moist; weak, coarse, blocky and weak, fine and medium, granular structure; friable when moist, soft when dry; many fine pores, fine roots, and root channels; a few small pebbles; noncalcareous; abrupt boundary.

Subsoil—

B_{21} 18 to 27 inches, dark grayish-brown (10YR 4/2) heavy loam; very dark brown (10YR 2/2) when moist; weak, coarse, prismatic and moderate, medium, subangular blocky structure; firm when moist, slightly hard when dry; nearly continuous thin clay films on most ped faces; many fine pores, roots, and root channels; noncalcareous; clear boundary.

B_{22} 27 to 35 inches, grayish-brown (10YR 5/2) light silty clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, medium and fine, blocky structure; firm when moist, slightly hard when dry; nearly continuous thin to moderate clay films on most ped faces; common fine roots, root channels, and pores; noncalcareous; clear boundary.

B_{23} 35 to 50 inches, grayish-brown (10YR 5/2) silty clay loam; very dark grayish brown (10YR 3/2) when moist; weak, coarse, subangular blocky and moderate, medium and fine, subangular blocky structure; firm when moist, slightly hard when dry; patchy to nearly continuous thin clay films on most ped faces; few fine roots and common fine pores and root channels; noncalcareous; clear boundary.

Substratum—

C 50 to 60 inches, pale-brown (10YR 6/3) silt loam; brown (10YR 4/3) when moist; massive (structureless); friable when moist, soft when dry; no roots; noncalcareous.

The subsoil ranges from 16 to 30 inches in thickness. The content of clay varies slightly. In some places, calcium carbonate occurs at a depth of more than 24 inches. Some small bits of broken rock may occur at a depth of more than 36 inches.

Goshen loam, 0 to 1 percent slopes (Go).—This soil is well suited to all crops grown in the county. Capability unit IIc-1 (dryland); Silty range site; Silty to Clayey woodland site.

Goshen loam, 1 to 3 percent slopes (GoA).—This soil occurs on foot slopes and on gently sloping sides of narrow valleys. Conserving moisture and controlling erosion are the main problems of management. Capability unit IIIe-1 (dryland); Silty range site; Silty to Clayey woodland site. This soil is in capability unit IIe-1 (dryland) in the Keith-Rosebud association (see General Soil Map) because of the more favorable climatic conditions.

Gravelly land

About 60 percent of this land type consists of gravel ridges and breaks that have a thin gravelly surface soil, and about 40 percent consists of soils that are very shallow over gravel. Gravelly land occurs as eroded remnants and deeply gullied edges of old high fans on uplands or stream terraces (fig. 17).

In some places, the upper few inches of gravel are darkened by organic matter. The gravel contains enough silt and clay to be slightly sticky when wet. Because surface runoff is moderate and internal drainage is rapid, Gravelly land is droughty. Production of native grasses is low.

Gravelly land (Gv).—This land type is on nearly level to steep slopes. Capability unit VIIs-3 (dryland); Very Shallow range site; this land type is not suited to trees.

Havre series

The Havre series consists of moderately dark colored, calcareous, loamy soils that are at high levels on the flood plains along large streams. These soils have formed in dominantly medium-textured alluvium. Although they are at high levels, they are likely to be flooded at least once a year.

The soils are fairly uniform in texture in the solum, generally ranging from silt loam to very fine sandy loam. They have moderate, granular to weak, blocky structure and are calcareous. Because of organic staining, the upper foot of this soil is slightly darker than the lower part. Layers of coarse sand or gravel normally occur below a depth of 3 or 4 feet.

Figure 17.—**Gravelly land that occurs as ridges and moderately steep to steep edges of old stream terraces and fans on uplands.**

The Havre soils are slightly lighter colored and more sandy than the Tripp soils. Their horizons are not so distinct as those in the Tripp soils.

The native vegetation is mixed grasses, mainly blue grama, western wheatgrass, needle-and-thread, and side-oats grama. Woody shrubs and broad-leaved trees are dominant in some areas. Surface drainage is moderate. These soils are moderately well drained to well drained.

Typical profile: Havre silt loam in a cultivated field (*location* 60 feet north and 70 feet east of the SW. corner of sec. 20, T. 15 N., R. 55 W.):

Surface soil and subsurface soil—
- A_{1p} 0 to 3 inches, grayish-brown (10YR 5/2) silt loam; very dark grayish brown (10YR 3/2) when moist; weak, fine, crumb structure; very friable when moist, soft when dry; slightly calcareous; slight effervescence; abrupt boundary.
- A_{12} 3 to 13 inches, grayish-brown (10YR 5/2) silt loam; very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular structure; very friable when moist, soft when dry; worm burrows, root channels, and pores common; calcareous; weak effervescence; clear boundary.

Transition layer—
- AC 13 to 20 inches, light brownish-gray (10YR 6/2) very fine sandy loam; very dark grayish brown (10YR 3/2 when moist; moderate, medium, granular structure; very friable when moist, soft when dry; worm burrows, root channels, and pores common; calcareous; weak effervescence; clear boundary.

Substratum—
- C_1 20 to 32 inches, pale-brown (10YR 6/3) very fine sandy loam; dark grayish brown (10YR 4/2) when moist; weak, coarse, subangular blocky and weak, crumb structure; very friable when moist, soft when dry; worm burrows and root channels few to common; a few lime-filled fine pores and root channels; calcareous; violent effervescence; clear boundary.
- C_2 32 to 48 inches, grayish-brown (10YR 5/2) light loam; very dark grayish brown (10YR 3/2) when moist; massive (structureless); very friable when moist, soft when dry; a light sprinkling of small pebbles; little observable biological activity; calcareous; strong effervescence; gradual boundary.
- C_3 48 to 55 inches, grayish-brown (10YR 5/2) loamy coarse sand; very dark grayish brown (10YR 3/2) when moist; single grain (structureless); loose when dry and moist; few to common small pebbles; calcareous; slight effervescence; gradual boundary.
- D 55 to 60 inches, clean coarse sand and gravel.

These soils may vary slightly in color, texture, and depth because of variations in the stream deposits. They also vary in the degree of organic staining below the upper one or two soil horizons. In places buried profiles occur. These profiles may have a darker A horizon than the one described.

Havre silt loam (He).—This soil is nearly level. It produces good yields of wheat under dryland farming and good yields of all crops under irrigation. Under dryland farming, this soil may become droughty near the end of the growing season. Under irrigation, it has a storage capacity of about 6 inches of available water in the upper 3 feet. Because this soil normally does not need drainage, it is one of the best soils on bottom lands in the county for irrigation. Capability units IIc–1 (dryland) and I–1 (irrigated); Silty range site; Silty to Clayey woodland site.

Keith series

In the Keith series are deep, dark-colored, loamy soils with a clayey subsoil. They occur on gently undulating uplands that are covered by loess.

The surface soil is grayish-brown loam with a granular to blocky structure. It is very friable and easily tilled. The surface soil combined with the subsurface soil is about 10 inches thick.

The subsoil is lighter colored than the surface soil and contains more clay. It is heavy silt loam to silty clay loam, about 18 inches thick. Its structure is blocky.

These soils have developed in loess, 3 or 4 feet thick over sandy material. In places the sandy material may be mixed with the silty material.

The Keith soils are less sandy through the profile than the Rosebud soils, and they do not contain rock fragments. The Keith soils contain slightly more clay in the subsoil than the Tripp soils, which are on terraces instead of uplands.

These soils have developed under a grass vegetation, mainly western wheatgrass, blue grama, needle-and-thread, and side-oats grama. They are well drained and moderately permeable.

Typical profile: A Keith loam in a cultivated field (*location* 1,320 feet south and 30 feet west of the NE. corner of sec. 16, T. 16 N., R. 54 W.):

Surface soil—
- A_{1p} 0 to 5 inches, grayish-brown (10YR 5/2) loam; very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; noncalcareous; abrupt, smooth boundary.
- A_{12} 5 to 7 inches, grayish-brown (10YR 5/2) silt loam; very dark grayish brown (10YR 3/2) when moist; weak, coarse, subangular blocky structure; soft when dry, very friable when moist; noncalcareous; abrupt, smooth boundary.

Subsoil—
- B_1 7 to 10 inches, grayish-brown (10YR 5/2) heavy silt loam; dark brown (10YR 3/3) when moist; compound, weak, coarse, subangular blocky and weak, medium, subangular blocky structure; slightly hard when dry, friable when moist; broken clay films on faces of peds; noncalcareous; clear, smooth boundary.
- B_{21} 10 to 18 inches, light brownish-gray (10YR 6/2) silty clay loam; dark brown (10YR 3/3) when moist; compound, weak, coarse, prismatic and moderate, fine and medium, subangular blocky structure; hard when dry, firm when moist; continuous clay films on faces of peds; noncalcareous; clear, smooth boundary.
- B_{22} 18 to 23 inches, light brownish-gray (10YR 6/2) light silty clay loam; dark brown (10YR 4/3) when moist; compound, weak, coarse, prismatic and moderate, medium, subangular blocky structure; hard when dry, firm when moist; broken clay films on faces of peds; noncalcareous; abrupt, smooth boundary.

Substratum—
- C_{1ca} 23 to 32 inches, light-gray (10YR 7/2) silt loam; pale brown (10YR 6/3) when moist; compound, weak, coarse, prismatic and weak, medium, subangular blocky structure; slightly hard when dry, very friable when moist; calcareous; disseminated lime in root channels and on ped faces; violent effervescence; gradual, smooth boundary.
- C_2 32 to 40 inches, light-gray (10YR 7/2) silt loam; brown (10YR 5/3) when moist; weak, coarse, prismatic structure; slightly hard when dry, very friable when moist; calcareous; violent effervescence; clear, smooth boundary.
- C_3 40 to 57 inches, light-gray (10YR 7/2) very fine sandy loam; pale brown (10YR 6/3) when moist; weak, coarse, prismatic structure to massive (structureless); soft when dry, very friable when moist; calcareous; violent effervescence; some pockets of fine gravel; abrupt, smooth boundary.
- C_4 57 to 64 inches, very pale brown (10YR 7/3) loamy sand; brown (10YR 5/3) when moist; massive (structureless); loose; calcareous; strong effervescence.

The surface soil ranges from 6 to 12 inches in thickness and from silt loam to loam in texture. In some places the clay films on the peds are very faint. A few pebbles may be scattered through the profile. The material below a depth of 60 inches may be rock or gravel.

Keith loam, 0 to 1 percent slopes (Ke).—This soil is well suited to cultivated crops and to grasses. Capability unit IIIc–1 (dryland); Silty range site; Silty to Clayey woodland site. This soil is in capability unit IIc–1 (dryland) in the Keith-Rosebud association (see General Soil Map) because of more favorable climatic conditions.

Keith loam, 1 to 3 percent slopes (KeAW).—Although this soil is susceptible to erosion, it is well suited to cultivated crops and to grasses. Capability unit IIIe–1 (dryland); Silty range site; Silty to Clayey woodland site. This soil is in capability unit IIe–1 (dryland) in the Keith-Rosebud association because of more favorable climatic conditions.

Keith loam, 3 to 5 percent slopes (KeBW).—Except that its surface layers (A horizon) are about 8 inches thick, this soil has a profile similar to the one described as typical of the Keith series. It is susceptible to water and wind erosion. Capability unit IIIe–1 (dryland); Silty range site; Silty to Clayey woodland site.

Loamy alluvial land

This land type consists of alluvial materials and poorly developed soils that could not be mapped separately. Most of the soils are silty to sandy in texture. Some soils are stratified or contain buried soils. The content of lime in the soils of this land type ranges from low to high.

This land type occurs on the frequently flooded bottom lands of the principal streams. Because soil material is washed in or is washed away by each overflow, the texture of the surface layer changes frequently.

Loamy alluvial land (Lx).—This land type is not suited to cultivation. It is best suited to grasses and to water-tolerant trees. Capability unit VIw–2 (dryland); Overflow range site; Moderately Wet woodland site.

Parshall series

The Parshall series consists of moderately dark colored loamy soils that occur on stream terraces.

The surface soil of these soils is loamy and has a weak, granular or weak, blocky structure. It is very friable and easily cultivated, but the soil material blows away readily. The surface soil combined with the subsurface soil is about a foot thick.

The subsoil is sandy loam that is slightly lighter colored and slightly browner than the surface soil. It has a weak, blocky structure and is slightly calcareous. It is about a foot thick.

The parent material is calcareous loamy to sandy alluvium. In some places, the alluvium is stratified.

The Parshall soils are more sandy than the Cheyenne soils, which are underlain by loose gravel. They are much more sandy than the Tripp soils. They are in higher and better drained positions than the Glendive soils and have developed in older, more uniform materials than those soils.

The native vegetation is mid and short grasses, mainly needle-and-thread, sandreed, blue grama, and threadleaf sedge. These soils are well drained. Runoff is slow, and internal drainage is medium to rapid.

Typical profile: A Parshall sandy loam in a cultivated field (*location* 530 feet north of the W¼ corner of sec. 25, T. 15 N., R. 55 W.):

Surface Soil—

A_{1p} 0 to 8 inches, grayish-brown (10YR 5/2) sandy loam; very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; very friable when moist, soft when dry; neutral; abrupt boundary.

Subsurface soil—

A_{12} 8 to 11 inches, grayish-brown (10YR 5/2) fine sandy loam; very dark grayish brown (10YR 3/2) when moist; weak, medium, blocky and weak, fine, granular structure; very friable when moist, soft when dry; few small pebbles; neutral; clear boundary.

Subsoil—

B_{21} 11 to 14 inches, grayish-brown (10YR 5/2) heavy sandy loam; very dark grayish brown (10YR 3/2) when moist; weak, coarse, prismatic and coarse, blocky structure that crushes to weak crumblike, porous clusters of sand grains weakly held together by clay and silt; very friable when moist, soft when dry; neutral; clear boundary.

B_{22} 14 to 24 inches, brown (10YR 5/3) sandy loam; dark grayish brown (10YR 4/2) when moist; weak, coarse, prismatic and coarse, blocky structure that crushes to weak crumblike porous clusters of sand grains weakly held together by clay and silt; very friable when moist, soft when dry; slightly alkaline; gradual boundary.

Substratum—

C_{ca1} 24 to 32 inches, brown (10YR 5/3) sandy loam; dark grayish brown (10YR 4/2) when moist; weak, medium, subangular blocky structure; very friable when moist, soft when dry; thin coating of lime on some ped faces and in pores and root channels; slight effervescence of soil matrix; gradual boundary.

Parshall sandy loam, deep, 0 to 1 percent slopes (Pn).—Although it is susceptible to wind erosion, this soil is suited to crops as well as to grasses. Capability units IIIe–3 (dryland) and IIe–3 (irrigated); Sandy range site; Sandy woodland site.

Parshall sandy loam, deep, 1 to 5 percent slopes (PnBW).—This soil is gently sloping to sloping. In some areas the surface soil is slightly lighter colored than that in the profile described as typical of the Parshall series. Capability units IIIe–3 (dryland) and IIIe–3 (irrigated); Sandy range site; Sandy woodland site.

Parshall sandy loam, deep, 5 to 9 percent slopes (PnCW).—Most of this soil has a slightly lighter colored surface soil than that in the profile described as typical of the Parshall series. Because of moderately steep slopes, this soil is susceptible to severe erosion. Capability units IVe–3 (dryland) and IVe–3 (irrigated); Sandy range site; Sandy woodland site.

Parshall sandy loam, moderately deep, 0 to 1 percent slopes (3Pn).—This soil is slightly more sandy than Parshall sandy loam, deep, 0 to 1 percent slopes. The lower part of the subsoil (B_{22} horizon) is sand and coarse sand, or a substratum of sand and gravel begins at a depth between 20 and 30 inches. Because of the sand and gravel, this soil has low available moisture-holding capacity and is droughty if dry-farmed. It is susceptible to wind erosion. If it is irrigated properly, this soil is suited to all crops grown in the county. Because of the low available moisture-holding capacity, the water should be applied frequently and in small amounts. This soil is best suited to grass. Capability units IVe–3 (dryland) and IIIe–3 (irrigated); Sandy range site; Sandy woodland site.

Parshall sandy loam, moderately deep, 1 to 5 percent slopes (3PnB).—Except that it is more sloping, this soil is similar to Parshall sandy loam, moderately deep, 0 to 1 percent slopes. Capability units IVe–3 (dryland) and IVe–3 (irrigated); Sandy range site; Sandy woodland site.

Riverwash

This land type consists of sediments that were recently deposited along the large streams. Whenever the streams rise high or overflow, more sediments are deposited or some of those already deposited are washed away. Consequently, Riverwash varies greatly in texture and has no soil development. Little or no vegetation is on this land, or there are only thin to moderate stands of trees and brush and scattered patches of grass and weeds.

Riverwash (Rw).—Because it is flooded frequently, this land has no agricultural value. It can be used as a habitat for wildlife and can be grazed occasionally in places. Capability unit VIIIs–1 (dryland); this land type is not suited to trees.

Rock land

This land type is made up of steep breaks, sides of canyons, and Canyon soils. The Canyon soils make up 10 to 20 percent of the land type. The soils of the canyons are mostly barren rock. This land has sparse vegetation. Its slopes have a gradient of more than 20 percent.

Rock land (Rv).—This land is suited to limited grazing and wildlife habitats. Capability unit VIIs–3 (dryland); Very Shallow range site; this land type is not suited to trees.

Rosebud series

In the Rosebud series are deep and moderately deep loamy soils that have a silty subsoil. These soils developed on uplands.

The surface soil is moderately dark colored loam. It has weak, granular to weak, blocky structure and is easily tilled. Unless protected, the soil washes or blows away. The surface soil combined with the subsurface soil is about 10 inches thick.

The subsoil is lighter colored than the surface soil. It is silt loam or loam in texture and blocky in structure. It is 6 to 14 inches thick. The upper part is calcareous in some places, and the lower part is calcareous in most places.

These soils developed in limy, moderately sandy materials that have weathered from sandstone and siltstone. Windblown material is mixed with the surface soil and the subsurface soil. Thin beds of calcareous sandstone normally occur at a depth between 3 and 5 feet in the deep Rosebud soils and at a depth of about 2 feet in the moderately deep Rosebud soils. In some places the parent rock consists of thin beds or strata of gravelly sandy loam or loamy sand, which are relatively low in lime, and of lenses or thin beds of hard siliceous limestone.

The Rosebud soils are associated with the Vebar soils. They contain more silt and clay and have a more distinct blocky structure than Vebar soils, which developed in materials weathered from thicker beds of rocks. These rocks contain more sandstone than those underlying the Rosebud soils. The Rosebud soils have horizons similar to those in the Keith soils, but their profile is shallower than that of the Keith. They also differ from the Keith soils in having more coarse sand throughout the profile and in containing rock fragments.

The Rosebud soils developed chiefly under short grasses in which there were some mid grasses. Blue grama is the predominant grass, but some western wheatgrass, little bluestem, and needlegrass also occur. These soils are well drained. Figure 18 shows the profile of a deep Rosebud loam.

***Figure 18.*—Profile of a deep Rosebud loam.**

Typical profile: A moderately deep Rosebud loam in a cultivated field (*location* 530 feet west and 120 feet north of the SE. corner of sec. 35, T. 13 N., R. 54 W.):

Surface soil and subsurface soil—

A_{1p} 0 to 6 inches, grayish-brown (10YR 5/2) loam; dark brown (10YR 3/3) when moist; weak, fine, granular structure; very friable when moist; slightly calcareous; slight effervescence; horizon appears to be overblow; abrupt, smooth boundary.

A_{12} 6 to 10 inches, grayish-brown (10YR 5/2) loam; very dark grayish brown (10YR 3/2) when moist; weak, coarse, subangular blocky structure; very friable when moist; slightly calcareous; slight effervescence; abrupt, smooth boundary.

Subsoil—

B_{ca} 10 to 16 inches, light brownish-gray (10YR 6/2) silt loam; dark grayish brown (10YR 4/2) when moist; compound, weak, coarse, prismatic and weak, medium, subangular blocky structure; very friable when moist; calcareous; violent effervescence; clear, wavy boundary.

Substratum—

C_1 16 to 28 inches, light-gray (10YR 7/2) loam; pale brown (10YR 6/3) when moist; weak, medium and coarse, subangular blocky structure; very friable when moist; calcareous; violent effervescence; smooth, gradual boundary.

D_r 28 to 34 inches, friable Tertiary material consisting of lime-covered sandstone fragments ranging from 5 to 25 millimeters in size in a matrix of pink (7.5YR 7/4, moist) loam; few fine and coarse pebbles.

The texture of the surface soil ranges from silt loam to sandy loam. The clay content of the B horizon averages about 25 percent and ranges from 18 to 33 percent. Where they are free of calcareous overwash or of material deposited by the wind, these soils are commonly noncalcareous in the A horizon and in the upper part of the B horizon. The rocks underlying these soils differ in texture, in hardness, and in the rate that they weather. Consequently, Rosebud soils are not uniform in depth to unaltered bedrock, in texture of the C horizon, or in characteristics of the D horizon.

Rosebud loam, deep, 0 to 1 percent slopes (Rb).—This soil is more than 3 feet deep to bedrock. It is well suited to cultivated crops and to grass. Conserving moisture and controlling wind erosion are the main problems of management. Capability unit IIIc–1 (dryland); Silty range site; Silty to Clayey woodland site. This soil is in capability unit IIc–1 (dryland) in the Keith-Rosebud association (see General Soil Map) because of more favorable climatic conditions.

Rosebud loam, deep, 1 to 3 percent slopes (RbAW).—This soil is suited to all crops grown in the county. If it is cultivated, controlling erosion and conserving moisture are the main problems of management. Capability unit IIIe–1 (dryland); Silty range site; Silty to Clayey woodland site. Because of more favorable climatic conditions, this soil is in capability unit IIe–1 (dryland) in the Keith-Rosebud association.

Rosebud loam, deep, 3 to 5 percent slopes (RbBW).—This soil occurs on gentle slopes. It is highly susceptible to erosion, which must be controlled if productivity is to be maintained. Capability unit IIIe–1 (dryland); Silty range site; Silty to Clayey woodland site.

Rosebud loam, deep, 5 to 9 percent slopes (RbCW).—Most of this soil has been moderately eroded, but a few small areas have been severely eroded. The soil is susceptible to further erosion and is best suited to grass. Small grains and other close-growing crops can be grown, but row crops should not be grown often. Capability unit IVe–1 (dryland); Silty range site; Silty to Clayey woodland site.

Rosebud loam, moderately deep, 0 to 1 percent slopes (3RbW).—This soil is underlain by bedrock at a depth of about 2 feet (fig. 19). Because of this moderate depth, the mositure-holding capacity and the root zone are limited. Wheat is the principal dryland crop. Although this soil is suited to all crops in the county, some crops are grown only under irrigation. Capability unit IIIc–1 (dryland); Silty range site; Silty to Clayey woodland site.

Rosebud loam, moderately deep, 1 to 3 percent slopes (3RAW).—This soil is underlain by rock at a depth of about 2 feet. A few small severely eroded spots that are too small to map separately are shown on the soil map by a symbol. Wheat is the principal dryland crop. Other crops are grown mainly under irrigation. This gently sloping soil is moderately susceptible to water and wind erosion. Conserving moisture is important. Capability unit IIIe–1 (dryland); Silty range site; Silty to Clayey woodland site.

Rosebud loam, moderately deep, 3 to 5 percent slopes (3RBW).—This soil occurs on sloping areas. Because of moderate depth and the severe hazard of erosion, it is best suited to grass. Close-growing crops can be grown, but row crops should be kept to a minimum or not grown at all. Capability unit IVe–1 (dryland); Silty range site; Silty to Clayey woodland site.

Rosebud loam, moderately deep, 5 to 9 percent slopes (3RCW).—This soil has a surface soil that is normally about 2 inches thinner than that in the profile described as typical of the Rosebud series. Bedrock occurs at a depth of about 2 feet. Because of the very severe hazard of erosion and moderate depth, this soil is best suited to grass. Close-growing crops are suited, but row crops are not. Capability unit IVe–1 (dryland); Silty range site; Silty to Clayey woodland site.

***Figure 19.*—Profile of Rosebud loam, moderately deep, 0 to 1 percent slopes. Weathered rock occurs at a depth of about 24 inches. Fragments of rock are scattered through the profile.**

Rosebud loam, 9 to 15 percent slopes (RbD).—This soil consists of both the deep and the moderately deep phases of Rosebud loam that occur on moderately steep slopes. It is too steep and too erosive for cultivated crops and is best suited to grass. Capability unit VIe-1 (dryland); Silty range site; Silty to Clayey woodland site.

Sandy alluvial land

This land type consists of sandy and gravelly alluvium. It occurs mainly along the flood plains of intermittent streams that carry a large volume of floodwater. Its surface layer is slightly darkened material underlain by stratified alluvium. The alluvium consists of sands, loamy sands, and gravelly sands that have been altered very little.

Sandy alluvial land (Sx).—This land is flooded by stream overflow or by runoff once or twice a year or at intervals greater than a year. In dry years, Sandy alluvial land is droughty. Capability unit VIs-4 (dryland); Shallow range site; Shallow woodland site.

Scott series

In the Scott series are deep, moderately dark colored soils on uplands. These soils have a thin, silty surface layer that is underlain by a thick layer of clay. They occur in basinlike depressions that are scattered through the more nearly level uplands.

The surface layer of these soils is grayish-brown silt loam about 6 inches thick. It has a weak, granular structure and is noncalcareous and friable.

A layer of grayish clay, 20 to 40 inches thick, underlies the surface layer. This layer is massive when wet. When the clay dries, it cracks into strong blocks. The cracks between the blocks are wide.

The parent material is windblown silt, or loess. In some places, sandy material is at a depth of about 3 feet.

The Scott soils have a thinner surface soil than the Goshen soils and a thicker, more clayey subsoil.

The native vegetation consists of annual weeds and grass, including western wheatgrass, switchgrass, and prairie dropseed. These soils are suited to crops in dry years but in wet years are covered by water. They receive more moisture than most other soils in the county. Internal drainage, surface drainage, and permeability are slow to very slow.

Typical profile: Scott silt loam (*location* 430 feet west and 100 feet south of the NE. corner of sec. 9, T. 16 N., R. 57 W.):

Surface soil and subsoil—

A_1 0 to 4 inches, grayish-brown (10YR 5/2) silt loam; very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; friable when moist, soft when dry; noncalcareous; abrupt boundary.

B_2 4 to 30 inches, gray (10YR 5/1) clay; very dark gray (10YR 3/1) when moist; weak, coarse, prismatic to strong, fine, blocky structure; very firm when moist, very hard when dry, sticky and plastic when wet; thin to thick, nearly continuous clay films on most ped faces; noncalcareous; clear boundary.

Transition layer—

BC 30 to 35 inches, brown (10YR 5/3) sandy clay loam; dark grayish brown (10YR 4/2) when moist; weak, coarse and medium, subangular blocky structure; firm when moist, very hard when dry; no readily discernible clay films on peds; noncalcareous; abrupt boundary.

Substratum—

D 35 to 60 inches, light yellowish-brown (10YR 6/4) light sandy loam; brown (10YR 5/3) when moist; massive (structureless); very friable when moist, soft when dry; noncalcareous.

The A horizon is as much as 10 inches thick and, in some places, includes an A_2 horizon that is 1 to 4 inches thick.

Only one soil in the Scott series is mapped in Kimbal County.

Scott silt loam (Se).—This soil occurs in nearly level depressions in areas of Keith and Rosebud soils. Water stands in these depressions in wet years. In dry years this soil is difficult to farm and the soil material blows easily. Fair yields of wheat can be produced in some years, but this soil is best suited to grass. Capability unit VIw-2 (dryland); Overflow range site; Moderately Wet woodland site.

Tripp series

In the Tripp series are deep, moderately dark colored soils that have a loamy surface soil and a silty subsoil. These soils are on the terraces along Lodgepole Creek and other creeks.

The surface soil is moderately dark colored loam or fine sandy loam that has weak, granular structure. It is friable and is easily tilled. The surface soil combined with the subsurface soil is about a foot thick.

The subsoil is brown silt loam about 2 feet thick. It has a blocky structure (fig. 20) and is slightly hard when dry. Soft lime spots and streaks occur in the lower part of the subsoil.

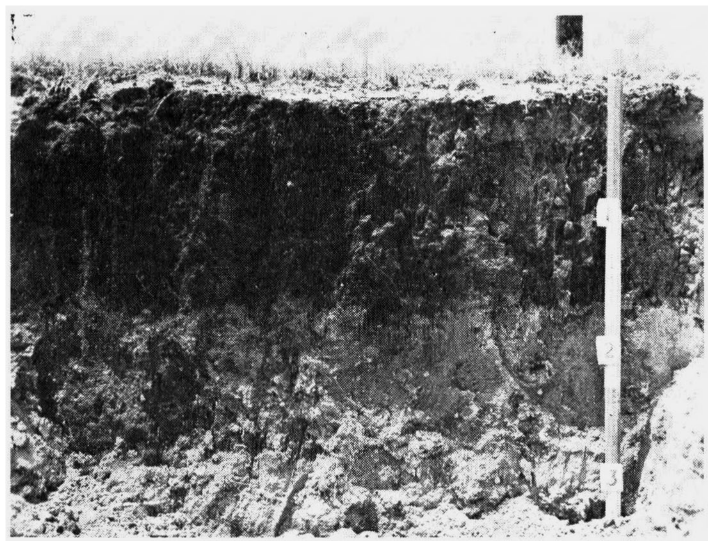

Figure 20.—**Profile of a Tripp loam. Note the blocky structure in the subsoil.**

The parent materials consist of mixed stream alluvium, loess, and alluvium washed from slopes in small drains fanning out on the terraces. In some areas the Tripp soils appear to have developed almost entirely in loess. This loess may have been transported by water after it was deposited by wind. In some places the soils contain thin layers of sandy loam or very fine sandy loam. In nearly all areas pebbles occur in the profile. These pebbles range in amount from a few to a sprinkling. The sandy surface soil that occurs in some areas is in local sandy wash or sandy overblow and is underlain by medium-textured materials.

The Tripp soils are darker colored and more clayey than the Bridgeport soils and are more blocky in the subsoil. The Tripp soils contain more clay in the subsoil than the Keith soils, which occur on uplands instead of stream terraces.

These soils developed under grass vegetation, mainly western wheatgrass, blue grama, side-oats grama, and needle-and-thread. They are well drained and very fertile.

Typical profile: A Tripp loam in an irrigated field (*location* 1,500 feet east and 600 feet north of the W¼ corner of sec. 35, T. 15 N., R. 54 W.):

Surface soil and subsurface soil—

A_{1p1} 0 to 3 inches, dark grayish-brown (10YR 4/2) loam; very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; friable when moist, soft when dry; slightly calcareous; a few limy rock fragments; few siliceous pebbles; clear boundary.

A_{1p2} 3 to 10 inches, grayish-brown (10YR 5/2) loam; very dark grayish brown (10YR 3/2) when moist; weak, coarse, blocky and weak, fine, granular structure; friable when moist, soft when dry; few siliceous pebbles; noncalcareous; clear boundary.

Subsoil—

B_{21} 10 to 16 inches, brown (10YR 5/3) silt loam; dark grayish brown (10YR 4/2) when moist; weak, coarse, prismatic and weak, medium, subangular blocky structure; friable when moist, slightly hard when dry; thin patchy clay films on some ped faces; few siliceous pebbles; noncalcareous; clear boundary.

B_{22} 16 to 22 inches, brown (10YR 5/3) silt loam; dark grayish brown (10YR 4/2) when moist; weak, coarse, prismatic and moderate, medium, blocky structure; slightly firm when moist, slightly hard when dry; thin patchy clay films on nearly all ped faces; siliceous pebbles; noncalcareous; clear boundary.

B_{23} 22 to 26 inches, brown (10YR 5/3) silt loam; brown (10YR 4/3) when moist; weak, coarse, prismatic and weak, medium, subangular blocky structure; friable when moist, slightly hard when dry; a few patches of clay films on some ped faces; no gravel; slightly calcareous; a few coarse, gray soft lime spots which effervesce violently; abrupt boundary.

B_{3ca} 26 to 31 inches, light brownish-gray (10YR 6/2) silt loam; grayish brown (10YR 5/2) when moist; weak, coarse, platy breaking to weak, medium, subangular blocky structure; friable when moist, slightly hard when dry; calcareous; some gray to white lime spots and streaks and thin lime coatings on some ped faces; clear boundary.

Substratum—

C_{ca} 31 to 39 inches, white (10YR 8/2) silt loam; grayish brown (10YR 5/2) when moist; massive (structureless) to weak, medium, subangular blocky structure; friable when moist, slightly hard when dry; moderate, soft lime accumulation; violent effervescence; gradual, wavy boundary.

C_1 39 to 51 inches, very pale brown (10YR 8/3) loam or silt loam; brown (10YR 5/3) when moist; massive (structureless); friable when moist, soft when dry; strongly calcareous but contains less carbonate than C_{ca} horizon; gradual, wavy boundary.

C_2 51 to 60 inches, very pale brown (10YR 8/3) very fine sandy loam; brown (10YR 5/3) when moist; massive (structureless); friable when moist, soft when dry; strongly calcareous but contains less carbonate than C_{ca} horizon; gradual, wavy boundary.

The surface layers (A horizon) range in thickness from 8 to 12 inches. The subsoil (B horizon) is 8 to 30 inches thick. It is 24 to 35 percent clay. Most of these soils are underlain by stratified coarse alluvium at a depth between 3 and 6 feet.

Tripp fine sandy loam, 0 to 1 percent slopes (Tr).—Except that tbe surface layer is fine sandy loam, this soil has a profile similar to that described as typical of the Tripp series. It is suited to all crops grown in the county and is well suited to irrigation. It should be managed so that soil material is prevented from blowing. Capability units IIIe–3 (dryland) and IIe–3 (irrigated); Sandy range site; Sandy woodland site.

Tripp fine sandy loam, 1 to 3 percent slopes (TrA).—This soil is suited to all crops grown in the county. Wheat is the principal dryland crop, but many of the other crops are grown under irrigation. Controlling erosion and conserving moisture are the main problems of management. Capability units IIIe–3 (dryland) and IIe–3 (irrigated); Sandy range site; Sandy woodland site.

Tripp fine sandy loam, 3 to 5 percent slopes (TrBW).—The surface layers (A horizon) of this soil are normally about 8 inches thick. Although the hazard of erosion is severe, this soil is suited to all crops grown in the county. Capability units IIIe–3 (dryland) and IIIe–3 (irrigated); Sandy range site; Sandy woodland site.

Tripp loam, 0 to 1 percent slopes (Ta).—This soil has a profile like the one described for the Tripp series. It is suited to the crops commonly grown in tbe county and can be irrigated successfully. Conserving moisture is the main problem of management, but protection from wind erosion is also needed. Capability units IIc–1 (dryland) and I–1 (irrigated); Silty range site; Silty to Clayey woodland site.

Tripp loam, 1 to 3 percent slopes (TaAW).—This soil is suited to the crops commonly grown in the county. Controlling erosion and conserving moisture are the main problems of management. Capability units IIIe–1 (dryland) and IIe–1 (irrigated); Silty range site; Silty to Clayey woodland site. This soil is in capability unit IIe–1 (dryland) in the Keith-Rosebud association (see General Soil Map) because of more favorable climatic conditions.

Tripp loam, 3 to 5 percent slopes (TaBW).—If this soil is protected against erosion, it is suited to dryland crops. It can be irrigated if the water is applied evenly so that erosion is prevented. Capability units IIIe–1 (dryland) and IIIe–1 (irrigated); Silty range site; Silty to Clayey woodland site.

Tripp loam, 5 to 9 percent slopes (TaCW).—This soil occurs on moderately steep slopes and is susceptible to severe erosion. It is not well suited to row crops. Under dryland farming or irrigation, close-growing crops can be grown if proper conservation measures are used. This soil is well suited to grass. Capability units IVe–1 (dryland) and IVe–1 (irrigated); Silty range site; Silty to Clayey woodland site.

Vebar series

The Vebar series consists of deep and moderately deep, moderately sandy soils on uplands. These soils have a weak, blocky subsoil.

The surface layer is moderately dark colored sandy loam or loamy sand. It has a weak, granular structure and is normally slightly calcareous. It is about 8 inches thick.

The subsoil is slightly browner than the surface layer. It is sandy loam or sandy clay loam with a weak, blocky structure. The subsoil is about 20 inches thick.

The parent material is light-colored sandy loam. It is massive and contains some fragments of sandstone. In places this material has been moved about by the wind. Thin layers of siltstone and hard sandstone occur at a depth of 20 to 50 inches or more.

The Vebar soils have a subsoil that is more sandy and weaker in structure than that in the Rosebud soils. They are deeper over sandstone than the Canyon soils.

These soils developed under grass, including blue grama, prairie sandreed, little bluestem, needle-and-thread, and western wheatgrass. Drainage is good. Runoff is slow, and internal drainage is moderate to rapid.

Most of the acreage of Vebar soils is cultivated. In dry years, yields of small grains are higher than those on most fine-textured soils that occur with Vebar soils. Wind erosion is a serious problem unless it is controlled.

Typical profile: A Vebar sandy loam in a cultivated field (*location* 310 feet east of the N¼ corner of sec. 3, T. 14 N., R. 54 W.):

Surface soil—
A_p 0 to 7 inches, grayish-brown (10YR 5/2) sandy loam; very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; friable when moist, soft when dry; slightly calcareous; slight effervescence; abrupt, smooth boundary.

Subsoil—
B_2 7 to 14 inches, brown (10YR 5/3) heavy sandy loam; dark brown (10YR 4/3) when moist; weak, coarse, prismatic breaking to weak, medium, subangular blocky structure; friable when moist, soft when dry; patchy clay films on ped faces; clear, wavy boundary.

B_{ca} 14 to 25 inches, brown (10YR 5/3) sandy loam; dark brown (10YR 4/3) when moist; weak, medium, subangular blocky structure; friable when moist, soft when dry; calcareous; violent effervescence; clear, irregular boundary.

Substratum—
C_{ca} 25 to 36 inches, pale-brown (10YR 6/3) sandy loam; brown (10YR 5/3) when moist; contains a few rock fragments from 1 to 3 inches in diameter; massive (structureless); friable when moist, soft when dry; calcareous; violent effervescence; gradual, irregular boundary.

D 36 to 48 inches +, weakly cemented or partly weathered calcareous Tertiary sandstone.

The texture of the surface soil ranges from sandy loam to loamy sand. Where these soils are in grass, the A_1 horizon may be slightly darker or slightly grayer than that described. The B horizon ranges from heavy sandy loam to light sandy clay loam. Where the soils have not received accretions of calcareous material, free lime carbonate has been leached from the A horizon and the upper B horizon. Parent rock consisting of thin strata of siltstone and hard sandstone is common in most areas and may underlie the soils at a depth of 20 to 50 inches or more.

Vebar sandy loam, 0 to 3 percent slopes (VrAW).—This soil is suited to the crops commonly grown in the county. Controlling wind erosion and conserving moisture are the main problems of management. Capability unit IIIe-3 (dryland); Sandy range site; Sandy woodland site.

Vebar sandy loam, 3 to 5 percent slopes (VrBW).—This soil is susceptible to severe wind erosion and is best suited to grass. Sorghum can be grown if the soil is protected at all times. Close-growing crops can be grown under irrigation if suitable practices are used. Capability unit IVe-3 (dryland); Sandy range site; Sandy woodland site.

Vebar sandy loam, 5 to 9 percent slopes (VrCW).—Because this soil has moderately steep slopes, it is subject to very severe water erosion. It is best suited to grass, but close-growing crops can be grown under irrigation if special practices are used. Capability IVe-3 (dryland); Sandy range site; Sandy woodland site.

Vebar sandy loam, 9 to 15 percent slopes (VrD).—This soil has slopes that are too steep and too erosive for cultivation. Much of it is in grass. Capability unit VIe-3 (dryland); Sandy range site; Sandy woodland site.

Wet alluvial land

This land type consists of areas along Lodgepole Creek that are permanently wet. These areas are less than 3 feet above the creek. The water table is less than 30 inches below the surface.

The soils in this land type range from silts to sands in texture and, in places, contain layers of various textures. Most of the soils are mottled and limy in the subsoil.

The native vegetation consists mainly of prairie cordgrass, alkali cordgrass, bluejoint reedgrass, northern reedgrass, and tall sedges.

Wet alluvial land (Wx).—This land type is not suited to cultivation. It is best suited to grass. Water-tolerant trees can also be grown. Capability unit Vw-1 (dryland); Wet Land range site; Wet woodland site.

Use and Management of Soils

In this section are discussed cropping practices and general management, land capability classification and management of dry-farmed and irrigated soils, estimated acre yields of dry-farmed and of irrigated soils under two levels of management, management of woodland and of range sites, and engineering uses of soils.

Crops and Cropping Practices

This subsection names the crops grown in Kimball County and discusses cropping practices. Turn to the subsection "Descriptions of Soils" if you want to know the present uses of each soil.

Winter wheat is the most extensive cultivated crop grown in Kimball County. Other crops in smaller acreages are spring wheat, oats, barley, rye, grain and forage sorghums, millet, and safflower. Alfalfa, corn, beans, and potatoes are also grown, usually under irrigation.

Winter wheat is planted in fall and is harvested in July. Most of the wheat is harvested with a combine that draws the grain from the standing stalks. To protect the soil, the straw is left as standing stubble. If the wheat has grown enough, it may be grazed early in winter and in spring. This grazing can continue until the wheat starts to joint or until heads start to form. Much forage is available if the soil contains enough moisture for good plant growth. Grazing prevents the wheat from growing so tall that it lodges and thereby makes harvesting difficult.

Only a small acreage of spring wheat is planted in Kimball County. Spring wheat may be planted in fields where winter wheat has been winterkilled or blown out.

Small acreages of oats, barley, and rye are grown for grain, hay, or pasture. Oats and barley are usually planted in spring, and rye is planted in fall.

Most of the sorghum in the county was once grown for forage. This was the practice because summers are cool, and sorghum grown for grain often fails to mature. The acreage in grain sorghum has increased, however, and is expected to increase further as varieties are developed that are better suited to the climate of the county. Sorghum is planted in summer after the soil warms. In most places, the grain sorghum is planted in rows and is cultivated. The grain is usually harvested with a combine. Sorghum grown for forage may be shocked in bundles and stacked, or it may be used as silage.

Millet is grown for grain or for forage. It is planted in spring after the soil warms, usually in closely spaced rows. If harvested for grain, it is combined. If it is cut for forage, millet is handled as other hays.

Safflower is grown for the oil in the seed. The meal that remains after the oil is extracted is used as a feed supplement for livestock and poultry. Safflower is planted between March 25 and May 10 in Kimball County. It is planted in rows 6 to 24 inches apart and can be harvested with an ordinary combine. Satisfactory yields are obtained under dryland management, but yields are higher if the crop is irrigated.

Alfalfa normally receives more water than other crops. It is irrigated or subirrigated, or it receives runoff from higher areas. The stands of alfalfa are allowed to remain for several years, or as long as they are vigorous and relatively free of weeds. Alfalfa is harvested for hay or for seed. Irrigated sweetclover, a biennial, is grown for pasture, seed, or green manure.

Because summers are cool and freezing temperatures are early, only a small acreage of corn is grown. Most of this acreage is irrigated. The corn is planted in widely spaced rows and is cultivated.

Dry beans are also grown under irrigation. They are planted in spring in widely spaced rows and are harvested with a combine.

Some Irish potatoes are grown, but the acreage in potatoes has decreased in recent years.

General Practices of Management

The small amount of rainfall in Kimball County greatly affects farming and the management of soils. Farmers in the county are chiefly concerned about the moisture available for each crop. The average rainfall in the county is slightly less than 17 inches per year, but the amount is extremely variable from year to year. Rainfall has been below average for more years than it has been above average.

Most dryland crops are grown after the soils have been fallowed for a year. The fallow period between two crops of winter wheat is about 15 months. In the fallow period, weeds and volunteer crops are destroyed and the soil surface is kept in a condition favorable for taking in water. In a system called black fallow, all crop residue is turned under by plowing and the soil is exposed and, in spring, is susceptible to blowing. This can be avoided. By using sweeps or other implements, the stubble can be kept on the soil surface so that the soil is protected from blowing or crusting. The stubble also reduces runoff and keeps the soil surface open so that more water enters.

On moderately sandy to clayey soils, terraces are built to save moisture and thus prevent soil blowing. According to how fast the soils absorb moisture, level terraces with closed ends or nearly level terraces with open ends are constructed. From the nearly level terraces, the runoff water is emptied into grassed waterways or onto pastures. Terraces are most effective if tillage is on the contour and the soils are in stubble-mulch fallow much of the time.

Stripcropping is effective in saving moisture and in controlling soil blowing and soil washing. In a stripcropped field, the strips planted to one kind of crop are alternated with strips planted to another kind, or are alternated with strips that are left fallow. The strips are 165 to 330 feet wide on silty and clayey soils and are 80 to 165 feet wide on the sandy soils. They may be on the contour or across the direction of the prevailing spring winds. The strips on the contour protect mainly against water erosion; those across the direction of the prevailing wind protect mainly against wind erosion.

Fallow, stubble-mulch tillage, terracing, and stripcropping are used in Kimball County to conserve moisture and to control wind and water erosion. When enough stubble or other vegetation is not produced to protect the soil from blowing, emergency tillage may be needed to check soil blowing. In emergency tillage, implements are used that bring clods to the surface. These clods protect the soil.

The main dryland cropping system in Kimball County provides that winter wheat is alternated with summer fallow. The fields are stubble-mulched and stripcropped to help control erosion and conserve moisture.

Land Capability Classification

Capability classification is a grouping of soils that shows, in a general way, how suitable they are for most kinds of farming. It is a practical grouping based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment.

In this system all the kinds of soil are grouped at three levels, the capability class, subclass, and unit. The eight capability classes in the broadest grouping are designated by Roman numerals I through VIII. In class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, grazing, or wood products.

The subclasses indicate major kinds of limitations within the classes. Within most of the classes there can be as many as four subclasses. The subclass is indicated by adding a small letter, *e*, *w*, *s*, or *c* to the class numeral, for example, IIIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* means that water in or on the soil will interfere with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c* indicates that the chief limitation is low rainfall or some other factor of climate.

In class I there are no subclasses, because the soils of this class have few or no limitations. Class V can contain, at the most, only subclasses *w*, *s*, and *c*, because the soils in it have little or no erosion hazard but have other limitations that limit their use largely to pasture, range, woodland, or wildlife.

Within the subclasses are the capability units, groups of soils enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping of soils for many statements about their management. Capability units are generally identified by numbers assigned locally, for example, IIIe-1, IIIe-3. These numbers are not consecutive in Kimball County, because not all of the capability units used in Nebraska occur in Kimball County. The soils in each unit have about the same hazards and limitations of use and require about the same treatment. There are no class I soils in Kimball County that are not irrigated.

Soils are classified in capability classes, subclasses, and units in accordance with the degree and kind of their permanent limitations. Not considered are major and generally expensive land-forming that would change the slope, depth, or other characteristics of the soil, and not considered are possible but unlikely major projects of reclamation.

Capability Groups of Dry-farmed Soils

In the following list, the capability classes, subclasses, and units for the dry-farmed soils in Kimball County are given, along with a brief description of the kinds of soils in these groups.

Class II.—Soils with some limitations that reduce the choice of plants or require moderate conservation practices.
  Subclass IIc: Soils with few limiting factors except climatic conditions.
    Unit IIc-1: Deep, medium-textured, nearly level soils.
  Subclass IIe: Soils that have a moderate erosion hazard when tilled.
    Unit IIe-1: Deep, medium-textured, gently sloping soils.

Class III.—Soils with severe limitations that reduce the choice of plants or require special conservation practices when tilled.
  Subclass IIIc: Soils with climatic conditions as the principal limiting factor.
    Unit IIIc-1: Deep or moderately deep, loamy, nearly level soils.
  Subclass IIIe: Soils with a severe erosion hazard when tilled.
    Unit IIIe-1: Deep or moderately deep, loamy, nearly level to gently sloping soils.
    Unit IIIe-3: Deep or moderately deep, sandy soils that are nearly level to gently sloping.

Class IV.—Soils with very severe limitations that restrict the choice of plants and require very careful management when tilled.
  Subclass IVe: Soils with a very severe erosion hazard when tilled.
    Unit IVe-1: Deep or moderately deep, loamy soils on gentle to strong slopes.
    Unit IVe-3: Deep or moderately deep, moderately sandy soils that are nearly level to strongly sloping.
    Unit IVe-5: Light-colored sandy soil on very gentle slopes.

Class V.—Soils with little or no erosion hazard, but with other limitations that are impractical to remove and that limit the use of the soils largely to pasture, range, woodland, or wildlife food and cover.
  Subclass Vw: Poorly drained soils.
    Unit Vw-1: Silty to moderately sandy soil on frequently flooded bottom lands.

Class VI.—Soils with severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.
  Subclass VIe: Soils subject to very severe erosion when tilled.
    Unit VIe-1: Deep, loamy soil on moderately steep slopes.
    Unit VIe-3: Sandy soils on gentle to moderately steep slopes.
  Subclass VIs: Shallow soils.
    Unit VIs-4: Shallow soils over rock or gravel.
  Subclass VIw: Soils subject to frequent overflow.
    Unit VIw-1: Soils on bottom lands or in depressions that are frequently flooded.

Class VII.—Soils with very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.
  Subclass VIIs: Soils with limited depth and moisture-holding capacity.
    Unit VIIs-3: Very shallow soils over rock or gravel.

Class VIII.—Soils and landforms with limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.
  Subclass VIIIs: Unstable soil materials.
    Unit VIIIs-1: Sandbars and recent riverwash.

Management of dryland capability units

In this subsection, the soils in Kimball County are placed in capability units and the suitability for use and the management of each capability unit are discussed.

The suggestions for management must be interpreted with judgment. They may have to be adjusted for each farm and within a farm. Before you decide what crops to plant and just how to manage your soils, consider the way the soils have been cropped in the past, how much they might yield under good management, and the nature of the soils.

A soil cannot always be used and managed as if it occurred alone. In many places it occurs with other soils that differ from it. These different soils may be farmed together. For example, some soils on steep slopes that are not suited to cultivation may be farmed in the same way as adjacent soils that are well suited.

In Kimball County, variations in the amount of effective rainfall is a factor to be considered in determining how the soils can be used and managed. Because of this variation, the county has been divided into two climatic zones.

The Keith-Rosebud association in northeastern Kimball County (see General Soil Map in the back of this report) is a part of the "Dalton Table," which occurs in several counties to the east and north. This nearly level tableland receives more annual effective rainfall and has more favorable conditions for crop growth than the remainder of Kimball County. Soils on nearly level slopes in the Keith-Rosebud association are placed in a higher capability class than soils with the same name in the rest of the county. Crop yields over a period of years in this area are slightly higher than those given in the table of estimated yields (see table 2). Because of the higher rainfall, crops are more certain and more stubble can be produced to protect the soil.

CAPABILITY UNIT IIc-1 (Dryland)

This unit consists of deep, medium-textured, nearly level soils. These soils are:

In the entire county:

Goshen loam, 0 to 1 percent slopes.
Havre silt loam.
Tripp loam, 0 to 1 percent slopes.

In the Keith-Rosebud soil association (see General Soil Map):

Altvan loam, deep, 0 to 1 percent slopes.
Keith loam, 0 to 1 percent slopes.
Rosebud loam, deep, 0 to 1 percent slopes.

These soils are suited to small grains, sorghum, safflower, millet, feed crops, and grass.

A scarcity of moisture limits crop yields. To increase yields, plant a field to crops one year and let it lay fallow the next. Crops may be planted each year if there is enough precipitation to meet plant needs for several consecutive years. When a field is fallow, use stubble-mulch tillage and other practices that increase the capacity of these soils to take in moisture.

Wind erosion, particularly in winter and spring, is a hazard if the fields are bare. Stubble mulch these soils so that they will be covered with crop residue when they are fallow. Roughen the surface if there is not enough stubble to protect the soils from the wind. Wind stripcropping and use of alternate bands of a crop and fallow also aid in reducing wind erosion.

CAPABILITY UNIT IIe-1 (Dryland)

This capability unit consists of only the deep, gently sloping, medium-textured soils in the Keith-Rosebud soil association (see General Soil Map). These soils are:

Altvan loam, deep, 1 to 3 percent slopes.
Bridgeport loam, 1 to 3 percent slopes.
Goshen loam, 1 to 3 percent slopes.
Keith loam, 1 to 3 percent slopes.
Rosebud loam, deep, 1 to 3 percent slopes.
Tripp loam, 1 to 3 percent slopes.

Areas of these soils in the Keith-Rosebud soil association receive slightly more rainfall and are slightly less limited by climate than are areas of these soils in other parts of the county. In the Keith-Rosebud soil association, crop yields are slightly higher than those shown in the table of estimated yields. Because of the higher rainfall, crops are more certain and more stubble can be produced to protect the soils.

These soils are suitable for small grains, sorghum, safflower, millet, feed crops, and grass.

Moisture is the limiting factor for crop production. Use measures such as fallowing and stubble-mulch tillage to conserve all the moisture possible. Both wind and water erosion are hazards. Stubble-mulch tillage, terraces, stripcropping, and contour farming will help control both wind and water losses. Grassed waterways may be necessary to remove large amounts of excess water from the terraces.

CAPABILITY UNIT IIIc-1 (Dryland)

This unit consists of deep or moderately deep, loamy, nearly level soils in that part of the county outside the Keith-Rosebud soil association. These soils are:

Altvan loam, deep, 0 to 1 percent slopes.
Cheyenne loam, 0 to 1 percent slopes.
Keith loam, 0 to 1 percent slopes.
Rosebud loam, deep, 0 to 1 percent slopes.
Rosebud loam, moderately deep, 0 to 1 percent slopes.

Some areas of the Altvan, Keith, and Rosebud soils on slopes of 0 to 1 percent occur in the Keith-Rosebud soil association. These areas receive more rainfall and have higher yields than areas of these soils that occur elsewhere in the county. These soils in the Keith-Rosebud association are in capability unit IIc–1.

The soils of this unit are suited to small grains, sorghum, safflower, millet, feed crops, and grass.

These soils are easy to work. They take in water well and store it for plant use. Nevertheless, a scarcity of moisture limits crop yields. Stubble mulch the fields and use summer fallow to conserve all the moisture possible. If these soils receive enough water in several consecutive years, crops may be planted each year.

Wind erosion, particularly in winter and spring, is a hazard if the fields are bare. Stubble mulch these soils so that they will be covered with crop residue when they are fallow. Roughen the surface if there is not enough stubble to protect the soils from the wind. Wind stripcropping also aids in reducing wind erosion.

CAPABILITY UNIT IIIe-1 (Dryland)

This unit consists of deep or moderately deep, nearly level to gently sloping, loamy soils. These soils are:

In the entire county:

Altvan loam, deep, 3 to 5 percent slopes.
Altvan loam, moderately deep, 1 to 3 percent slopes.
Bridgeport loam, 3 to 5 percent slopes.
Cheyenne loam, 1 to 3 percent slopes.
Keith loam, 3 to 5 percent slopes.
Rosebud loam, deep, 3 to 5 percent slopes.
Rosebud loam, moderately deep, 1 to 3 percent slopes.
Tripp loam, 3 to 5 percent slopes.

In that part of the county outside the Keith-Rosebud association (see General Soil Map):

Altvan loam, deep, 1 to 3 percent slopes.
Bridgeport loam, 1 to 3 percent slopes.
Goshen loam, 1 to 3 percent slopes.
Keith loam, 1 to 3 percent slopes.
Rosebud loam, deep, 1 to 3 percent slopes.
Tripp loam, 1 to 3 percent slopes.

Most of these soils with slopes of 1 to 3 percent are in the Keith-Rosebud soil association, but some of them are in other parts of the county. The areas in the Keith-Rosebud association receive more rainfall than do areas elsewhere, and crop yields are slightly higher. The soils in the Keith-Rosebud association are in capability unit IIe–1.

The soils in this capability unit are suited to small grains, sorghum, safflower, millet, feed crops, and grass.

These soils are easily worked. They take in water well and store it for plant use. A scarcity of moisture limits crop yields. Leave the soils fallow every other year to conserve moisture for the alternate crop years. Use stubble-mulch tillage to save all crop stubble and keep it on the surface. This will keep the surface soil open and permit water to soak in. Plant crops only when the moisture content in the subsoil is favorable for crop growth.

Water erosion is a severe hazard on these soils, especially on the ones with slopes of 3 to 5 percent. To control erosion and to save moisture, use stubble mulching, stripcropping, terracing, and contour farming. Diversion terraces may be needed on some fields to divert water from higher lying areas. Carry excess water from terraces by using grassed waterways. Also helpful in controlling erosion is a cropping system that provides long periods when grass and legumes are grown.

Wind erosion is also a hazard. Stubble mulch these soils so that they will be covered with residue when they are fallow. Roughen the surface if there is not enough stubble to protect the soils. Wind stripcropping helps to control soil blowing.

CAPABILITY UNIT IIIe-3 (Dryland)

This unit consists of deep or moderately deep, sandy soils that are nearly level to gently sloping. These soils are:

Altvan fine sandy loam, deep, 1 to 3 percent slopes.
Bayard fine sandy loam, 1 to 5 percent slopes.
Glendive fine sandy loam.
Parshall sandy loam, deep, 0 to 1 percent slopes.
Parshall sandy loam, deep, 1 to 5 percent slopes.
Tripp fine sandy loam, 0 to 1 percent slopes.
Tripp fine sandy loam, 1 to 3 percent slopes.
Tripp fine sandy loam, 3 to 5 percent slopes.
Vebar sandy loam, 0 to 3 percent slopes.

The soils in this unit are suited to small grains, sorghum, safflower, millet, feed crops, and grass.

These soils are easily worked. They take in water well but do not hold so much available for plants as do the more clayey soils. Water, air, and roots move freely through the soils. Use farming methods that will maintain the structure of these moderately sandy soils. Keep enough residue on the surface to protect them against blowing and washing. Work the excess residue into the soils so that organic matter is added and the structure is improved. Do not work the soils more than necessary.

To save moisture and control wind and water erosion, stubble mulch these soils, fallow them, plant crops in strips, and seed grass and legumes. Because they are sandy and are on irregular slopes, some soils in this unit cannot be terraced and farmed on the contour.

CAPABILITY UNIT IVe-1 (Dryland)

This unit consists of deep or moderately deep, loamy soils on gentle to strong slopes. These soils are:

Altvan loam, deep, 5 to 9 percent slopes.
Altvan loam, moderately deep, 3 to 5 percent slopes.
Altvan loam, moderately deep, 5 to 9 percent slopes.
Rosebud loam, deep, 5 to 9 percent slopes.
Rosebud loam, moderately deep, 3 to 5 percent slopes.
Rosebud loam, moderately deep, 5 to 9 percent slopes.
Tripp loam, 5 to 9 percent slopes.

The soils in this unit are suited to small grains, sorghum, safflower, millet, feed crops, and grass.

These soils are easily worked and are permeable to air, water, and plant roots. A scarcity of moisture limits crop yields. Plant crops only after a field has been fallowed or when the content of moisture in the subsoil is favorable. When the field is fallow, use stubble-mulch tillage to keep the surface open so that more water will enter.

If these soils are cultivated, the hazard of water and wind erosion is severe. To protect the soils, keep them in grass and legumes about one-half to two-thirds of the time during a 10- to 15-year period. Though no crop can be harvested, in years of low rainfall the soils must be protected. Chiefly to maintain the soils, planting of crops or emergency tillage may be needed. Use all suitable conservation practices, including stubble mulching, stripcropping, terracing, and contour farming. Grassed waterways may be needed to carry off the excess water from terraces, and diversion terraces may be required to carry off excess water from higher lying areas.

CAPABILITY UNIT IVe-3 (Dryland)

This unit consists of deep or moderately deep, moderately sandy soils that are nearly level to strongly sloping. These soils have a high content of lime. They are:

Chappell sandy loam, 1 to 3 percent slopes.
Parshall sandy loam, moderately deep, 0 to 1 percent slopes.
Parshall sandy loam, moderately deep, 1 to 5 percent slopes.
Parshall sandy loam, deep, 5 to 9 percent slopes.
Vebar sandy loam, 3 to 5 percent slopes.
Vebar sandy loam, 5 to 9 percent slopes.

On these soils, sorghum is the most suitable cultivated crop. Wind erosion often causes failure of other crops.

These soils are easily worked and are permeable to air, water, and plant roots. The high content of lime, especially in the Vebar soils, may reduce crop yields. It may also make the soil material more likely to blow away. Use farming methods that will maintain structure. Keep enough residue on the surface to protect the soils against blowing and washing. Work the excess residue into the soils so that organic matter is added and structure is improved. Do not work the soils more than necessary.

Cultivated areas of these soils are very susceptible to wind erosion and are moderately susceptible to water erosion. In a 10- to 15-year period, keep grass and legumes on these soils one-half to two-thirds of the time. Though no crop may be harvested, these soils must be protected. Chiefly to maintain the soils, planting of crops or emergency tillage may be needed. Use all suitable conservation practices, including stubble mulching, stripcropping, and planting grass. Windbreaks help to reduce soil blowing.

CAPABILITY UNIT IVe-5 (Dryland)

Dwyer loamy sand is the only soil in this capability unit. This sandy soil is light colored and is high in lime. It occurs on very gentle slopes.

Sorghum is the cultivated crop best suited to this soil. Other crops are often damaged by blowing sand.

This soil is easily worked. It is well drained and rapidly permeable. Because it is sandy and is underlain by gravel, it is droughty. The high content of lime may affect plant growth and may cause this soil to blow away more easily. Use farming methods that will maintain the soil. Keep enough residue on the surface to protect it against blowing. Work the excess residue into the soil so that organic matter is added and structure is improved. Do not work this soil more than is necessary.

If this soil is cultivated, the hazard of wind erosion is severe. Keep it in grass and legumes two-thirds of the time in a 10- to 15-year period. Even if no crop may be harvested, this soil must be protected in years of low rainfall. Mainly to maintain the soil, it may be necessary to plant crops, to use emergency tillage, or to allow weeds to grow. When harvesting sorghum, leave a high stubble to control soil blowing and to catch snow. Stripcropping and windbreaks also help to reduce soil blowing.

CAPABILITY UNIT Vw-1 (Dryland)

This capability unit consists of only Wet alluvial land, which is made up of silty to moderately sandy soils of various textures and depths. This land occurs along Lodgepole Creek and its main tributaries. It is frequently flooded and has a high water table. Some areas contain alkali salts.

Grasses are best suited to this land, but some kinds of trees will also grow.

CAPABILITY UNIT VIe-1 (Dryland)

This capability unit consists of one soil, Rosebud loam, 9 to 15 percent slopes. This deep, loamy soil is on moderately steep slopes.

This soil is eroded in some places. It is not suited to cultivated crops. It is best suited to native grasses, but some kinds of trees can also be grown.

CAPABILITY UNIT VIe-3 (Dryland)

This capability unit consists of sandy soils on gentle to moderately steep slopes. These soils are:

Chappell sandy loam, 3 to 5 percent slopes.
Chappell sandy loam, 5 to 9 percent slopes.
Vebar sandy loam, 9 to 15 percent slopes.

These sandy soils are moderately deep. They are eroded in some areas. They are not suited to crops and are best suited to native grasses. Suitable trees also can be grown.

CAPABILITY UNIT VIs-4 (Dryland)

This capability unit consists of soils that are shallow over rock or gravel. They are:

Canyon loam, 0 to 5 percent slopes.
Canyon loam, 0 to 5 percent slopes, eroded.
Canyon loam, 9 to 20 percent slopes.
Canyon-Rosebud loams, 5 to 9 percent slopes.
Canyon-Rosebud loams, 5 to 9 percent slopes, eroded.
Canyon sandy loam, 0 to 5 percent slopes.
Canyon sandy loam, 9 to 20 percent slopes.
Canyon-Vebar sandy loams, 5 to 9 percent slopes.
Dix loams, 3 to 9 percent slopes.
Dix complex, 9 to 20 percent slopes.
Sandy alluvial land.

These soils are too shallow over rock or gravel to be cultivated. They are best suited to native grasses. Redcedar is the only tree suited to these shallow soils.

CAPABILITY UNIT VIw-2 (Dryland)

This capability unit consists of soils on bottom lands or in depressions. These soils are frequently flooded or are ponded part of the time. They are:

Loamy alluvial land.
Scott silt loam.

These soils have slow to very slow surface drainage and medium to slow internal drainage. They are best suited to water-tolerant grasses and to trees.

CAPABILITY UNIT VIIs-3 (Dryland)

This capability unit consists of very shallow soils over rock or gravel. They are:

Canyon complex, 0 to 9 percent slopes.
Canyon complex, 9 to 20 percent slopes.
Gravelly land.
Rock land.

Outcrops of rock or gravel are common on these soils, which are suited only to native grasses.

CAPABILITY UNIT VIIIs-1 (Dryland)

Only the land type, Riverwash, is in this capability unit. Riverwash consists of sandbars and material that washed in along streams.

Because it is unstable, this land is difficult to improve. It is best suited as wildlife habitats. If areas of this land type are included in pastures, cattle will graze them to some extent.

Estimated Yields on Dry-farmed Soils

The estimated average acre yields for the principal dry-farmed crops are listed in table 2 for two levels of management. The yields in columns A are those to be expected under a management system that provides turning under the crop stubble, alternating crops and fallow, and stripcropping. The yields in columns B are those to be expected under a management system that includes stubble-mulch tillage, alternate crop and fallow, stripcropping, and conservation practices that provide terraces, waterways, and contour farming.

The yields in table 2 are those from harvested fields. Because dryland crops are grown on soils that are left fallow in summer, the yields listed can be expected only every other year. Not considered when the yields were estimated were the crop failures caused by drought, hail, insects, or wind erosion. Because of damage to the crops from 1932 to 1956, 24.9 percent of the wheat, 32.9 percent of the rye, and 28 percent of the corn planted in Kimball County were not harvested. These crop failures cannot be correlated accurately with the soils. Nevertheless, crop failures caused by drought are more frequent on the more sloping soils and on soils that have a low water-holding capacity. Soils with a low water-holding capacity are generally coarse textured or are shallow and underlain by sand and gravel. Hail damage on crops in the southwestern part of the county is greater than that in the northeastern part. The farmer ought to consider the probability of crop damage when he estimates yields.

The yields in table 2 are based on data and opinions received from farmers, ranchers, the county agricultural agent, technicians of the Soil Conservation Service, and others familiar with the county. They are actually a longtime average. In periods when rainfall is above average, yields will be higher than those listed in the table. Yields will be lower when crops are damaged by hail, disease, insects, or other natural causes.

The effect of climate on yields of wheat is discussed in the subsection on climate in the section "General Nature of the Area."

TABLE 2.—*Estimated average yields per harvested acre of principal dry-farmed crops*

[Yields in columns A are those to be expected when all practices required for a high level of management are *not* carried out; yields in columns B are those to be expected under a high level of management; absence of yield indicates crop is not suited to the soil or that it is seldom grown on the soil]

Soil	Wheat		Oats		Barley		Millet		Sorghum		Safflower	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Lb.*	*Lb.*
Altvan fine sandy loam, deep, 1 to 3 percent slopes	13	17	14	19	13	17	9	12	0.7	0.9	------	------
Altvan loam, deep, 0 to 1 percent slopes [1]	24	32	26	35	25	33	17	23	2.1	2.9	860	1,160
Altvan loam, deep, 1 to 3 percent slopes [1]	21	29	23	31	22	30	15	21	1.9	2.5	770	1,040
Altvan loam, deep, 3 to 5 percent slopes	19	24	21	28	20	27	13	17	1.4	2.6	660	890
Altvan loam, deep, 5 to 9 percent slopes	14	20	15	21	14	20	10	14	.8	1.0	520	700
Altvan loam, moderately deep, 1 to 3 percent slopes	17	23	19	25	17	23	12	16	1.2	1.6	610	830
Altvan loam, moderately deep, 3 to 5 percent slopes	12	16	13	17	12	16	8	11	.7	.9	430	570
Altvan loam, moderately deep, 5 to 9 percent slopes	10	14	11	15	10	14	7	10	------	------	------	------
Bayard fine sandy loam, 1 to 5 percent slopes	10	14	11	15	10	14	7	9	.5	.7	------	------
Bridgeport loam, 1 to 3 percent slopes [1]	20	27	21	29	21	28	14	18	1.5	2.1	700	940
Bridgeport loam, 3 to 5 percent slopes	17	23	19	25	17	23	12	16	1.2	1.6	610	830
Canyon loam, 0 to 5 percent slopes	------	------	------	------	------	------	------	------	------	------	------	------
Canyon loam, 0 to 5 percent slopes, eroded	------	------	------	------	------	------	------	------	------	------	------	------
Canyon-Rosebud loams, 5 to 9 percent slopes	------	------	------	------	------	------	------	------	------	------	------	------
Canyon-Rosebud loams, 5 to 9 percent slopes, eroded	------	------	------	------	------	------	------	------	------	------	------	------
Canyon loam, 9 to 20 percent slopes	------	------	------	------	------	------	------	------	------	------	------	------
Canyon sandy loam, 0 to 5 percent slopes	------	------	------	------	------	------	------	------	------	------	------	------
Canyon-Vebar sandy loams, 5 to 9 percent slopes	------	------	------	------	------	------	------	------	------	------	------	------
Canyon sandy loam, 9 to 20 percent slopes	------	------	------	------	------	------	------	------	------	------	------	------
Canyon complex, 0 to 9 percent slopes	------	------	------	------	------	------	------	------	------	------	------	------
Canyon complex, 9 to 20 percent slopes	------	------	------	------	------	------	------	------	------	------	------	------
Chappell sandy loam, 1 to 3 percent slopes	10	14	11	15	10	14	7	9	.4	.6	------	------
Chappell sandy loam, 3 to 5 percent slopes	------	------	------	------	------	------	------	------	------	------	------	------
Chappell sandy loam, 5 to 9 percent slopes	------	------	------	------	------	------	------	------	------	------	------	------
Cheyenne loam, 0 to 1 percent slopes	15	21	16	32	15	21	11	15	.8	1.2	550	750
Cheyenne loam, 1 to 3 percent slopes	14	20	15	21	14	20	10	14	.8	1.0	520	700
Dix loams, 3 to 9 percent slopes	------	------	------	------	------	------	------	------	------	------	------	------
Dix complex, 9 to 20 percent slopes	------	------	------	------	------	------	------	------	------	------	------	------
Dwyer loamy sand	------	------	------	------	------	------	7	9	.5	.7	------	------
Glendive fine sandy loam	13	17	14	19	13	17	9	12	.7	.9	------	------
Goshen loam, 0 to 1 percent slopes	26	35	28	37	27	36	18	24	2.5	3.5	860	1,160
Goshen loam, 1 to 3 percent slopes [1]	24	32	26	35	25	33	17	23	2.1	2.9	860	1,160
Gravelly land	------	------	------	------	------	------	------	------	------	------	------	------
Havre silt loam	24	32	26	35	25	33	17	23	2.1	2.9	860	1,160
Keith loam, 0 to 1 percent slopes [1]	24	32	26	35	25	33	17	23	2.1	2.9	860	1,160
Keith loam, 1 to 3 percent slopes [1]	23	31	25	33	24	32	16	22	2.0	2.6	820	1,110
Keith loam, 3 to 5 percent slopes	20	27	21	29	21	28	14	18	1.5	2.1	700	940
Loamy alluvial land	------	------	------	------	------	------	------	------	------	------	------	------
Parshall sandy loam, deep, 0 to 1 percent slopes	17	23	19	25	17	23	12	16	1.2	1.6	------	------
Parshall sandy loam, deep, 1 to 5 percent slopes	16	22	18	24	16	22	11	15	.8	1.2	------	------
Parshall sandy loam, deep, 5 to 9 percent slopes	14	18	16	22	14	18	11	15	.8	1.2	------	------
Parshall sandy loam, moderately deep, 0 to 1 percent slopes	10	14	11	15	10	14	7	9	.5	.7	------	------
Parshall sandy loam, moderately deep, 1 to 5 percent slopes	9	13	10	14	9	13	6	8	.4	.8	------	------
Riverwash	------	------	------	------	------	------	------	------	------	------	------	------
Rock land	------	------	------	------	------	------	------	------	------	------	------	------
Rosebud loam, deep, 0 to 1 percent slopes [1]	21	29	23	31	22	30	15	21	1.9	2.5	770	1,040
Rosebud loam, deep, 1 to 3 percent slopes [1]	20	27	21	29	21	28	14	18	1.5	2.1	700	940
Rosebud loam, deep, 3 to 5 percent slopes	17	23	19	25	17	23	12	16	1.2	1.6	610	830
Rosebud loam, deep, 5 to 9 percent slopes	14	20	15	21	14	20	10	14	.8	1.0	520	700
Rosebud loam, 9 to 15 percent slopes	------	------	------	------	------	------	------	------	------	------	------	------
Rosebud loam, moderately deep, 0 to 1 percent slopes	17	23	19	25	17	23	12	16	1.2	1.6	610	830
Rosebud loam, moderately deep, 1 to 3 percent slopes	14	20	15	21	14	20	10	14	.8	1.0	520	700
Rosebud loam, moderately deep, 3 to 5 percent slopes	12	16	13	17	12	16	8	11	.7	.9	430	570
Rosebud loam, moderately deep, 5 to 9 percent slopes	10	14	11	15	10	14	7	10	------	------	------	------
Sandy alluvial land	------	------	------	------	------	------	------	------	------	------	------	------
Scott silt loam	------	------	------	------	------	------	------	------	------	------	------	------

See footnote at end of table.

TABLE 2.—*Estimated average yields per harvested acre of principal dry-farmed crops*—Continued

Soil	Wheat		Oats		Barley		Millet		Sorghum		Safflower	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Lb.*	*Lb.*
Tripp fine sandy loam, 0 to 1 percent slopes	21	29	23	31	22	30	15	21	1.9	2.5		
Tripp fine sandy loam, 1 to 3 percent slopes	19	25	21	30	20	27	13	17	1.4	2.0		
Tripp fine sandy loam, 3 to 5 percent slopes	15	21	16	22	15	21	11	15	.8	1.2		
Tripp loam, 0 to 1 percent slopes	24	32	26	35	25	33	17	23	2.1	2.9	860	1,160
Tripp loam, 1 to 3 percent slopes [1]	21	29	23	31	22	30	15	21	1.9	2.5	770	1,040
Tripp loam, 3 to 5 percent slopes	17	23	19	25	17	23	12	16	1.2	1.6	610	830
Tripp loam, 5 to 9 percent slopes	13	18	14	20	13	18	9	13	.7	.9	490	660
Vebar sandy loam, 0 to 3 percent slopes	12	16	13	17	12	16	8	11	.7	.9		
Vebar sandy loam, 3 to 5 percent slopes	9	12	10	14	9	12	6	8	.4	.6		
Vebar sandy loam, 5 to 9 percent slopes			10	14	9	12	6	8				
Vebar sandy loam, 9 to 15 percent slopes												
Wet alluvial land												

[1] Yields on these soils in the Keith-Rosebud association (see General Soil Map) will be slightly higher than those given.

Management of Irrigated Soils

The irrigated soils in Kimball County are mainly in the valley of Lodgepole Creek. Water for irrigation is obtained from this creek or from wells. Some of the soils on uplands are suited to irrigation, but water is not available. Only the soils that are irrigated are considered in the discussion that follows.

Irrigation methods

To apply water uniformly, different methods of irrigation are needed for the different kinds of crops. The method of irrigation is usually changed when a field is changed from a close-growing crop to a row crop. Because this change is difficult on slopes greater than 2 percent, some farmers have bench leveled their irrigated soils so that all slopes are 1 percent or less. These farmers can easily change their method of irrigation when they change the kind of crop grown.

Water is generally distributed on the field in furrows, in corrugations, between borders, by controlled flooding, or by sprinklers.

Furrow irrigation.—This is the most common method for irrigating row crops. The water is applied through a gated pipe or through siphon tubes to furrows between the plant rows. Furrow irrigation is suitable on slopes less than 1 percent, but on steeper slopes, either bench leveling or furrows on the contour should be used. Furrows on the contour are suitable for irrigating corn, sorghum, and potatoes on slopes of 1 to 5 percent. They are not suitable for irrigating beans and sugar beets. Where needed, the contour furrows should be supplemented with terraces.

Corrugation irrigation.—In this method, the water is applied in small furrows 18 to 30 inches apart. The water spreads laterally through the soil and wets the entire field. This method is suited to alfalfa and similar close-growing crops on medium- to fine-textured soils with slopes less than 5 percent.

Border irrigation.—In this method, flooding is controlled by borders along the sides of narrow cultivated areas that have slopes of less than 2 percent. The rate the soil takes in water ought to be one-fourth inch or more per hour. After it is applied, the water flows in a uniform sheet down a narrow strip between low ridges, or borders. The water is absorbed by the soil as it advances. To prevent ponding, smooth the strip and make its grade uniform. The ridges ought to be low and rounded so that they can be planted along with the strips.

Controlled flooding.—In this method, the applied water flows down the slope between closely spaced field ditches and is distributed uniformly on the field through many openings in these ditches. This method is suitable for irrigating close-growing crops on slopes greater than 0.25 percent.

Sprinkler irrigation.—Water is applied by sprinkler at the rate the soil will absorb without allowing an excess that would be wasted in runoff. Sprinklers can be used for irrigating most crops if the soil takes in water at a rate of more than 0.3 inch per hour. Grass or close-growing crops on level or nearly level fields can be irrigated by sprinklers if the intake rate is 0.2 inch per hour. If they are to be sprinkled, row crops on slopes of more than 1 percent should be planted on the contour. In conservation irrigation, sprinklers are helpful in establishing pastures and for other uses. In sprinkler irrigation, much water is lost through evaporation and water is applied unevenly because it is blown by the wind.

Application of water

A good irrigator supplies a crop with all the water it needs without wasting too much. Because a soil holds only a limited amount, the water ought to be applied at regular intervals during the growing season. This interval varies according to the crop. The water is applied only as fast as the soil will absorb it.

Choose a method of irrigation that is suited to the crop and that applies water evenly over the entire field. The water should be controlled from the time it enters the ditches or pipe to the time when only a small part flows from the field as waste water. It should be applied in such a way that it wets the roots of the plants without much loss from runoff or percolation.

The texture and structure of a soil and the depth of water-holding material over gravel or bedrock greatly affect the amount of available moisture that a soil stores for the use of plants. This storage capacity determines the frequency of irrigation, the size of stream flow, and the length of runs. In general, the inches of available moisture that can be stored in 1 foot of soil of various textures are as follows:

Sand	0.25 to 0.75
Loamy sand	0.75 to 1.25
Sandy loam	1.00 to 1.75
Silt loam and loam	1.50 to 2.00
Clay loam	1.75 to 2.25
Clay	2.00 to 3.00

If a soil is planted to a crop that has roots reaching to a depth of 6 feet or more, it is more efficient to apply more water less often than if it is planted to a crop having roots that reach down only 3 feet. If greater amounts of water are applied each time, the irrigation runs can be longer or the irrigation stream can be smaller.

The amount of water in each irrigation depends on how much water the soil can hold, and on how nearly all of the available water is taken from the soil by plants between irrigations. A silty soil normally stores about 2 inches of usable water in each foot of soil. But all this water should not be removed before irrigating again. Usually, at least 1 inch of water per foot of soil should be left in the soil if the crop is to grow rapidly. Thus, if the root zone of the crop is 3 feet, about 3 inches of water should be stored in each irrigation. If the efficiency of the system is 75 percent, 4 inches of water would have to be applied, because 1 inch of water is wasted. Assuming that the plants take in water at the medium rate of 0.2 inch a day, the 3 inches stored would last 15 days, or the intervals between irrigations would be about 2 weeks.

Drainage

On most irrigated soils, drainage is needed to remove excess water or to control the level of the water table. Excess water in the root zone restricts root growth and prevents the soils from warming in spring. Surface drainage is especially important on the saline or alkali soils and on all the imperfectly drained soils, if these soils are to be dry enough for seedbed preparation early in spring. Proper drainage also helps remove salts from the soils and prevents the upward movement of soluble salts into the root zone.

Erosion control

Applying irrigation water so that it does not wash away the soil is another problem. If it is not applied uniformly, the water may strip away the soil at an alarming rate. Water is normally absorbed by a soil faster if the structure of the surface soil has been improved. Soil erosion on irrigated soils can be reduced by planting legumes in a cropping system, by plowing under green-manure crops and crop residue, by stubble mulching, and by applying barnyard manure.

Choosing a suitable method of distributing water on sloping soils is important. If row crops are to be grown, terraces, along with contour furrows, are suggested on slopes of more than 1 percent. Careful management is needed on irrigated soils that are cultivated on the contour. Overirrigation tends to move the small particles of soil downstream, but this kind of erosion can be prevented by regulating the rate at which water is applied and by constructing runs of the proper length. On deep soils with slopes of 3 to 6 percent, erosion can be prevented by bench leveling.

When some irrigated crops are harvested, the entire top growth is removed and the soil is left bare. The soil remains unprotected until the next crop has grown enough to protect it. Unless soils are protected at all times, wind erosion may remove the surface layer or move it about and make the surface uneven. This uneven surface affects the distribution of water over the field. The particles of windblown soil may fill irrigation ditches and make them costly to maintain. If an irrigation system is to work well, erosion must be controlled on the irrigated soils and on the soils in nearby fields.

Soil fertility

When soils are irrigated, crop yields frequently are several times larger than they were before irrigation. But the plants take a larger amount of nutrients, especially of nitrogen and phosphorus, from the irrigated soils. Maintaining soil fertility, therefore, is a problem on irrigated soils. The amounts of commercial fertilizer needed depend on the kind of soil, the soil management, the efficiency of irrigation, and the yield expected. Soil tests will aid in determining the fertility level of the various soils. Information about soil tests can be obtained from the county agricultural agent.

Where deep cuts are made in the more friable soils, much of the surface soil is lost. In these areas, much manure, crop residue, and other amendments are needed to help offset the loss of surface soil and to increase crop yields. A good growth of stubble, managed in a stubble-mulch system, protects a soil against washing and blowing and keeps its surface layer open so that water soaks in rapidly.

Crops and cropping practices

Irrigated crops in Kimball County are alfalfa, sweetclover, sugar beets, dry beans, corn, small grains, grasses, sorghum, potatoes, and safflower. The acreage of potatoes has decreased in recent years. Safflower, a relatively new crop in the area, is grown for the oil that is extracted from the seed.

Corn, sorghum, and potatoes are grown in 40-inch rows; beans and sugar beets in 20-inch rows; and alfalfa, sweetclover, small grains, grasses, and safflower in more closely spaced rows. The crops grown in 20- and 40-inch rows are cultivated for weed control and are normally irrigated by the furrow or sprinkler system. The close-growing crops are irrigated by the corrugation, border, controlled-flooding, or sprinkler method. Weeds are killed by chemicals or by cultivation before the crop is planted.

In a cropping system, sugar beets generally are not grown after a legume crop. One cropping system used is alfalfa for 3 to 5 years, a crop of potatoes, a crop of sugar beets, and then small grains for 1 to 3 years. Another is alfalfa for 3 to 5 years, small grains or sorghum for 1 year, and beets for 1 year.

Planning irrigation

The irrigation system should be planned for each farm so that it fits the pattern of soils and lay of the land. Also to be considered are the farm enterprise as a whole and the ability and finances of the farmer. A single plan cannot be used for all irrigated farms.

Most farmers need technical help in planning and laying out the irrigation system. This help can be obtained from technicians of the Soil Conservation Service, who aid the local Soil Conservation District; from the agricultural extension agent; and from representatives of companies that manufacture irrigation equipment. The final decisions regarding irrigation must be made by the farmer himself.

In planning, constructing, and operating an irrigation system, the farmer, assisted by technicians, should:

1. Take an inventory of the soils and the water supply.
2. Obtain a topographic map that shows the lay of the land on each field to be irrigated.
3. Plan the irrigation system.
4. Level the land and otherwise prepare it for the type of irrigation selected.
5. Use irrigation water efficiently by adjusting the amount and rate of water applied to fit the soil and the irrigation system.

The success of an irrigation system will be greatly affected by care in planning. This report provides essential information about soils. Other points to be considered are—

1. Location of well or other sources of water.
2. Division of fields.
3. Direction of crop rows.
4. Length of runs.
5. Methods of distributing water.
6. Location of irrigation ditches and pipes.
7. Location of mechanical structures.
8. System of drainage.
9. Necessary leveling, including an estimate of the depths of cuts and fills.
10. Selection of suitable crops.
11. Testing soils for fertility.

Capability Groups of Irrigated Soils

In classifying the soils in Kimball County for use under irrigation, it was assumed that enough water would be available to meet the needs of plants to be grown. The differences in initial costs of installing irrigation systems were not considered. The classification, however, does reflect the limitations to use that will continue after irrigation begins and the risks of damage when a soil is irrigated. The irrigated soils in Kimball County have been placed in the following classes, subclasses, and units.

Class I.—Irrigated soils that have few limitations that restrict their use.

Unit I-1: Deep, loamy, nearly level soils.

Class II.—Irrigated soils that have some limitations that reduce the choice of plants or require moderate conservation practices.

Subclass IIe: Very gently sloping soils that are susceptible to moderate erosion if cultivated.

Unit IIe-1: Deep or moderately deep, loamy soils on nearly level slopes.

Unit IIe-3: Deep, moderately sandy soils on nearly level slopes.

Subclass IIs: Soils with limitations due to soil characteristics.

Unit IIs-5: Moderately deep, loamy soils on nearly level slopes.

Class III.—Irrigated soils that have severe limitations that reduce the choice of plants, or require special conservation practices, or both.

Subclass IIIe: Gently sloping soils that are susceptible to severe erosion if cultivated.

Unit IIIe-1: Deep, loamy soils on gentle slopes.

Unit IIIe-3: Deep, moderately sandy soils on gentle slopes.

Class IV.—Irrigated soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.

Subclass IVe: Soils that are susceptible to very severe erosion.

Unit IVe-1: Deep, loamy soil on moderately steep slopes.

Unit IVe-3: Deep, moderately sandy soils on gentle to moderately steep slopes.

Management of irrigated capability units

In this subsection the soils in Kimball County that are suited to irrigation are placed in capability units, and use and management are discussed for each unit.

CAPABILITY UNIT I-1 (Irrigated)

This unit consists of deep soils with a loamy surface soil and a moderately sandy to silty subsoil. These soils are nearly level. They are:

Havre silt loam.
Tripp loam, 0 to 1 percent slopes.

These soils have a moisture-holding zone 3 to 4 feet thick. Their available water-holding capacity is about 2 inches per foot of depth. They take in water at a rate of about 1.25 inches per hour. In places, runoff water from higher lying areas sometimes covers these soils and stands for a few hours before soaking in or running off.

Sprinkler irrigation or a gravity method is suited to these soils. Adjust the method of applying water to the crop grown. Maintain fertility and the content of organic matter. To prevent soil blowing, stubble mulch the soils or use other conservation practices.

CAPABILITY UNIT IIe-1 (Irrigated)

This unit consists of deep or moderately deep soils with a loamy surface soil and a silty subsoil. These soils are nearly level. They are:

Bridgeport loam, 1 to 3 percent slopes.
Cheyenne loam, 1 to 3 percent slopes.
Tripp loam, 1 to 3 percent slopes.

These soils have a moisture-holding zone 2 to 4 feet thick. Their available water-holding capacity is about 2 inches per foot of depth. They take in water at a rate of about 1.25 inches per hour. In places, runoff water from higher lying areas sometimes floods these soils and causes some washing. Because they are mainly on slopes of 1 and 2 percent, these soils are susceptible to moderate erosion unless adequately protected.

Use either a sprinkler or a gravity method of irrigation on these soils. Where a gravity method is used, bench leveling will help spread the water uniformly. If these soils are not bench leveled, use contour furrows, and and where needed, use terraces. Protect the soils to prevent blowing.

CAPABILITY UNIT IIe-3 (Irrigated)

This unit consists of deep soils with a moderately sandy surface soil and subsoil. These soils are nearly level. They are:

Glendive fine sandy loam.
Parshall sandy loam, deep, 0 to 1 percent slopes.

Tripp fine sandy loam, 0 to 1 percent slopes.
Tripp fine sandy loam, 1 to 3 percent slopes.

These soils have a moisture-holding zone 3 to 4 feet thick. Their available water-holding capacity is about 1.75 inches per foot of depth. They take in water at a rate of about 2.0 inches per hour. These soils are susceptible to moderate water erosion and moderate wind erosion unless they are adequately protected.

Use either sprinklers or a gravity method of irrigation on these soils. Where slopes of more than 1 percent are irrigated by gravity, bench leveling or contour furrows will help spread the water uniformly. If contour furrows are used, supplement them with terraces. Keep the content of organic matter of the surface soil high enough to maintain good soil structure. Work crop stubble and all available manure into the soils. Protect them to prevent blowing.

CAPABILITY UNIT IIs-5 (Irrigated)

The only soil in this capability unit is Cheyenne loam, 0 to 1 percent slopes. It is moderately deep and loamy and is nearly level.

This soil has a moisture-holding zone 2 to 3 feet thick. Its available water-holding capacity is about 1.75 inches per foot of depth. It takes in water at a rate of about 1.25 inches per hour. Unless it is adequately protected, this soil is susceptible to moderate water erosion and moderate wind erosion.

Use sprinklers or a gravity method of irrigation on this soil. Bench leveling or contour furrows will help spread the water uniformly. Protect this soil from blowing.

CAPABILITY UNIT IIIe-1 (Irrigated)

This unit consists of deep soils with a loamy surface soil and silty subsoil. These soils are on gentle slopes. They are:

Bridgeport loam, 3 to 5 percent slopes.
Tripp loam, 3 to 5 percent slopes.

These soils have a moisture-holding zone 3 to 4 feet thick. Their available water-holding capacity is about 2.0 inches per foot of depth. They take in water at a rate of about 1.25 inches per hour. Because these soils are on slopes of 3 to 5 percent, they are susceptible to water erosion and to wind erosion unless they are adequately protected.

Water can be applied by sprinklers or by a gravity method. If a gravity method is used, bench leveling or contour furrows will help spread the water uniformly. If the soils are not bench leveled, use terraces and other conservation measures.

CAPABILITY UNIT IIIe-3 (Irrigated)

This unit consists of deep soils with a moderately sandy surface soil and subsoil. These soils are on gentle slopes. They are:

Bayard fine sandy loam, 1 to 5 percent slopes.
Parshall sandy loam, deep, 1 to 5 percent slopes.
Parshall sandy loam, moderately deep, 0 to 1 percent slopes.
Tripp fine sandy loam, 3 to 5 percent slopes.

The moisture-holding zone of these soils is 3 to 4 feet thick. The available water-holding capacity is about 1.75 inches per foot. These soils take in water at a rate of about 2.0 inches per hour. Because slopes range up to 5 percent, these soils are susceptible to water erosion and to wind erosion unless they are adequately protected.

Water can be applied by sprinklers or by a gravity method of irrigation. If a gravity method is used, bench leveling or contour furrows will help spread the water uniformly. If the soils are not bench leveled, use dryland conservation practices. Keep the content of organic matter in the surface soil high enough to maintain good soil structure. Work crop stubble and all available manure into the soils.

CAPABILITY UNIT IVe-1 (Irrigated)

Tripp loam, 5 to 9 percent slopes, is the only soil in this unit. It is a deep, moderately steep soil with a loamy surface soil and a silty subsoil.

The moisture-holding zone of this soil is 3 to 4 feet thick, and the available water-holding capacity is about 2.0 inches per foot of depth. The rate of water intake is about 1.25 inches per hour. Because it is on slopes of 5 to 9 percent, this soil is susceptible to very severe erosion unless it is adequately protected.

Water can be applied by sprinklers or by a gravity method. If a gravity system is used, bench leveling or contour furrows will help spread the water uniformly. If the soil is not bench leveled, use dryland conservation practices and plant only grasses, legumes, and close-growing crops.

CAPABILITY UNIT IVe-3 (Irrigated)

This unit consists of deep and moderately deep soils with a moderately sandy surface soil and subsoil. These soils are gently sloping to moderately steep. They are:

Parshall sandy loam, deep, 5 to 9 percent slopes.
Parshall sandy loam, moderately deep, 1 to 5 percent slopes.

The moisture-holding zone of these soils is 3 to 4 feet thick, and the available water-holding capacity is about 1.75 inches per foot of depth. The rate of water intake is about 2.0 inches per hour. Because they are on slopes as steep as 9 percent, these soils are susceptible to very severe erosion unless they are adequately protected.

Water can be applied by sprinklers or by a gravity method. If a gravity method is used, bench leveling will help spread the water more uniformly. If these soils are not bench leveled, use dryland conservation practices and seed only grasses, legumes, and close-growing crops. Keep the content of organic matter in the surface soil high enough to maintain good soil structure. Work crop stubble and all available manure into the soil.

Estimated Yields on Irrigated Soils

The estimated yields of the principal crops grown under irrigation in Kimball County are listed in table 3. The yields are listed under two levels of management, average management and the best management practical.

Yields in columns A can be expected under average management. Under this management some fertilizer is applied; irrigation water is not applied uniformly and is not in sufficient amounts at the right time; there is little control of insects and diseases; and the amounts of crop residue and manure used are insufficient.

The yields in columns B can be expected under the best practical management. Under this management fertilizer is applied in the amounts needed; land is leveled so that the soils are not eroded if a gravity method of irrigation is used; water is applied uniformly at the right time

TABLE 3.—*Estimated average yields per harvested acre of the principal irrigated crops*

[Yields in columns A are those to be expected when all practices required for a high level of management are *not* carried out; yields in columns B are those to be expected under the best management practical; absence of yield indicates the crop is not suited to the soil or that it is seldom grown on the soil]

Soil	Corn		Beans		Wheat		Oats		Alfalfa		Potatoes		Safflower	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Lb.*	*Lb.*
Bayard fine sandy loam, 1 to 5 percent slopes	45	77	20	23	26	36	36	50	3. 0	4. 3	250	375	1, 000	1, 500
Bridgeport loam, 1 to 3 percent slopes	54	87	29	33	33	46	43	60	3. 4	4. 7	280	420	1, 000	1, 500
Bridgeport loam, 3 to 5 percent slopes	53	85	28	32	32	45	42	59	3. 3	4. 6	265	405	940	1, 440
Cheyenne loam, 0 to 1 percent slopes	51	83	26	30	31	43	41	57	3. 2	4. 5	280	320	1, 120	1, 620
Cheyenne loam, 1 to 3 percent slopes	50	82	25	29	30	42	40	56	3. 2	4. 5	265	292	1, 060	1, 560
Glendive fine sandy loam	45	77	20	23	26	36	36	50	2. 7	4. 0	250	375	1, 000	1, 500
Havre silt loam	62	100	37	42	40	56	50	70	4. 0	5. 3	355	530	1, 420	1, 920
Parshall sandy loam, deep, 0 to 1 percent slopes	57	80	32	37	35	48	45	63	3. 5	4. 8	295	440	1, 180	1, 680
Parshall sandy loam, deep, 1 to 5 percent slopes	55	78	30	35	34	47	44	61	3. 3	4. 6	280	420	1, 120	1, 620
Parshall sandy loam, deep, 5 to 9 percent slopes	------	------	------	------	------	------	40	55	3. 2	4. 5	------	------	------	------
Parshall sandy loam, moderately deep, 0 to 1 percent slopes	45	77	20	23	26	36	36	50	2. 7	4. 0	250	375	1, 000	1, 500
Parshall sandy loam, moderately deep, 1 to 5 percent slopes	43	75	16	21	24	34	34	47	2. 6	3. 9	235	355	940	1, 540
Tripp fine sandy loam, 0 to 1 percent slopes	60	95	35	40	38	50	48	68	3. 8	5. 1	325	485	11, 300	1, 800
Tripp fine sandy loam, 1 to 3 percent slopes	55	88	30	35	36	50	46	64	3. 7	5. 0	295	440	1, 240	1, 740
Tripp fine sandy loam, 3 to 5 percent slopes	48	78	23	27	28	38	38	53	3. 3	4. 6	265	395	1, 060	1, 560
Tripp loam, 0 to 1 percent slopes	62	100	37	42	40	56	50	70	4. 0	5. 3	355	530	1, 420	1, 920
Tripp loam, 1 to 3 percent slopes	58	90	33	38	38	53	48	68	3. 8	5. 1	325	485	1, 360	1, 860
Tripp loam, 3 to 5 percent slopes	53	85	28	32	34	47	44	61	3. 5	4. 8	295	440	1, 240	1, 740
Tripp loam, 5 to 9 percent slopes	------	------	------	------	30	42	40	56	3. 4	4. 7	------	------	------	------

in the amounts needed; enough crop residue and manure are used; and insects and diseases are controlled.

The yields in table 3 are for harvested crops. The damage to crops, especially that by hail, is high in Kimball County and losses cannot be calculated for a certain field in a certain year. Therefore, losses that are the result of damage to crops are not included in the estimates. Nevertheless, the possibility of such losses should be considered in the overall planning that covers long periods.

The yields listed are based on data and opinions received from farmers, ranchers, the county agricultural agent, Soil Conservation Service technicians, and others familiar with conditions in the county.

Use and Management of Rangeland [2]

The original cover on most of Kimball County was grass, and more than one-fourth of the county is still covered by native grasses that are grazed. The management of rangeland, therefore, is important in the county.

The purpose of this subsection is to furnish some of the information a rancher needs to know to conserve soil, water, and plants on rangeland. He can get additional information from the county agricultural agent or from technicians of the Soil Conservation Service.

Know your grasses

Different kinds of grass have different characteristics and different habits of growth. Some grasses grow best when it is cool; and others grow best when it is warm. Some grow well on moist sands on lowlands; others are better suited to drier uplands. Some grasses spread by underground stems, and others spread by seed or by stems on top of the ground. Usually several kinds of plants having somewhat different habits grow together on ranges and produce more than any one of the kinds would alone. The kinds of plants that grow best depend on the nature of the site.

Range sites

Range vegetation is influenced by water, air, and plant nutrients in the soil, as well as by light, humidity, and temperature. Because these factors differ from place to place, the vegetation also differs. Kinds of land, therefore, can be separated on the basis of their capacity to produce different kinds and amounts of vegetation. Such kinds of lands are called range sites. A range site is a kind of

[2] Prepared by LORENZ F. BREDEMEIER, range conservationist, Soil Conservation Service.

rangeland that differs from other rangeland because it can produce a significantly different kind or amount of climax (or original) vegetation. Range sites are named from one or more prominent features of the soil or the topography. Examples in Kimball County are the Wet Land, the Silty, and the Shallow range sites.

In the following pages the soils of Kimball County have been placed in seven range sites, and the dominant grasses on these range sites when they are in excellent condition are given.

WET LAND RANGE SITE

This range site consists of only one mapping unit—Wet alluvial land. This land is frequently flooded in the early part of the growing season. Its water table is at a depth of less than 30 inches from the surface.

The dominant grasses on this range site when it is in excellent condition are prairie cordgrass, alkali cordgrass, bluejoint reedgrass, northern reedgrass, western wheatgrass, and tall sedges.

OVERFLOW RANGE SITE

This range site consists of soils that frequently receive more water than do other soils in the county. The water is runoff from higher lying soils and stream overflow. The soils in this unit are:

Loamy alluvial land.
Scott silt loam.

The dominant grasses on this range site when it is in excellent condition are switchgrass, western wheatgrass, and prairie sandreed.

SANDS RANGE SITE

This range site consists of only one mapping unit—Dwyer loamy sand. This is a deep, loose, coarse-textured soil.

The dominant grasses on this range site when it is in excellent condition are sand bluestem, prairie sandreed, little bluestem, and needle-and-thread.

SANDY RANGE SITE

This range site consists of sandy loams. These soils are:

Altvan fine sandy loam, deep, 1 to 3 percent slopes.
Bayard fine sandy loam, 1 to 5 percent slopes.
Chappell sandy loam, 1 to 3 percent slopes.
Chappell sandy loam, 3 to 5 percent slopes.
Chappell sandy loam, 5 to 9 percent slopes.
Glendive fine sandy loam.
Parshall sandy loam, deep, 0 to 1 percent slopes.
Parshall sandy loam, deep, 1 to 5 percent slopes.
Parshall sandy loam, deep, 5 to 9 percent slopes.
Parshall sandy loam, moderately deep, 0 to 1 percent slopes.
Parshall sandy loam, moderately deep, 1 to 5 percent slopes.
Tripp fine sandy loam, 0 to 1 percent slopes.
Tripp fine sandy loam, 1 to 3 percent slopes.
Tripp fine sandy loam, 3 to 5 percent slopes.
Vebar sandy loam, 0 to 3 percent slopes.
Vebar sandy loam, 3 to 5 percent slopes.
Vebar sandy loam, 5 to 9 percent slopes.
Vebar sandy loam, 9 to 15 percent slopes.

The dominant grasses on this range site when it is in excellent condition are needle-and-thread, western wheatgrass, prairie sandreed, little bluestem, and blue grama.

SILTY RANGE SITE

This range site consists of deep and moderately deep, medium-textured soils. They are:

Altvan loam, deep, 0 to 1 percent slopes.
Altvan loam, deep, 1 to 3 percent slopes.
Altvan loam, deep, 3 to 5 percent slopes.
Altvan loam, deep, 5 to 9 percent slopes.
Altvan loam, moderately deep, 1 to 3 percent slopes.
Altvan loam, moderately deep, 3 to 5 percent slopes.
Altvan loam, moderately deep, 5 to 9 percent slopes.
Bridgeport loam, 1 to 3 percent slopes.
Bridgeport loam, 3 to 5 percent slopes.
Cheyenne loam, 0 to 1 percent slopes.
Cheyenne loam, 1 to 3 percent slopes.
Goshen loam, 0 to 1 percent slopes.
Goshen loam, 1 to 3 percent slopes.
Havre silt loam.
Keith loam, 0 to 1 percent slopes.
Keith loam, 1 to 3 percent slopes.
Keith loam, 3 to 5 percent slopes.
Rosebud loam, deep, 0 to 1 percent slopes.
Rosebud loam, deep, 1 to 3 percent slopes.
Rosebud loam, deep, 3 to 5 percent slopes.
Rosebud loam, deep, 5 to 9 percent slopes.
Rosebud loam, 9 to 15 percent slopes.
Rosebud loam, moderately deep, 0 to 1 percent slopes.
Rosebud loam, moderately deep, 1 to 3 percent slopes.
Rosebud loam, moderately deep, 3 to 5 percent slopes.
Rosebud loam, moderately deep, 5 to 9 percent slopes.
Tripp loam, 0 to 1 percent slopes.
Tripp loam, 1 to 3 percent slopes.
Tripp loam, 3 to 5 percent slopes.
Tripp loam, 5 to 9 percent slopes.

The dominant grasses on this range site when it is in excellent condition are western wheatgrass, needle-and-thread, blue grama, and threadleaf sedge.

SHALLOW RANGE SITE

This range site consists of soils that are at least 10 inches deep. A few roots penetrate to a depth of 20 inches or more. The soils in this range site are:

Canyon loam, 0 to 5 percent slopes.
Canyon loam, 0 to 5 percent slopes, eroded.
Canyon loam, 9 to 20 percent slopes.
Canyon-Rosebud loams, 5 to 9 percent slopes.
Canyon-Rosebud loams, 5 to 9 percent slopes, eroded.
Canyon sandy loam, 0 to 5 percent slopes.
Canyon sandy loam, 9 to 20 percent slopes.
Canyon-Vebar sandy loams, 5 to 9 percent slopes.
Dix loams, 3 to 9 percent slopes.
Dix complex, 9 to 20 percent slopes.
Sandy alluvial land.

The dominant grasses on this range site when it is in excellent condition are needle-and-thread, side-oats grama, western wheatgrass, blue grama, and threadleaf sedge.

VERY SHALLOW RANGE SITE

This range site consists of mixed soils in which few roots penetrate to a depth of more than 10 inches. These soils are:

Canyon complex, 0 to 9 percent slopes.
Canyon complex, 9 to 20 percent slopes.
Gravelly land.
Rock land.

The dominant grasses on this range site when it is in excellent condition are side-oats grama, little bluestem, needle-and-thread, and threadleaf sedge.

Response of plants to grazing

If the range is overgrazed during the growing season, the taller, more productive grasses that livestock prefer are grazed so closely that they give way to other shorter, less productive grasses. The taller grasses on native ranges regularly decrease in the total cover under continued close grazing and are called *decreasers*. The shorter grasses that were a part of the original vegetation will increase as the taller grasses decrease. These shorter grasses are called *increasers*. Such grasses fill in spaces left by the weakened decreasers and, for a time, produce a larger part of the total forage than they formerly did. But under continued close grazing, the increasers also eventually lose ground. Then the space formerly filled by decreasers and increasers is invaded by kinds of plants that could not withstand the competition of the original vegetation. Such plants are called *invaders*. Some invaders were present before settlement, but they existed only where the soil had been exposed by burrowing animals, game trails, streams, and other disturbances.

Range condition

A system for classifying range condition based on the behavior of range plants is used to evaluate the condition of a native grass pasture in relation to its potential. This system compares the proportion of decreasers, increasers, and invaders on the range to be classified with samples of the original vegetation on protected areas having soils and climate similar to that of the range. If the proportion of invaders is sufficiently high, the range is in poor condition. Pastures with decreasers and increasers in proper amounts are in excellent condition. If certain increasers occupy much more ground than they did in the original vegetation, the range is in less than top condition.

The system of classifying range condition used by the Soil Conservation Service recognizes four condition classes (*3*). These are excellent, good, fair, and poor.

A range in *excellent* condition consists mostly of decreasers and increasers but essentially no invaders. On a range in *good* condition the amount of decreasers is less and the amount of the increasers is greater; a few invaders may be seen. A range in *fair* condition normally has only a very small proportion of decreasers, but a high proportion of increasers and invaders. A range in *poor* condition has no decreasers, and a small amount of weak increasers; the invaders make up the greatest part of the vegetation.

Seeding native grasses

All soils in the county are suited to native grasses. By using the best management practices, the most net income from pastures ordinarily will be obtained if native grasses are grown on nonarable land and introduced or tame grasses are planted on land suitable for cultivation. The best seed mixture of native grasses for a site is one that corresponds closest to the composition of the climax vegetation on the site. The county agricultural agent and local technicians of the Soil Conservation Service can give the amounts of the various grass seed to use in mixtures for seeding various range sites.

If stands are to be successful, weed competition with grass seedlings should be at a minimum, soil blowing and washing should be prevented, and a firm seedbed should be prepared. The best way to prepare a seedbed is to drill a stubble crop and then to seed the grass in the stubble the following year. Sudangrass, cane,-millet, or a similar crop is drilled during the year that precedes planting the grass. This crop may be harvested, leaving an 8- to 18-inch stubble, and the grass seed drilled into the stubble. The best depth to place the seed is one-half of an inch in silty soils and three-quarters of an inch in sands and sandy soils. A packer pulled behind the drill to firm the soil over the seed will help establish the stand. New stands should not be summer grazed for two years or until the grass is well established. Then manage the grass the same as native range.

Range management

Successful grazing management of rangeland depends on: (1) proper degree of use, (2) proper season of use, (3) proper distribution of grazing, and (4) use of proper kinds of grazing animals.

Proper degree of use.—The number of livestock and the length of grazing period should be in balance with the available forage. In a correct balance half of the current year's growth is grazed by the end of the growing season. The rancher can adjust the number of livestock or the length of the grazing period to accomplish this. The forage left on the ground does these things:

1. Permits the manufacture of plant food for vigorous growth of tops and roots.
2. Makes a mulch that increases water intake and storage of soil moisture.
3. Protects soil from wind and water erosion.
4. Permits the growth and reproduction of the taller and more productive grasses and enables them to crowd out weeds.
5. Enables plant food to be stored in roots and used in quick and vigorous growth in spring and after droughts.
6. Helps hold snow and rain where it falls and thereby causes more uniform distribution of the soil moisture throughout the pasture.
7. Provides a greater feed reserve for dry spells that otherwise might force the sale of livestock at a loss.

Proper season of use.—Grazing at different seasons can be used to improve the condition of the range, to allow maximum forage production, and to obtain the greatest livestock gains. Some pastures may need rest during the growing season to improve their production and their condition. Pastures in excellent condition do not need rest so urgently. A survey of range sites and their condition classes made with the help of Soil Conservation Service technicians will help determine the most desirable season of use for each pasture.

Proper distribution of grazing.—Distribute the grazing throughout the pasture so that the closely grazed portion does not exceed 10 percent of the pasture and is balanced by an equal amount that is grazed lightly. Distribution of grazing can be controlled by fencing, salting, and herding. Because of its high labor cost, herding is almost prohibited.

The best location and arrangement of fences provide pasture in summer, fall, and winter for all kinds of livestock. Where possible, put fences on the boundaries between range sites. The Wet Land range sites can be managed best when fences separate them from Shallow range sites. This is because the two range sites have two different combinations of grasses, and if such range sites are fenced together, grazing the whole pasture uniformly is difficult.

Proper kinds of grazing animals.—Select the kind of grazing animals that are best suited to the vegetation and the condition of the range. Most of the range in Kimball County is best suited to cattle. Sheep also do very well on it.

Forage production

The production of available forage on rangeland varies from year to year and from one range site to another. This production varies mainly because of the differences in the total and seasonal precipitation, in the kinds of vegetation, and in the vigor of plants. In determining the amount of forage that can be grazed, the growth of the current grazing season is used as a guide and no more than half should be taken. In very favorable years, the amount of ungrazed forage may equal or exceed the total growth during an unfavorable year. Table 4 gives the relative productivity of the range sites in Kimball County when range vegetation is in excellent, good, fair, and poor condition. All four condition classes may be seen in either wet or dry years, since these classes reflect the effects of past grazing history on a particular pasture.

TABLE 4.—*Relative productivity of range sites*

[Based on a productivity of 100 for the Silty range site in excellent condition]

Range site	Range condition			
	Excellent	Good	Fair	Poor
Wet Land	300	225	150	75
Overflow	133	100	67	33
Sands	100	75	50	25
Sandy	100	75	50	25
Silty	100	75	50	25
Shallow	75	56	37	19
Very Shallow	33	25	17	8

Use and Management of Woodland [3]

Native woodland does not occur in large areas in Kimball County. Some willows and cottonwoods grow along the streams, and scattered, scrubby ponderosa pine trees are in some of the rough, broken canyon areas. The only natural stand of limber pine (*Pinus flexilis*) in Nebraska is in a small area in the extreme southwestern part of the county. Scattered juniper also grow in this area. Because of the small number and limited growth of the trees, the native woodland in Kimball County has little commercial value.

Windbreaks

Under proper care and management, trees as windbreaks can be grown in Kimball County. The benefits from windbreaks more than pay for the expense and labor of their establishment and maintenance. The protection in winter for the farm home cuts heating costs nearly in half. Wind velocities in the farmstead area and the blowing of snow and soil are reduced, and drifting of snow in the yards is prevented during winter (fig. 21). Windbreaks also provide shelter for livestock and, by protecting them in feedlots, reduce the feed requirements.

To protect farm buildings and feedlots in winter, the windbreaks should be wide enough—seven to ten rows of trees—to hold most of the snow within the trees. The windbreaks should be located on the north and west sides of the area to be protected. They should not be closer than 100 feet from the main buildings. A combination of shrubs, low trees, medium-height trees, and tall trees should be included in the windbreaks to provide a satisfactory barrier. For adequate winter protection and longer life, a windbreak should be made up of at least 50 percent conifers. Redcedar makes an excellent outside row because its branches grow close to the ground.

[3] This subsection was written by SIDNEY S. BURTON, woodland conservationist, Soil Conservation Service.

Figure 21.—**Good windbreaks can be grown in Kimball County.**

Field windbreaks are of particular value in controlling wind erosion on some of the lighter textured cultivated soils. A complete system of field windbreaks helps to control soil blowing, increases soil moisture by holding snow on the fields, prevents damage to crops from strong winds, reduces evaporation, and furnishes food and cover for wildlife.

Tree belts protect for a distance of about 20 times the height of the trees. For this reason, complete protection of large fields can be obtained only by planting a series of belts at regular intervals across the field. Wide belts are not needed for field protection, but the belts should consist of trees that have dense foliage and do not take much moisture from the field. Belts of one to three rows of trees, chiefly of redcedar and pine, are suggested.

Tree planting

The proper preparation of the soil for planting trees varies for different sites. Summer fallow is desirable to store moisture in the heavier textured soils and in all sod ground. Prepare only a narrow band of fallow for each row of trees. Between the rows establish a cover crop before the trees are planted so that the small trees will be protected from strong winds and drifting soil.

The soils of Kimball County have been grouped into six woodland planting sites according to the capacity of the sites to sustain similar tree growth. These woodland sites are discussed in the following pages, and suitable trees and shrubs for the different sites are listed.

SILTY TO CLAYEY WOODLAND SITE

This woodland site consists of deep, well-drained, silty and clayey soils. Some of these soils have a claypan layer. The site occupies a large part of the county and is expected to be one on which much tree planting will be done. The soils in this site are:

Altvan loam, deep, 0 to 1 percent slopes.
Altvan loam, deep, 1 to 3 percent slopes.
Altvan loam, deep, 3 to 5 percent slopes.
Altvan loam, deep, 5 to 9 percent slopes.
Altvan loam, moderately deep, 1 to 3 percent slopes.

Altvan loam, moderately deep, 3 to 5 percent slopes.
Altvan loam, moderately deep, 5 to 9 percent slopes.
Bridgeport loam, 1 to 3 percent slopes.
Bridgeport loam, 3 to 5 percent slopes.
Cheyenne loam, 0 to 1 percent slopes.
Cheyenne loam, 1 to 3 percent slopes.
Goshen loam, 0 to 1 percent slopes.
Goshen loam, 1 to 3 percent slopes.
Havre silt loam.
Keith loam, 0 to 1 percent slopes.
Keith loam, 1 to 3 percent slopes.
Keith loam, 3 to 5 percent slopes.
Rosebud loam, deep, 0 to 1 percent slopes.
Rosebud loam, deep, 1 to 3 percent slopes.
Rosebud loam, deep, 3 to 5 percent slopes.
Rosebud loam, deep, 5 to 9 percent slopes.
Rosebud loam, moderately deep, 0 to 1 percent slopes.
Rosebud loam, moderately deep, 1 to 3 percent slopes.
Rosebud loam, moderately deep, 3 to 5 percent slopes.
Rosebud loam, moderately deep, 5 to 9 percent slopes.
Rosebud loam, 9 to 15 percent slopes.
Tripp loam, 0 to 1 percent slopes.
Tripp loam, 1 to 3 percent slopes.
Tripp loam, 3 to 5 percent slopes.
Tripp loam, 5 to 9 percent slopes.

If trees can be established, their growth will be generally satisfactory. Wind, blowing soil, and drought are the chief hazards to establishment. To overcome these hazards, keep the soils fallow in summer before planting, plant cover crops, cultivate, and, if practical, water the young trees by diverting water from other areas or by other means.

Suitable species for planting are the *shrubs*, cotoneaster, lilac, sumac, and chokecherry; the *conifers*, redcedar, Rocky Mountain juniper, and ponderosa pine; and the *broad-leaved* trees, Russian-olive, boxelder, honeylocust, hackberry, Siberian elm, and green ash.

SANDY WOODLAND SITE

This woodland site consists of slightly sandy soils and nearly level, very sandy soils. Although these soils are not extensive in Kimball County, they occur in sites suitable for tree planting. The soils in this site are:

Altvan fine sandy loam, deep, 1 to 3 percent slopes.
Bayard fine sandy loam, 1 to 5 percent slopes.
Chappell sandy loam, 1 to 3 percent slopes.
Chappell sandy loam, 3 to 5 percent slopes.
Chappell sandy loam, 5 to 9 percent slopes.
Dwyer loamy sand.
Glendive fine sandy loam.
Parshall sandy loam, deep, 0 to 1 percent slopes.
Parshall sandy loam, deep, 1 to 5 percent slopes.
Parshall sandy loam, deep, 5 to 9 percent slopes.
Parshall sandy loam, moderately deep, 0 to 1 percent slopes.
Parshall sandy loam, moderately deep, 1 to 5 percent slopes.
Tripp fine sandy loam, 0 to 1 percent slopes.
Tripp fine sandy loam, 1 to 3 percent slopes.
Tripp fine sandy loam, 3 to 5 percent slopes.
Vebar sandy loam, 0 to 3 percent slopes.
Vebar sandy loam, 3 to 5 percent slopes.
Vebar sandy loam, 5 to 9 percent slopes.
Vebar sandy loam, 9 to 15 percent slopes.

Soil blowing is a hazard on these soils. To overcome this hazard, cultivate only in the tree rows and leave a strip of growing vegetation or stubble between the rows.

Suitable species for planting are the *shrubs*, American plum, cotoneaster, three-leaved sumac, and western sandcherry; the *conifers*, redcedar, Rocky Mountain juniper, and ponderosa pine; and the *broad-leaved* trees, boxelder, Russian mulberry, honeylocust, Siberian elm, and green ash.

MODERATELY WET WOODLAND SITE

This woodland site consists of soils of the bottom lands, upland valleys, and depressions on uplands that are occasionally wet because of a high water table or flooding. Some areas are frequently flooded for short periods. The soils in this site are:

Loamy alluvial land.
Scott silt loam.

Because these soils occur in wet sites that are only fair for trees, they should be planted only to water-tolerant trees and shrubs.

Suitable species for planting are the *shrubs*, purple willow, basket willow, red-osier dogwood, buffaloberry, and western chokecherry; the *conifer*, redcedar can be planted on the drier sites; and the *broad-leaved* trees, boxelder, diamond willow, Russian-olive, green ash, golden willow, white willow, cottonwood, and Siberian elm.

WET WOODLAND SITE

This woodland site consists of only one soil—Wet alluvial land. This soil occurs on the bottom lands and is extremely wet because of flooding, a high water table, or poor drainage.

Extreme wetness is a factor limiting the establishment of trees on these soils. Only water-tolerant trees can survive on these very wet soils.

Suitable species for planting are the *shrubs*, purple willow, basket willow, and red-osier dogwood; and the *broad-leaved* trees, diamond willow, golden willow, white willow, and cottonwood.

SHALLOW WOODLAND SITE

This woodland site consists of soils that are shallow over bedrock, shale, or gravel. Some of the scattered native pine and juniper in the county are on these soils. The soils in this site are:

Canyon loam, 0 to 5 percent slopes.
Canyon loam, 0 to 5 percent slopes, eroded.
Canyon loam, 9 to 20 percent slopes.
Canyon sandy loam, 0 to 5 percent slopes.
Canyon sandy loam, 9 to 20 percent slopes.
Canyon-Rosebud loams, 5 to 9 percent slopes.
Canyon-Rosebud loams, 5 to 9 percent slopes, eroded.
Canyon-Vebar sandy loams, 5 to 9 percent slopes.
Dix loams, 3 to 9 percent slopes.
Dix complex, 9 to 20 percent slopes.
Sandy alluvial land.

Tree planting is extremely difficult on these sites. Because of the location of these soils and their use, windbreaks are seldom needed. If tree plantings are desired, thorough examination of the proposed site should be made before planting to locate the areas of deeper soils. Although some areas of these soils can be successfully planted, trees are not generally suggested.

SOILS NOT SUITED TO TREES

This woodland site consists of strongly saline or alkali soils, steep, very shallow soils, and riverwash. The soils in this site are:

Canyon complex, 0 to 9 percent slopes.
Canyon complex, 9 to 20 percent slopes.
Gravelly land.
Riverwash.
Rock land.

Trees cannot be successfully established on these soils, although occasionally natural growth of sandbar willow may occur on Riverwash.

Maintenance of tree plantings

The establishment of trees in the High Plains region largely depends on proper care and protection. Keep a cover crop or stubble between the rows in a windbreak for at least 3 years after planting the trees. Clean cultivate the rows of trees until they form a canopy that will shade out weeds and grass. Water the trees occasionally during dry weather to help establish them. Possibly, you can divert runoff from other areas to the windbreaks to provide additional water.

Assistance in planning a windbreak can be obtained from technicians of the Soil Conservation Service or the county agricultural agent.

Engineering Applications [4]

This soil survey report of Kimball County, Nebraska, contains information helpful to engineers in—

1. Making studies for soil and land use that will aid in the selection and development of industrial, business, residential, and recreational sites.
2. Making estimates of runoff and erosion characteristics for use in designing structures and planning dams and other structures for water and soil conservation.
3. Making reconnaissance surveys of soil and ground conditions that will aid in the selection of highway and airport locations and in planning detailed soil studies for the intended locations.
4. Estimating drainage areas and runoff characteristics for use in designing culverts and bridges.
5. Classifying soils along the proposed highway route and using this information in making preliminary estimates of the required thickness of flexible pavements.
6. Estimating the necessity of clay surfacing on nonpaved roads.
7. Locating deposits of sand, gravel, rock, mineral filler, and soil binder for use in construction of subbase courses, base courses, and surface courses of flexible pavements for highways and other structures.
8. Estimating terrain conditions such as topography, surface drainage, subsurface drainage, and height of water table, in connection with the design of highway embankments, subgrades, and pavements.
9. Correlating structure performance with types of soil and thus developing information that will be useful in designing and maintaining such structures.
10. Determining the suitability of soils for cross-country movements of vehicles and construction equipment.
11. Supplementing information obtained from other published maps and reports and from aerial photographs for the purpose of making soil

[4] This section was prepared in part by the Division of Materials and Tests, Nebraska Department of Roads; the U.S. Bureau of Public Roads; and the Nebraska State Engineering Office, Soil Conservation Service.

TABLE 5.—*Engineering*

Soil name and location	Parent or underlying material	Nebraska Department of Roads or Bureau of Public Roads report No.	Depth	Horizon [2]	Moisture-density: Maximum dry density	Moisture-density: Optimum moisture	Mechanical analysis [3] — Percentage passing sieve: 2 in.	1½ in.	1 in.	¾ in.
			Inches		*Lb. per cu. ft.*	*Percent*				
Altvan loam, deep:										
300 feet north and 100 feet west of SE. corner, sec. 30, T. 16 N., R. 57 W. (Modal profile.)	Loess over gravel	S32344	0–6	A_{1p}	107	17	------	------	------	100
		S32345	11–17	B_{21}	105	18	------	------	------	------
		S32346	27–32	C_1	117	13	------	------	------	100
60 feet south and 480 feet west of N¼ corner, sec. 31, T. 16 N., R. 58 W. (Modal profile.)	Loess over gravel	S32347	0–6	A_{1p}	112	12	------	------	------	100
		S32348	12–18	B_{21}	99	21	------	------	------	------
		S32349	26–32	C_1	111	16	------	100	99	97
75 feet north and 120 feet east of S¼ corner, sec. 3, T. 15 N., R. 54 W. (Minimal profile.)	Loess over gravel	S32350	0–6	A_p	112	14	------	------	------	100
		S32351	6–11	B_2	107	17	------	------	------	------
		S32352	22–38	C_1	110	15	------	------	------	------
210 feet south and 60 feet east of NW. corner, sec. 11, T. 15 N., R. 54 W. (Maximal profile.)	Loess over gravel	S32353	0–6	A_p	109	15	------	------	------	100
		S32354	11–15	B_{21}	97	23	------	------	------	------
		S32355	29–36	C_1	120	11	100	99	99	99

See footnotes at end of table.

maps and reports that can be readily used by engineers.

Most areas in a mapping unit have soil material like that described in the soil descriptions, but in some mapping units small inclusions occur that differ from the rest of the mapping unit. The descriptions of the mapping units and the tabular data, therefore, should be used only in planning. They should be supplemented by detailed field studies that are made to determine the condition of the soil in place at the site of the proposed engineering construction.

Soil science terminology

Some of the terms used by the agricultural soil scientist may be unfamiliar to the engineer, and some words—for example, soil, clay, silt, sand, and aggregate—have special meaning in soil science. These and other special terms that are used in the soil survey report are defined in the Glossary.

Soil test data and engineering soil classification

To be able to make the best use of the soil maps and the soil survey reports, the engineer should know the physical properties of the soil materials and the condition of the soil in place. After testing soil materials and observing the behavior of soils in engineering structures and foundations, the engineer can develop design recommendations for the soil units delineated on the maps. In this subsection, soil test data on some of the soils are presented in table 5, and the AASHO and Unified systems of soil classification used in engineering are explained.

SOIL TEST DATA

Samples of 8 different soil types were taken at 30 different sites by members of the Soil Conservation Service and were tested by the Bureau of Public Roads. In addition, samples of 6 different soil types from 7 sites were tested by the Division of Materials and Tests, Nebraska Department of Roads. All these tests were made according to the standard procedures of the American Association of State Highway Officials (AASHO) (*2*). The test data are given in table 5.

Some of the soil test data in table 5 are from samples obtained and tested in soil surveys of highway projects located in Kimball County. Each soil was sampled by natural horizons, but the terminology used by the Nebraska Department of Roads in describing each horizon differs from that used by the Soil Conservation Service. Therefore, the horizons of the soils tested by the Nebraska Department of Roads are described as upper, middle, and lower. For an explanation of symbols designating horizon for the soils tested by the Bureau of Public Roads, see the Glossary of this report and the "Soil Survey Manual" (*9*).

The soils listed in table 5 were sampled in one or more locations. The test data for a soil sampled in only one location indicate the engineering characteristics for the soil at that location. It must be recognized that there may be variations in the physical test characteristics of the soil at other locations in the county. Even for those soils sampled in more than one location, the test data probably do not show the maximum range in characteristics of materials that may be found.

test data [1]

Mechanical analysis [3]—Continued										Liquid limit	Plasticity index	Classification	
Percentage passing sieve—Continued						Percentage smaller than—							
⅜ in.	No. 4 (4.76 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.			AASHO [4]	Unified [5]
99	97	92	77	72	59	51	35	20	17	30	10	A-4(5)	CL.
100	99	91	81	76	67	61	43	29	24	39	18	A-6(10)	CL.
99	96	90	73	65	47	36	22	15	12	26	8	A-4(2)	SC.
99	96	90	72	67	58	50	32	18	14	29	8	A-4(5)	CL.
------	------	100	93	91	85	77	53	37	33	43	20	A-7-6(13)	CL.
93	89	80	62	55	46	41	27	20	15	31	10	A-4(2)	SC.
99	97	94	83	76	60	50	33	21	15	27	8	A-4(5)	CL.
100	99	95	84	78	64	54	38	27	23	36	18	A-6(9)	CL.
100	99	97	88	82	65	52	34	20	16	28	8	A-4(6)	CL.
99	97	93	82	77	69	58	36	22	16	30	8	A-4(7)	CL.
------	------	100	96	94	89	82	58	41	37	49	25	A-7-6(16)	CL.
97	93	86	70	61	40	30	20	14	11	25	8	A-4(1)	SC.

TABLE 5.—*Engineering*

Soil name and location	Parent or underlying material	Nebraska Department of Roads or Bureau of Public Roads report No.	Depth	Horizon [2]	Moisture-density: Maximum dry density	Moisture-density: Optimum moisture	Mechanical analysis [3] — Percentage passing sieve: 2 in.	1½ in.	1 in.	¾ in.
			Inches		*Lb. per cu. ft.*	*Percent*				
Altvan loam, moderately deep: 500 feet north and 100 feet east of SW. corner, sec. 29, T. 16 N., R. 57 W. (Modal profile.)	Loess underlain by outwash gravel at depth of 30 inches.	S32380	0–6	A_{1p}	118	13	------	------	------	100
		S32381	15–24	B_2	104	19	------	------	------	------
		S32382	30–48+	D	124	10	------	------	------	100
0.2 mile west and 90 feet north of SE. corner, sec. 30, T. 16 N., R. 58 W. (Maximal profile.)	Loess underlain by outwash gravel at depth of 24 inches.	S32383	0–8	A_p	121	10	------	------	------	100
		S32384	11–16	B_2	108	17	------	------	------	------
		S32385	24–40+	D	127	9	------	------	100	99
0.1 mile east and 110 feet north of SW. corner, sec. 31, T. 16 N., R. 56 W. (Minimal profile.)	Loess underlain by outwash gravel at depth of 27 inches.	S32386	0–5	A_{1p}	124	10	------	------	------	100
		S32387	13–18	A_e	114	14	------	------	------	------
		S32388	27–33+	D	124	9	------	100	99	99
Bridgeport loam: 1,200 feet west and 35 feet south of NE. corner, sec. 4, T. 14 N., R. 53 W.	Colluvial silts and sands.	S54–3614	18–48	Middle	106	17	------	------	------	100
Canyon loam: 0.3 mile west and 250 feet north of SE. corner, sec. 3, T. 13 N., R. 55 W. (Modal profile. Eroded.)	Tertiary sediments with limestone fragments; Ogallala formation at depth of 18 inches.	S32313	0–6	A_{1p}	113	14	------	100	98	96
		S32314	11–18	C_1	109	16	------	100	97	95
300 feet east and 140 feet north of S¼ corner, sec. 27, T. 13 N., R. 56 W. (Modal profile. Eroded.)	Tertiary sediments with limestone fragments; Ogallala formation at depth of 16 inches.	S32315	0–4	A_{1p}	111	14	------	------	------	100
		S32316	9–16	C	103	19	100	98	94	92
500 feet south of E¼ corner, sec. 18, T. 14 N., R. 56 W. (Maximal profile.)	Tertiary sandstone with limestone fragments.	S32318	0–5	A_{1p}	113	13	------	------	------	100
		S32319	17–21	C	115	13	------	------	------	100
Canyon sandy loam: 330 feet north of E¼ corner, sec. 18, T. 14 N., R. 56 W. (Minimal profile.)	Limestone; Ogallala formation at depth of 14 inches.	S32317	0–7	A_p	114	12	------	100	99	98
Glendive fine sandy loam: 3,145 feet southeast on U.S. Highway 30 and 35 feet south of NW. corner, sec. 33, T. 15 N., R. 56 W.	Alluvial sands and silts.	S54–3436	0–60	Upper	------	------	------	------	------	------
Goshen loam: 2,650 feet south and 40 feet west of NE. corner, sec. 7, T. 16 N., R. 55 W.	Loess	S57–1005	0–24	Upper	------	------	------	------	------	------
Keith loam: 0.25 mile south and 30 feet west of NE. corner, sec. 16, T. 16 N., R. 54 W. (Modal profile.)	Loess	S32320	0–5	A_{1p}	112	15	------	------	------	------
		S32321	10–18	B_{21}	101	21	------	------	------	------
		S32322	40–57	C_3	111	15	------	------	------	------

See footnotes at end of table.

test data [1]—Continued

Mechanical analysis [3]—Continued										Liquid limit	Plasticity index	Classification	
Percentage passing sieve—Continued						Percentage smaller than—						AASHO [4]	Unified [5]
⅜ in.	No. 4 (4.76 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
99	96	87	66	60	48	40	25	15	11	26	5	A-4(3)	SM-SC.
100	99	97	89	85	78	72	48	33	29	47	23	A-7-6(15)	CL.
99	95	81	30	20	11	10	7	6	6	[6]	[6]	A-1-b(0)	SW-SM.
98	93	83	60	51	39	32	21	14	11	25	7	A-4(1)	SM-SC.
100	99	97	84	78	67	59	42	32	26	38	17	A-6(9)	CL.
96	89	78	45	32	18	16	12	9	8	19	4	A-1-b(0)	SM-SC.
99	96	86	63	51	29	23	16	11	9	21	4	A-2-4(0)	SM-SC.
100	99	96	79	66	45	38	28	22	19	30	13	A-6(3)	SC.
98	94	79	30	19	10	9	7	7	6	[6]	[6]	A-1-b(0)	SW-SM.
94	91	89	81	[7] 77	56	36	--------	16	--------	28	7	A-4(4)	CL-ML.
94	92	88	73	62	44	35	25	18	14	27	9	A-4(2)	SC.
91	87	82	66	57	45	39	30	25	20	34	14	A-6(3)	SC.
99	98	95	84	76	49	40	28	18	14	26	6	A-4(3)	SM-SC.
89	87	85	73	66	49	43	32	24	17	36	14	A-6(4)	SC.
99	97	93	84	75	46	33	20	14	11	23	4	A-4(2)	SM-SC.
98	93	82	66	59	36	30	22	16	13	28	10	A-4(0)	SC.
95	93	89	78	66	33	25	17	12	9	[6]	[6]	A-2-4(0)	SM.
------	100	99	86	[7] 80	50	33	--------	15	--------	24	5	A-4(3)	SM-SC.
------	100	98	92	[7] 89	69	48	--------	16	--------	29	2	A-4(7)	ML.
------	--------	100	91	85	70	58	36	22	19	28	8	A-4(7)	CL.
------	--------	100	98	96	89	79	52	36	31	40	17	A-6(11)	CL.
------	--------	100	96	92	79	60	32	18	14	26	5	A-4(8)	CL-ML.

TABLE 5.—*Engineering*

Soil name and location	Parent or underlying material	Nebraska Department of Roads or Bureau of Public Roads report No.	Depth	Horizon[2]	Moisture-density: Maximum dry density	Moisture-density: Optimum moisture	Mechanical analysis[3] — Percentage passing sieve: 2 in.	1½ in.	1 in.	¾ in.
			Inches		*Lb. per cu. ft.*	*Percent*				
Keith loam—Continued										
0.4 mile north and 100 feet east of SW. corner, sec. 18, T. 16 N., R. 53 W. (Modal profile.)	Loess	S32323	0–6	A_{1p}	108	16	----	----	----	----
		S32324	11–17	B_{21}	100	21	----	----	----	----
		S32325	41–55	C_3	106	17	----	----	----	----
900 feet south and 150 feet east of NW. corner, sec. 16, T. 16 N., R. 53 W. (Maximal profile.)	Loess	S32326	0–6	A_{1p}	108	17	----	----	----	----
		S32327	8–14	B_{21}	97	21	----	----	----	----
		S32328	20–29	C_{ca}	103	20	----	----	----	----
0.15 mile west and 45 feet north of SE. corner, sec. 33, T. 16 N., R. 56 W. (Minimal profile.)	Loess	S32329	0–5	A_{1p}	120	11	----	----	----	----
		S32330	9–14	B_{21}	114	14	----	----	----	----
		S32331	34–59	C_2	119	13	----	----	----	----
Parshall sandy loam, moderately deep:										
950 feet west and 95 feet south of NE. corner, sec. 2, T. 14 N., R. 54 W.	Wind-modified sand over alluvial sand and gravel.	S54–3573	0–48	Upper	----	----	----	----	----	----
Rock land:										
2,390 feet south and 40 feet west of NE. corner, sec. 30, T. 14 N., R. 55 W.	Algal limestone and caliche.	S55–4528	0–108	Upper	----	----	----	----	----	----
	Sandstone of the Kimball Formation.	S55–4529	108–228	Lower	----	----	----	----	----	----
Rosebud loam, deep:										
0.15 mile east and 420 feet north of SW. corner, sec. 9, T. 13 N., R. 53 W. (Modal profile.)	Loess over Tertiary sediments, with granitic gravel and limestone fragments; Ogallala formation at depth of 24 inches.	S32332	0–6	A_{1p}	109	15	----	----	----	100
		S32333	11–20	B_2	102	20	----	----	----	----
		S32334	23–28	C_1	105	18	----	----	----	----
0.1 mile west and 150 feet north of S¼ corner, sec. 12, T. 14 N., R. 55 W. (Maximal profile.)	Loess over Tertiary gravel and sandstone fragments; Ogallala formation at depth of 36 inches.	S32338	0–6	A_p	112	14	----	----	----	----
		S32339	9–15	B_{22}	104	19	----	----	----	----
		S32340	15–25	C_{ca}	108	17	----	----	----	----
0.4 mile east and 100 feet north of W¼ corner, sec. 24, T. 14 N., R. 58 W. (Minimal profile.)	Loess over Tertiary sediments; Ogallala formation at depth of 38 inches.	S32335	0–6	A_{1p}	112	14	----	----	----	----
		S32336	10–15	B_{21}	112	15	----	----	----	----
		S32337	26–32	C_1	106	18	----	----	----	----
0.23 mile north and 50 feet west of SE. corner, sec. 27, T. 14 N., R. 54 W. (Modal profile.)	Loess over Tertiary sediments with granitic gravel and limestone fragments; Ogallala formation at depth of 37 inches.	S32341	0–6	A_{1p}	111	14	----	----	----	----
		S32342	10–20	B_2	107	16	----	----	----	----
		S32343	23–30	C_1	110	15	----	----	----	----

See footnotes at end of table.

test data [1]—Continued

Mechanical analysis [3]—Continued										Liquid limit	Plasticity index	Classification	
Percentage passing sieve—Continued						Percentage smaller than—						AASHO [4]	Unified [5]
⅜ in.	No. 4 (4.76 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
------	------	100	96	93	80	68	42	26	21	30	10	A-4(8)	CL.
------	------	------	100	99	93	82	53	36	30	41	17	A-7-6(11)	CL.
------	------	------	100	99	89	73	37	21	16	26	4	A-4(8)	ML.
100	99	97	91	88	78	66	40	24	20	30	9	A-4(8)	CL.
------	------	100	98	96	89	80	53	40	36	47	24	A-7-6(15)	CL.
------	------	100	99	98	92	79	46	27	20	32	8	A-4(8)	ML.
------	------	100	83	70	40	31	20	14	11	22	5	A-4(1)	SM-SC.
------	------	100	90	77	48	38	25	19	17	28	10	A-4(3)	SC.
------	------	100	91	80	46	31	19	12	10	23	5	A-4(2)	SM-SC.
100	99	80	28	[7] 19	10	6	------	4	------	[6]	[6]	A-2-4(0)	SW-SM.
------	------	100	76	[7] 69	42	23	------	8	------	[6]	[6]	A-4(1)	SM.
------	------	100	86	[7] 80	40	18	------	5	------	[6]	[6]	A-4(1)	SM.
99	98	95	86	81	72	62	38	22	18	30	8	A-4(7)	CL.
------	------	100	95	92	84	77	52	38	33	46	23	A-7-6(14)	CL.
------	------	100	95	90	78	68	43	28	21	35	13	A-6(9)	CL.
100	99	96	84	78	63	54	36	23	16	28	9	A-4(6)	CL.
------	------	100	92	88	79	70	49	35	31	44	22	A-7-6(14)	CL.
------	------	100	94	90	75	63	39	26	19	30	10	A-4(8)	CL.
------	100	99	95	91	61	47	31	21	17	25	6	A-4(5)	CL-ML.
------	------	100	96	92	67	51	34	25	20	28	9	A-4(6)	CL.
------	------	100	98	96	80	65	40	27	20	30	9	A-4(8)	CL.
------	------	100	86	78	63	53	35	22	17	28	9	A-4(6)	CL.
------	------	100	89	81	67	59	41	29	24	37	18	A-6(10)	CL.
------	------	100	93	87	70	58	38	27	21	31	11	A-6(7)	CL.

TABLE 5.—*Engineering*

Soil name and location	Parent or underlying material	Nebraska Department of Roads or Bureau of Public Roads report No.	Depth	Horizon [2]	Moisture-density: Maximum dry density	Moisture-density: Optimum moisture	Mechanical analysis [3] — Percentage passing sieve: 2 in.	1½ in.	1 in.	¾ in.
			Inches		*Lb. per cu. ft.*	*Percent*				
Rosebud loam, moderately deep:										
0.35 mile east and 100 feet north of SW. corner, sec. 3, T. 13 N., R. 53 W. (Modal profile.)	Tertiary calcareous sandstone.	S32356	0–7	A_{1p}	106	16	----	----	----	----
		S32357	7–15	B_{ca}	104	18	----	----	----	----
		S32358	15–26	C_1	106	18	----	----	----	----
0.1 mile west and 120 feet north of SE. corner, sec. 35, T. 13 N., R. 54 W. (Modal profile.)	Tertiary calcareous sandstone.	S32359	0–6	A_{1p}	109	16	----	----	----	----
		S32360	10–16	B_{ca}	96	23	----	----	----	----
		S32361	16–28	C_1	99	22	100	99	99	99
210 feet south and 45 feet east of W¼ corner, sec. 31, T. 16 N., R. 56 W. (Maximal profile.)	Tertiary sandy limestone with some loess.	S32365	0–6	A_p	108	17	----	----	----	----
		S32366	13–17	B_{21}	104	19	----	----	----	----
		S32367	17–23	C	100	21	----	----	----	----
150 feet south and 660 feet east of N¼ corner, sec. 8, T. 13 N., R. 53 W. (Minimal profile.)	Tertiary sandy limestone of the Ogallala formation.	S32362	0–5	A_{1p}	111	15	----	----	----	----
		S32363	10–17	B_2	105	19	----	----	----	----
		S32364	17–23	C	104	19	----	----	----	----
60 feet north and 330 feet east of SW. corner, sec. 30, T. 13 N., R. 56 W. (Modal profile. Eroded.)	Loess over Tertiary sediments with gravel and limestone fragments.	S32368	0–4	A_{1p}	107	17	----	----	----	----
		S32369	4–12	B_2	96	23	----	----	----	----
		S32370	15–22	C_1	101	21	----	----	----	----
0.25 mile west of NE. corner, sec. 22, T. 13 N., R. 54 W. (Maximal profile.)	Loess over Tertiary limestone of the Ogallala formation.	S32374	0–5	A_{1p}	107	17	----	----	----	----
		S32375	7–13	B_2	97	22	----	----	----	----
		S32376	13–17	C_{ca}	95	25	----	----	----	----
50 feet north and 60 feet west of SE. corner, sec. 19, T. 13 N., R. 57 W. (Minimal profile.)	Loess over Tertiary sandstone.	S32371	0–6	A_p	104	18	----	----	----	----
		S32372	9–18	B_2	97	22	----	----	----	----
		S32373	18–25	C	95	25	----	----	----	----
135 feet north and 720 feet east of S¼ corner, sec. 4, T. 13 N., R. 55 W. (Modal profile. Eroded.)	Loess over Tertiary sandstone with gravel.	S32377	0–4	A_{1p}	108	15	----	----	----	----
		S32378	4–11	B_2	102	19	----	----	----	----
		S32379	19–23	C_2	116	14	----	100	99	98
Tripp loam:										
445 feet southeast on U.S. Highway 30 and 35 feet south of NW. corner, sec. 33, T. 15 N., R. 55 W.	Alluvial silts	S54-3422	0–30	Upper	----	----	----	----	----	----
		S54-3423	30–48	Middle	----	----	----	----	----	100
945 feet southeast on Highway 30 and 35 feet south of NW. corner, sec. 33, T. 15 N., R. 55 W.	Alluvial silts	S54-3424	0–18	Upper	----	----	----	----	----	----
		S54-3425	18–36	Middle	----	----	----	----	----	----
		S54-3426	36–48	Lower	----	----	----	----	----	----

See footnotes at end of table.

test data [1]—Continued

Mechanical analysis [3]—Continued										Liquid limit	Plasticity index	Classification	
Percentage passing sieve—Continued						Percentage smaller than—							
¾ in.	No. 4 (4.76 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.			AASHO [4]	Unified [5]
100	99	97	89	80	62	51	35	23	18	32	10	A-4(5)	CL.
------	100	99	90	82	66	56	41	32	26	38	16	A-6(9)	CL.
------	------	100	92	85	65	56	37	27	21	31	12	A-6(7)	CL.
------	------	100	90	80	59	49	33	21	16	29	10	A-4(5)	CL.
------	------	100	95	90	80	74	54	39	34	47	21	A-7-6(14)	CL.
98	97	96	88	82	72	65	50	36	29	42	17	A-7-6(11)	CL.
------	------	100	91	84	70	58	37	25	20	31	11	A-6(7)	CL.
------	------	100	95	90	77	67	46	33	28	40	19	A-6(12)	CL.
------	------	100	97	95	85	70	43	29	22	36	13	A-6(9)	CL.
100	99	97	84	77	54	44	27	17	14	27	6	A-4(4)	CL-ML.
100	99	98	87	79	61	50	33	22	18	33	12	A-6(6)	CL.
------	------	100	89	81	61	51	36	26	20	32	12	A-6(6)	CL.
------	------	100	94	88	71	63	43	28	22	32	13	A-6(8)	CL.
------	------	100	98	95	84	76	56	42	38	52	28	A-7-6(18)	CH.
------	------	100	99	96	82	74	52	38	33	41	18	A-7-6(11)	CL.
------	------	100	96	92	83	73	47	29	23	33	11	A-6(8)	CL.
------	------	100	98	97	93	86	61	42	36	49	24	A-7-6(15)	CL.
------	------	100	98	96	89	82	55	37	30	44	17	A-7-6(12)	ML.
------	------	100	93	84	63	52	36	26	21	30	12	A-6(6)	CL.
------	------	100	96	90	63	54	39	30	24	34	14	A-6(7)	CL.
------	------	100	92	79	40	33	23	14	11	21	5	A-4(1)	SM-SC.
------	------	100	90	81	65	57	38	24	20	30	11	A-6(6)	CL.
------	------	100	94	87	72	64	46	34	29	41	19	A-7-6(11)	CL.
96	95	93	76	65	44	37	29	21	17	26	8	A-4(2)	SC.
100	97	92	76	[7] 70	36	22	--------	10	--------	21	3	A-4(0)	SM.
82	81	78	63	[7] 58	35	23	--------	9	--------	27	7	A-2-4(0)	SM-SC.
100	98	96	85	[7] 78	39	30	--------	16	--------	20	3	A-4(1)	SM.
------	------	100	89	[7] 83	54	37	--------	16	--------	25	6	A-4(4)	CL-ML.
------	------	100	97	[7] 95	84	34	--------	27	--------	35	13	A-6(9)	CL.

TABLE 5.—*Engineering*

Soil name and location	Parent or underlying material	Nebraska Department of Roads or Bureau of Public Roads report No.	Depth	Horizon [2]	Moisture-density: Maximum dry density	Moisture-density: Optimum moisture	Mechanical analysis [3] — Percentage passing sieve: 2 in.	1½ in.	1 in.	¾ in.
			Inches		*Lb. per cu. ft.*	*Percent*				
Vebar sandy loam: 310 feet east of N¼ corner, sec. 3, T. 14 N., R. 54 W. (Modal profile.)	Tertiary sandstone at depth of 36 inches.	S32389	0–7	A_p	120	11				
		S32390	7–14	B_2	120	12				
		S32391	25–36	C_1	124	10				
250 feet north and 120 feet east of W¼ corner, sec. 11, T. 14 N., R. 54 W. (Maximal profile.)	Tertiary sandstone at depth of 48 inches.	S32395	0–6	A_p	120	11				
		S32396	9–16	B_{21}	114	14				
		S32397	29–48+	C	121	11				
0.4 mile south and 75 feet west of NE. corner, sec. 4, T. 13 N., R. 58 W. (Minimal profile.)	Tertiary sandstone at depth of 40 inches.	S32392	0–6	A_p	117	11				
		S32393	6–14	B_2	114	14				
		S32394	21–40	C	114	14				100

[1] Tests performed by the Bureau of Public Roads and the Division of Materials and Tests, Nebraska Department of Roads, in accordance with standard procedures of the American Association of State Highway Officials (AASHO).

[2] For an explanation of the symbols describing the horizons in the soils tested by the Bureau of Public Roads, see the Glossary at the back of this report and the "Soil Survey Manual."

[3] Mechanical analysis according to the American Association of State Highway Officials Designation T 88. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette

The engineering soil classifications in table 5 are based on data obtained by mechanical analysis and by tests to determine liquid limits and plastic limits. The mechanical analysis data for each soil sample identified in table 5 were obtained by a combination of sieve and hydrometer analyses. Percentages of clay obtained by the hydrometer method should not be used in naming soil textural classes.

The liquid limit and plastic limit tests measure the effects of water on the consistence of the soil material. As the moisture content of a clay soil increases from a very dry state, the material changes from a solid to a semisolid or plastic state. As the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material passes from a solid to a plastic state. The liquid limit is the moisture content at which the material passes from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is in a plastic condition.

Table 5 also gives compaction (moisture-density) data for a number of the tested soils. If a soil material is compacted at progressively higher moisture content, assuming that the compactive force remains constant, the density of the compacted material will increase until the "optimum moisture content" is reached; after that the density decreases with increase in moisture content. The highest dry density obtained in the compaction test is termed "maximum dry density." Moisture-density data are important in earthwork, for, as a rule, optimum *test data*[1]—Continued

Mechanical analysis[3]—Continued										Liquid limit	Plasticity index	Classification	
Percentage passing sieve—Continued						Percentage smaller than—						AASHO[4]	Unified[5]
¾ in.	No. 4 (4.76 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
------	-------	100	79	68	40	30	19	14	10	22	4	A-4(1)	SM-SC.
------	100	99	76	66	41	30	23	19	16	25	8	A-4(1)	SC.
100	99	95	66	55	27	22	18	16	12	20	4	A-2-4(0)	SM-SC.
------	-------	100	80	67	43	36	23	14	11	22	4	A-4(2)	SM-SC.
------	-------	100	87	74	54	45	31	23	20	30	12	A-6(5)	CL.
------	-------	100	82	67	42	32	19	13	11	21	4	A-4(1)	SM-SC.
100	99	98	87	72	35	26	18	14	12	20	3	A-2-4(0)	SM.
100	99	97	86	74	39	30	22	16	14	24	6	A-4(1)	SM-SC.
99	98	96	84	75	50	41	35	27	19	23	7	A-4(3)	SM-SC.

method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils. The percentages of 0.02 millimeter and 0.002 millimeter size particles are not determined by the Nebraska Department of Roads.

[4] Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (Pt. 1, Ed. 7): The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, AASHO Designation M 145-49.

[5] Based on the Unified Soil Classification System. Tech. Memo. No. 3-357, v. 1, Waterways Experiment Station, Corps of Engineers, March 1953.

[6] Nonplastic.

[7] Percentage passing the No. 50 sieve. The Nebraska Department of Roads does not report the No. 60 sieve.

stability is obtained if the soil is compacted to about the maximum dry density when it is at approximately the optimum moisture content.

ENGINEERING CLASSIFICATION SYSTEMS

Most highway engineers classify soil materials in accordance with the system approved by the American Association of State Highway Officials (*2*).

Table 6 outlines the AASHO system of classification. In this system soil materials are classified in seven principal groups. The groups range from A-1, consisting of gravelly soils of high bearing capacity, to A-7, which is made up of clay soils having low strength when wet. Within each group, the relative engineering value of the material is indicated by a group index number, ranging from 0 for the best material in the soil groups A-1, A-2, and A-3, to 8, 12, 16, and 20 for the poorest soils in groups A-4, A-5, A-6, and A-7, respectively. The group index number is shown in parentheses, following the soil group symbol, in the next to last column of table 5.

Many engineers prefer to use the Unified soil classification system (*10*). In this system soils are identified by their texture and plasticity and are grouped according to their performance as engineering construction materials. The characteristics of the soils in each group in the Unified system are shown in table 7. The system establishes 15 soil groups, which are divided as coarse-grained soils (eight classes), fine-grained soils (six classes), and highly organic soils. Boundary classifications are provided for soils that have characteristics of two groups. Table 7 lists the letter symbols for the 15 soil groups and the physical characteristics of each group. The system provides for a simple field method and a laboratory method for determining the amount and type of the basic constituents of a soil. Both methods are based on gradation and plasticity and vary only in degree of accuracy. The laborabory method uses mechanical analyses, liquid limit data, and plasticity index data for an exact classification. A plasticity chart, on which the liquid limit and the plasticity index may be plotted, is used in classifying the fine-grained component of the silty and clayey sands and gravels. The classification of the tested soils, according to the Unified system, is given in the last column of table 5.

TABLE 6.—*Classification of soils by American*

General classification	Granular materials (35 percent or less passing No. 200 sieve)				
	A–1		A–3	A–2	
Group classification	A–1–a	A–1–b		A–2–4	A–2–5
Sieve analysis:					
Percent passing—					
No. 10	50 maximum.				
No. 40	30 maximum	50 maximum	51 minimum.		
No. 200	15 maximum	25 maximum	10 maximum	35 maximum	35 maximum
Characteristics of fraction passing No. 40 sieve:					
Liquid limit			NP [2]	40 maximum	41 minimum
Plasticity index	6 maximum	6 maximum	NP [2]	10 maximum	10 maximum
Group index	0	0	0	0	0
Usual types of significant constituent materials.	Stone fragments, gravel, and sand.	Stone fragments, gravel, and sand.	Fine sand	Silty gravel and sand.	Silty gravel and sand.
General rating as subgrade	Excellent to good				

[1] Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (Pt. 1; Ed. 7): The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, AASHO Designation: M 145–49.

Association of State Highway Officials [1]

Granular materials (35 percent or less passing No. 200 sieve)—Continued		Silt-clay materials (more than 35 percent passing No. 200 sieve)				
A-2—Continued		A-4	A-5	A-6	A-7	
A-2-6	A-2-7				A-7-5	A-7-6
35 maximum	35 maximum	36 minimum	36 minimum	36 minimum	36 minimum	36 minimum.
40 maximum	41 minimum	40 maximum	41 minimum	40 maximum	41 minimum	41 minimum.
11 minimum	11 minimum	10 maximum	10 maximum	11 minimum	11 minimum [3]	11 minimum.[3]
4 maximum	4 maximum	8 maximum	12 maximum	16 maximum	20 maximum	20 maximum.
Clayey gravel and sand.	Clayey gravel and sand.	Nonplastic to moderately plastic silty soils.	Highly elastic silts.	Medium plastic clays.	Highly plastic clays.	Highly plastic clays.
Fair to poor						

[2] NP—Nonplastic.

[3] Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30.

TABLE 7.—*Characteristics of soil groups*

Major divisions	Group symbol	Soil description	Value as foundation material [2]	Value as base course directly under bituminous pavement	Value for embankments
Coarse-grained soils (*less than 50 percent passing No. 200 sieve*):					
Gravels and gravelly soils (*more than half of coarse fraction retained on No. 4 sieve*).	GW	Well-graded gravels and gravel-sand mixtures; little or no fines.	Excellent	Good	Very stable; use in pervious shells of dikes and dams.
	GP	Poorly graded gravels and gravel-sand mixtures; little or no fines.	Good to excellent.	Poor to fair	Reasonably stable; use in pervious shells of dikes and dams.
	GM	Silty gravels and gravel-sand-silt mixtures.	Good	Poor to good	Reasonably stable; not particularly suited to shells, but may be used for impervious cores or blankets.
	GC	Clayey gravels and gravel-sand-clay mixtures.	Good	Poor	Fairly stable; may be used for impervious cores.
Sands and sandy soils (*more than half of coarse fraction passing No. 4 sieve*).	SW	Well-graded sands and gravelly sands; little or no fines.	Good	Poor	Very stable; may be used in pervious sections; slope protection required.
	SP	Poorly graded sands and gravelly sands; little or no fines.	Fair to good	Poor to not suitable.	Reasonably stable; may be used in dike section having flat slopes.
	SM	Silty sands and sand-silt mixtures.	Fair to good	Poor to not suitable.	Fairly stable; not particularly suited to shells, but may be used for impervious cores or dikes.
	SC	Clayey sands and sand-clay mixtures.	Fair to good	Not suitable	Fairly stable; use as impervious cores for flood-control structure.
Fine-grained soils (*more than 50 percent passing No. 200 sieve*):					
Silts and clays (*liquid limit of 50 or less*).	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, and clayey silts of slight plasticity.	Fair to poor	Not suitable	Poor stability; may be used for embankments if properly controlled.
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, and lean clays.	Fair to poor	Not suitable	Stable; use in impervious cores and blankets.
	OL	Organic silts and organic clays having low plasticity.	Poor	Not suitable	Not suitable for embankments.
Silts and clays (*liquid limit greater than 50*).	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, and elastic silts.	Poor	Not suitable	Poor stability; use in core of hydraulic fill dam; not desirable in rolled fill construction.
	CH	Inorganic clays having high plasticity and fat clays.	Poor to very poor.	Not suitable	Fair stability on flat slopes; use in thin cores, blankets, and dike sections of dams.
	OH	Organic clays having medium to high plasticity and organic silts.	Poor to very poor.	Not suitable	Not suitable for embankments.
Highly organic soils	Pt	Peat and other highly organic soils.	Not suitable	Not suitable	Not used in embankments, dams, or subgrades for pavements.

[1] Based on information in the Unified Soil Classification System Technical Memorandum No. 3–357, vols. 1, 2, and 3, Waterways Experiment Station, Corps of Engineers, 1953. Ratings and ranges in test values are for guidance only. Design should be based on field survey and test of samples from construction site.

in Unified soil classification system [1]

Compaction (characteristics and recommended equipment)	Approximate range in AASHO maximum dry density [3]	Field (in place) CBR	Subgrade modulus, k	Drainage characteristics	Comparable groups in AASHO classification
	Lb./cu ft.		*Lb./sq. in./in.*		
Good; use crawler-type tractor, pneumatic-tire roller, or steel-wheel roller.	125–135	60–80	300+	Excellent	A–1.
Good; use crawler-type tractor, pneumatic-tire roller, or steel-wheel roller.	115–125	25–60	300+	Excellent	A–1.
Good, but needs close control of moisture; use pneumatic-tire or sheepsfoot roller.	120–135	20–80	200–300+	Fair to practically impervious	A–1 or A–2.
Fair; use pneumatic-tire or sheepsfoot roller.	115–130	20–40	200–300	Poor to practically impervious	A–2.
Good; use crawler-type tractor or pneumatic-tire roller.	110–130	20–40	200–300	Excellent	A–1.
Good; use crawler-type tractor or pneumatic-tire roller.	100–120	10–25	200–300	Excellent	A–1 or A–3.
Good, but needs close control of moisture; use pneumatic-tire or sheepsfoot roller.	110–125	10–40	200–300	Fair to practically impervious	A–1, A–2, or A–4.
Fair; use pneumatic-tire roller or sheepsfoot roller.	105–125	10–20	200–300	Poor to practically impervious	A–2, A–4, or A–6.
Good to poor; close control of moisture is essential; use pneumatic-tire or sheepsfoot roller.	95–100	5–15	100–200	Fair to poor	A–4, A–5, or A–6.
Fair to good; use pneumatic-tire or sheepsfoot roller.	95–120	5–15	100–200	Practically impervious	A–4, A–6, or A–7.
Fair to poor; use sheepsfoot roller [4]	80–100	4–8	100–200	Poor	A–4, A–5, A–6, or A–7.
Poor to very poor; use sheepsfoot roller.[4]	70–95	4–8	100–200	Fair to poor	A–5 or A–7.
Fair to poor; use sheepsfoot roller [4]	75–105	3–5	50–100	Practically impervious	A–7.
Poor to very poor; use sheepsfoot roller.[4]	65–100	3–5	50–100	Practically impervious	A–5 or A–7.
----------	----------	----------	----------	Fair to poor	None.

[2] Ratings are for subgrades and subbases for flexible pavement.
[3] Determined in accordance with test designation T 99–49, AASHO.
[4] Pneumatic-tire rollers may be advisable, particularly when moisture content is higher than optimum.

Soil engineering data and interpretations

Engineering information about each soil in the county is given in tables 8 and 9. For more detailed information on the soils it will often be necessary to refer to the text of the report, particularly to the subsection "Descriptions of Soils." Information on the geology of Kimball County is found under "Parent Materials" in the section "Formation and Classification of Soils."

The soil test data in table 5, together with information given in the remainder of the report and experience with the same soils in other counties, were used as a basis for preparing the information in tables 8 and 9.

TABLE 8.—*Characteristics and classification of soils of Kimball County, Nebr.,*

[Dashed lines indicate that engineering properties were not determined because

Map symbol	Soil	Position	Parent or underlying material [2]	Runoff	Depth to water table [3]	Depth to bedrock or mixed sand and gravel	Depth of horizons
					Feet	*Inches*	*Inches*
AfAW	Altvan fine sandy loam, deep, 1 to 3 percent slopes.	Uplands	Pleistocene sand and gravel.	Slow to moderate	--------	30–72	0–10 10–24 24–30 30–48
Aa	Altvan loam, deep, 0 to 1 percent slopes.	Uplands	Pleistocene sand and gravel.	Slow to moderate	--------	30–72	0–12 12–26 26–32
AaAW	Altvan loam, deep, 1 to 3 percent slopes.						
AaBW	Altvan loam, deep, 3 to 5 percent slopes.						
AaCW	Altvan loam, deep, 5 to 9 percent slopes.						
3AAW	Altvan loam, moderately deep, 1 to 3 percent slopes.	Uplands	Pleistocene sand and gravel.	Slow to moderate	--------	20–30	0–15 15–30 30–48
3ABW	Altvan loam, moderately deep, 3 to 5 percent slopes.						
3ACW	Altvan loam, moderately deep, 5 to 9 percent slopes.						
BfBW	Bayard fine sandy loam, 1 to 5 percent slopes.	Colluvial slopes	Eolian and colluvial sand.	Moderate	--------	([4])	0–10 10–22
BhA	Bridgeport loam, 1 to 3 percent slopes.	Colluvial slopes and fans.	Alluvial and colluvial silt and sand.	Moderate	--------	([4])	0–13 13–60
BhB	Bridgeport loam, 3 to 5 percent slopes.						
CcBW	Canyon loam, 0 to 5 percent slopes.	Uplands	Limy sandstone (Ogallala formation).	Moderate to very rapid.	--------	12–18	0–11 11–18
CcB3	Canyon loam, 0 to 5 percent slopes, eroded.						
CcD	Canyon loam, 9 to 20 percent slopes.						
CnBW	Canyon sandy loam, 0 to 5 percent slopes.	Uplands	Limy sandstone (Ogallala formation).	Moderate to very rapid.	--------	12–18	0–7
CnD	Canyon sandy loam, 9 to 20 percent slopes.						
CRC	Canyon-Rosebud loams, 5 to 9 percent slopes.	Uplands	Limy sandstone (Ogallala formation).	Moderate to rapid	--------	12–36	--------
CRC3	Canyon-Rosebud loams, 5 to 9 percent slopes, eroded.						
CVC	Canyon-Vebar sandy loams, 5 to 9 percent slopes.	Uplands	Limy sandstone (Ogallala formation).	Moderate to rapid	--------	0–36	--------

See footnotes at end of table.

The texture (grain size) of alluvial (water-deposited) materials varies considerably. It should not, therefore, be assumed that the engineering soil classification given in tables 8 and 9 will apply to all parts, or layers, of an alluvial soil or to the alluvial soil wherever it occurs. Special field studies must be made for engineering structures that are to be constructed on alluvial soils so that the class of the specific materials present can be accurately determined.

The adaptability of soils for winter grading varies from year to year, depending on the moisture content of the soil and the temperatures during winter. In some

and physical properties that affect their engineering uses

mapping unit has variable characteristics or is a complex of two or more soils [1]]

Classification			Estimated percent passing—			Permeability	Soil structure	Available water	Dispersion	Shrink-swell potential
USDA	AASHO	Unified	No. 4 sieve	No. 10 sieve	No. 200 sieve					
						In. per hr.		*In. per ft.*		
Fine sandy loam.	A-4	SM-SC	100	99	50	2. 5-5. 0	Granular	1. 75	Low	Low.
Clay loam	A-7	CL	99	97	78	0. 2-0. 8	Blocky	2. 0	Low	Moderate.
Loam	A-4	SM-SC	96	87	48	0. 8-2. 5	Blocky	2. 0	Low	Low.
Gravelly sandy loam.	A-1	SW-SM	95	81	11		Single grain	1. 75		Low.
Loam	A-4	CL	96	90	58	0. 8-2. 5	Granular	2. 0	Low	Moderate.
Clay loam	A-6	CL	100	100	85	0. 2-0. 8	Blocky	2. 0	Low	Moderate.
Loam	A-4	SC	89	80	46	0. 8-2. 5	Blocky	2. 0	Low	Low.
Loam	A-4	SM-SC	96	87	48	0. 8-2. 5	Granular	2. 0	Low	Low.
Clay loam	A-7	CL	99	97	78	0. 2-0. 8	Blocky	2. 0	Low	Moderate.
Gravelly sandy loam.	A-1	SW-SM	95	81	11	5. 0-10. 0	Single grain		Low	Low.
Fine sandy loam.	A-4	SM	89-100	89	36	2. 5-5. 0	Granular	1. 75	Low	Low.
Fine sandy loam.	A-2	SM-SC	86-100	86	31	2. 5-5. 0	Massive	1. 75	Low	Low.
Loam	A-4	CL-ML	98-100	98	51	0. 8-2. 5	Granular	2. 0	Low	Low.
Loam	A-4	CL-ML	91	89	56	0. 8-2. 5	Blocky	2. 0	Low	Low.
Loam	A-4	SC	92	88	44	0. 8-2. 5	Granular	2. 0	Low	Low.
Loam	A-6	SC	87	82	45	0. 8-2. 5	Massive	2. 0	Low	Low.
Sandy loam	A-2	SM	93	89	33	2. 5-5. 0	Granular	1. 75	Moderate to high.	Low.

TABLE 8.—*Characteristics and classification of soils of Kimball County, Nebr.,*

Map symbol	Soil	Position	Parent or underlying material [2]	Runoff	Depth to water table [3]	Depth to bedrock or mixed sand and gravel	Depth of horizons
					Feet	*Inches*	*Inches*
C-C	Canyon complex, 0 to 9 percent slopes.	Uplands	Limy sandstone (Ogallala formation).	Rapid to very rapid.	--------	0–12	--------
C-D	Canyon complex, 9 to 20 percent slopes.						
ChAW	Chappell sandy loam, 1 to 3 percent slopes.	Uplands	Pleistocene sand and gravel.	Moderate to rapid	--------	20–36	0–12
ChBW	Chappell sandy loam, 3 to 5 percent slopes.						12–24
ChC	Chappell sandy loam, 5 to 9 percent slopes.						24–48
Cy	Cheyenne loam, 0 to 1 percent slopes.	Terraces	Alluvial gravel	Moderate	--------	20–40	0–8 8–25 25–36
CyA	Cheyenne loam, 1 to 3 percent slopes.						
DxC	Dix loams, 3 to 9 percent slopes.	Uplands	Pleistocene sand and gravel.	Moderate to rapid	--------	12–18	0–4 4–13 13+
DxD	Dix complex, 9 to 20 percent slopes.	Uplands	Pleistocene sand and gravel.	Rapid to very rapid.	--------	0–18	--------
Dy	Dwyer loamy sand	Terraces	Eolian sand	Slow	--------	48+	0–23 23–48
Gd	Glendive fine sandy loam	Bottom lands	Alluvial sand and gravel.	Moderate	8+	36–60	0–60
Go	Goshen loam, 0 to 1 percent slopes.	Upland swales	Loess and alluvial silt.	Slow to moderate	--------	72+	0–24 24–50
GoA	Goshen loam, 1 to 3 percent slopes.						50+
Gv	Gravelly land	Uplands	Pleistocene sand and gravel.	Moderate	--------	0–10	0–72
He	Havre silt loam	Bottom lands	Alluvial silt and sand.	Slow to moderate	4–8	48+	0–13 13–48
Ke	Keith loam, 0 to 1 percent slopes.	Uplands	Loess	Moderate	--------	72+	48+
KeAW	Keith loam, 1 to 3 percent slopes.						0–7 7–17 17–55
KeBW	Keith loam, 3 to 5 percent slopes.						
Lx	Loamy alluvial land.	Bottom lands	Alluvium	Slow	--------	(4)	--------
Pn	Parshall sandy loam, deep, 0 to 1 percent slopes.	Terraces	Wind-modified sand over alluvial sand and gravel.	Slow	--------	30–72	0–44
PnBw	Parshall sandy loam, deep, 1 to 5 percent slopes.						44–60
PnCw	Parshall sandy loam, deep, 5 to 9 percent slopes.						
3Pn	Parshall sandy loam, moderately deep, 0 to 1 percent slopes.	Terraces	Wind-modified sand over alluvial sand and gravel.	Slow	--------	20–30	0–20
3PnB	Parshall sandy loam, moderately deep, 1 to 5 percent slopes.						20–40
Rw	Riverwash.	Bottom lands	Alluvial sand and gravel.	Slow	0–4	0–6	--------

See footnotes at end of table.

and physical properties that affect their engineering uses—Continued

Classification			Estimated percent passing—			Permeability	Soil structure	Available water	Dispersion	Shrink-swell potential
USDA	AASHO	Unified	No. 4 sieve	No. 10 sieve	No. 200 sieve					
						In. per hr.		*In. per ft.*		
Fine sandy loam.	A–4	SM–SC	100	79	40	2. 5–5. 0	Granular	1. 75	Low	Low.
Silty clay loam.	A–7	CL	100	100	85	0. 2–0. 8	Blocky	2. 0	Low	Moderate.
Gravel	A–1	SW–SM	95	81	11	10+	Single grain			Low.
Loam	A–4	ML	90–95	75–90	50–75	0. 8–2. 5	Granular	2. 0	Low	Low.
Loam	A–4	ML–CL	90–95	80–90	60–80	0. 8–2. 5	Blocky	2. 0	Low	Low.
Gravel	A–3	SW or SW–SM.	50–75	5–50	0–10	10+	Single grain			Low.
Loam	A–4	ML–CL	91–100	91	54	0. 8–2. 5	Granular	2. 0	Low	Low.
Sandy loam	A–2	SM	90–100	90	31	2. 5–5. 0	Blocky	1. 75	Low	Low.
Sand and gravel.	A–1	SW	50–75	5–65	0–5	10+	Single grain			Low.
Loamy sand	A–2	SP or SP–SM.	95–100	95–100	0–10	5. 0–10. 0	Single grain	1. 25	Low	Low.
Loamy fine sand.	A–2	SP–SM or SM.	95–100	90–95	10–30	5. 0–10. 0	Single grain	1. 25	Low	Low.
Fine sandy loam.	A–4	SM–SC	100	99	50	2. 5–5. 0	Single grain	1. 75	Low	Low.
Loam	A–4	ML	100	98	69	0. 8–2. 5	Granular	2. 0	Low	Moderate.
Silty clay loam.	A–6	ML to CL	95–100	95–100	67–100	0. 2–0. 8	Blocky	2. 0	Low	Moderate.
Silt loam	A–4	ML	100	100	80–100	0. 8–2. 5	Massive	2. 0	Low	Moderate.
Gravel	A–1	SW	50–75	5–50	0–5	10+	Single grain		Low	Low.
Loam	A–4	ML	100	100	60	0. 8–2. 5	Crumb	2. 0	Low	Low.
Very fine sandy loam.	A–2	SM	100	100	30	0. 8–2. 5	Blocky	2. 0	Low	Low.
Sand and gravel.	A–1	SW or SW–SM.	50–75	5–50	0–10	10+	Single grain			Low.
Loam	A–4	CL	100	100	80	0. 8–2. 5	Granular	2. 0	Low	Moderate.
Clay loam	A–7	CL	100	100	93	0. 2–0. 8	Blocky	2. 0	Low	Moderate.
Silt loam	A–4	ML	100	100	89	0. 8–2. 5	Massive	2. 0	Low	Moderate.
Sandy loam	A–2 or A–4.	SM	100	95–100	30–50	2. 5–5. 0	Granular	1. 75	Low	Low.
Loamy sand	A–3	SP or SP–SM.	100	95–100	0–10	5. 0–10. 0	Single grain	1. 25	Low	Low.
Sandy loam	A–2 or A–4.	SM	100	95–100	30–50	2. 5–5. 0	Granular	1. 75	Low	Low.
Sand and gravel.	A–1	SW	50–75	5–50	0–5	10+	Single grain			Low.

TABLE 8.—*Characteristics and classification of soils of Kimball County, Nebr.,*

Map symbol	Soil	Position	Parent or underlying material [2]	Runoff	Depth to water table [3]	Depth to bedrock or mixed sand and gravel	Depth of horizons
					Feet	*Inches*	*Inches*
Rv	Rock land.	Uplands	Limy sandstone (Ogallala formation).	Very rapid		0–6	
Rb	Rosebud loam, deep, 0 to 1 percent slopes.	Uplands	Limy sandstone (Ogallala formation).	Moderate to rapid		36–72	0–10
RbAW	Rosebud loam, deep, 1 to 3 percent slopes.						10–20
RbBW	Rosebud loam, deep, 3 to 5 percent slopes.						20–30
RbCW	Rosebud loam, deep, 5 to 9 percent slopes.						
RbD	Rosebud loam, 9 to 15 percent slopes.						
3RbW	Rosebud loam, moderately deep, 0 to 1 percent slopes.	Uplands	Limy sandstone of the Ogallala formation.	Moderate to rapid		18–36	0–7 7–15 15–26
3RAW	Rosebud loam, moderately deep, 1 to 3 percent slopes.						
3RBW	Rosebud loam, moderately deep, 3 to 5 percent slopes.						
3RCW	Rosebud loam, moderately deep, 5 to 9 percent slopes.						
Sx	Sandy alluvial land.	Bottom lands	Alluvial sand	Slow		[4]	
Se	Scott silt loam.	Upland depressions	Loess and silty alluvium.	Very slow		72+	0–4 4–30 30–35 35–60
Tr	Tripp fine sandy loam, 0 to 1 percent slopes.	Terraces	Alluvial silt	Moderate		[4]	0–10
TrA	Tripp fine sandy loam, 1 to 3 percent slopes.						10–48
TrBW	Tripp fine sandy loam, 3 to 5 percent slopes.						
Ta	Tripp loam, 0 to 1 percent slopes.	Terraces	Alluvial silt	Moderate		[4]	0–30 30–48
TaAW	Tripp loam, 1 to 3 percent slopes.						
TaBW	Tripp loam, 3 to 5 percent slopes.						
TaCW	Tripp loam, 5 to 9 percent slopes.						
VrAW	Vebar sandy loam, 0 to 3 percent slopes.	Uplands	Limy sandstone and eolian sand (Ogallala formation).	Slow		36–48	0–7 7–14 14–36
VrBW	Vebar sandy loam, 3 to 5 percent slopes.						
VrCW	Vebar sandy loam, 5 to 9 percent slopes.						
VrD	Vebar sandy loam, 9 to 15 percent slopes.						
Wx	Wet alluvial land	Bottom lands	Alluvial silt and sand	Very slow	0–2.5	[4]	

[1] The characteristics of the soils in a complex can be learned by referring to mapping units in which the same soils occur separately.
[2] The geologic formation or the materials lying beneath the soil profile.

and physical properties that affect their engineering uses—Continued

Classification			Estimated percent passing—			Permeability	Soil structure	Available water	Dispersion	Shrink-swell potential
USDA	AASHO	Unified	No. 4 sieve	No. 10 sieve	No. 200 sieve					
						In. per hr.		*In. per ft.*		
Loam	A-4	CL	100	100	63	0. 8-2. 5	Granular	2. 0	Low	Moderate.
Loam	A-6	CL	100	100	67	0. 8-2. 5	Blocky	2. 0	Low	Moderate.
Loam	A-6	CL	100	100	70	0. 8-2. 5	Blocky		Low	Moderate.
Loam	A-4	CL	99	97	62	0. 8-2. 5	Granular	2. 0	Low	Moderate.
Loam	A-6	CL	100	99	66	0. 8-2. 5	Blocky	2. 0	Low	Moderate.
Loam	A-6	CL	100	100	65	0. 8-2. 5	Blocky	2. 0	Low	Moderate.
Silt loam	A-4	ML	100	100	98	0. 8-2. 5	Granular	2. 0	Low	Moderate.
Clay	A-7	CH	100	100	96	. 05-. 2	Blocky	2. 2	Low	High.
Silty clay loam.	A-6	CL	100	100	85	0. 2-0. 8	Blocky	2. 0	Low	Moderate.
Sandy loam	A-2	SM	93	89	33	2. 5-5. 0	Massive	1. 75	Low	Low.
Fine sandy loam.	A-4	SM-SC	100	79	40	2. 5-5. 0	Granular	1. 75	Low	Low.
Silt loam	A-2 or A-4.	SM-SC	81	78	30-40	0. 8-2. 5	Blocky	2. 0	Low	Low.
Loam	A-4	SM	97	92	36	0. 8-2. 5	Granular	2. 0	Low	Low.
Loam	A-4 or A-6.	CL	95-100	85-90	60-70	0. 8-2. 5	Blocky	2. 0	Low	Low.
Sandy loam	A-4	SM-SC	100	100	40	2. 5-5. 0	Granular	1. 75	Low	Low.
Sandy loam	A-4	SC	100	99	41	2. 5-5. 0	Blocky	1. 75	Low	Low.
Sandy loam	A-2	SM-SC	99	95	27	2. 5-5. 0	Massive	1. 75	Low	Low.

[3] Seasonal high water table.
[4] Depth is not restrictive.

winters, soil moisture is low and no frost forms in the soil. If the soil is warm enough, moisture can be added to it so that the moisture content is suitable for grading and compaction. In winters when soil moisture is high and temperatures are below freezing for extended periods, it is difficult or impractical to grade, move, or compact the soil. Gravelly or sandy materials that contain only a small percentage of silt or clay are generally more suitable for winter grading than are soils that have relatively high percentage of silt and clay. Gravelly or sandy soils should be graded only if the standards of compaction can be maintained and frozen material excluded.

All soils in Kimball County are susceptible to wind erosion where the vegetation is removed. The soils on bottom lands are likely to be flooded occasionally. Although soils on high bottom lands and on the terraces are seldom flooded, structures should be planned that will dispose of runoff waters.

Frost action is a minor problem of engineering in Kimball County. The susceptibility of soils to frost action varies. A soil generally is not susceptible if less than 10 percent of the soil material passes a No. 200 sieve. Soils with a high percentage of silt and clay are usually more susceptible to the softening action of frost than are those with a low percentage of these fine-textured materials. However, the susceptibility of a soil to frost action is also affected by the permeability of the underlying material, the water table, moisture content, temperature, drainage, and other factors.

The ratings given in table 9 for suitability of soils as sources of topsoil and gravel apply only to Kimball County. Many of the soils are rated *poor* as a source of topsoil because the material is too sandy to be high in fertility. Although a soil may be rated *good* as a source of sand and gravel, all of this soil may not meet gradation requirements and several areas of it may have to be explored to find suitable sand and gravel.

Under the three columns headed Suitability of soil material for (table 9), the soils have been rated according to their suitability for use in a road fill and in the upper part of the subgrade of a bituminous road. The upper part of the subgrade receives the gravel surfacing.

The ratings in the column headed Paved refer to the subgrade of the roadbed for bituminous and concrete roads. Since sand is the best subgrade for roads of this type, the soil was rated *good* for the subgrade if it was classified A–1, A–2, or A–3. If the soils are silts or clays, the AASHO classification ranges from A–4 to A–7. The soils classified A–4 were rated *fair* for the subgrade, and those classified A–7 were rated *poor*.

In the column headed Gravel, the ratings refer to that part of the subgrade that receives gravel surfacing. Since sand is noncohesive, it does not provide a stable surface. All soils classified A–1, A–2, or A–3 are rated *poor*. Silts or clay soils are classified A–4 to A–7. They are usually acceptable in the part of the upper subgrade that receives surfacing and are rated *good* or *fair*.

The ratings of the soils under the column headed Road fill were based on the same criteria as the ratings of the soils for subgrade under bituminous pavement.

The range in ratings in all three columns, for example, good to poor, is the result of the variation of the soil in the profile.

The compaction characteristics of the soils were rated for only that part of the profile normally used in preparing foundations, which excludes the material in the top 6 to 12 inches. The ratings apply only to the depths of the profiles given in table 8. Compaction characteristics have been rated as *good* or *poor* on the basis of the workability of the soil with standard compaction equipment.

In general, the soil features listed in table 9 as affecting agricultural structures were selected according to the extent of problems that these features might cause in construction and maintenance of the structures. The soil features listed for a soil were based on the profile of that soil, as described in table 8. A variation in this profile, such as a variation in depth to gravel, will change the ratings for the soil when it is used in some structures.

The soil features of saline-alkali soils that affect agricultural structures have not been rated. Depending on the degree of salinity or alkalinity and the quantity of materials affected, a saline-alkaline condition may seriously affect the piping hazard, internal drainage, and workability of a soil. Also, this condition restricts the use of vegetation in waterways and other structures.

In table 9, the bearing capacity and piping hazard of soils in foundations have been rated. These ratings are for soils in the foundations of small dams and concrete structures. They apply to the depths of the profiles given in table 8.

Under low dams, the soil features affecting the reservoir area and embankments have been listed for small earth dams. These data may serve to guide preliminary design for larger structures that require grade stabilization, such as irrigation structures and those that retard floodwater. However, for these large structures a detailed geologic investigation of sites should be made.

In rating soils for dikes or levees, only suitability for relatively low dikes and levees was considered. The information given is for the material in 30 inches of the profile. This information should help in the preliminary planning for large dikes and levees, but for these large structures, a detailed investigation of sites should be made.

For agricultural drainage, the rate of permeability and surface conditions were generally stated. The permeability ratings were assigned on a basis of penetration of moisture as follows:

Inches per hour	*Rating*
0.05 to 0.2	Slow.
.2 to .8	Moderately slow.
.8 to 2.5	Moderate.
2.5 to 5.0	Moderately rapid.
5.0 to 10.0	Rapid.
Over 10	Very rapid.

Under irrigation, the water-holding capacity and water intake have been rated. Irrigation hazards related to slope are not shown.

The water-holding capacity is for the top 4 feet of the soil profile. The terms used indicate amount of water held, as follows:

Water-holding capacity	*Rating*
More than 8 inches	High.
5 to 8 inches	Moderate.
3 to 5 inches	Low.
Less than 3 inches	Very low.

The intake of water is listed as *rapid*, *moderate*, or *slow*. A *slow* intake rate is less than ½ inch per hour, and a *rapid* intake rate is 2 inches per hour, or more. A *moderate* intake rate is between these two extremes. For all soils, the intake rate was based on border or sprinkler irrigation, with a plant cover.

In the last column of table 9, the erosiveness of terraces and waterways is rated. This rating applies to terraces as a whole and to the slopes and channels of waterways. Climate and topography may affect the use of terraces and waterways. Hummocky topography may limit the use of terraces. On the other hand, terraces are often constructed to conserve water when they are not needed for erosion control. The semiarid climate of Kimball County makes it difficult to establish vegetation unless supplemental water is available.

At many construction sites, major soil variations may occur within the depth of proposed excavation. Several different soils may be excavated within a short distance. The soil maps and profile descriptions, as well as the engineering data and recommendations given in this section, should be used in planning detailed surveys of soils at construction sites. Using the information in the soil survey reports will enable the soils engineer to concentrate on the most suitable soil units. Then a minimum number of soil samples will be required for laboratory testing, and an adequate soil investigation can be made at minimum cost.

Formation and Classification of Soils

This section consists of two main parts. The first part discusses the factors of soil formation and how they affected the development of the soils in this county. In the second part, the soils in the county are placed in classes according to their morphology and some of the factors that affected morphology are given.

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on materials deposited or accumulated by geologic forces. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent materials; (2) the climate under which the material has accumulated and existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of development have acted on the soil material.

Climate and vegetation are active factors of soil genesis. They act on the parent material accumulated through the weathering of rocks and slowly change it into a natural body with genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. It may be much or little, but some time is always required for horizon differentiation. Generally, a long time is required for the development of distinct horizons.

The interrelationships among the factors of soil formation are complex, and, therefore, the effects of any one factor are difficult to isolate with certainty. It is convenient to discuss the individual factors and their effect on soil formation, but the reader should remember that it is the interaction of these factors, rather than their simple sum, that determines the nature of the soil profile.

Parent materials

Table 10 lists the geologic formations in Kimball County and the materials that make up these formations.

During the Tertiary period repeated uplifts in the Rocky Mountain region resulted in recurrent deposition of materials by streams. In the Plains region to the east, materials possibly were also deposited by winds. The periods of deposition were separated by periods when erosion removed the deposited material to various depths, thus adding to the complexity of the geologic sequences.

The early Tertiary deposits, Paleocene and Eocene, may occur near the surface in some areas of Kimball County, but the oldest Tertiary rock at or near the surface is the Brule formation of Oligocene age. The Brule formation generally overlies the Chadron formation, which is also of Oligocene age. It is exposed in large areas at the lower part of valley sides along Lodgepole Creek and other drainageways in the southern part of Kimball County. It consists of pinkish-brown to flesh-colored silts and clays and, in some places, thin layers of volcanic ash and channel sands. During much or all of the Miocene period, the Brule formation in Kimball County was subjected to erosion. In the Pliocene period, which followed the Miocene, Ogallala materials were deposited over the eroded surface of the Brule formation by streams that flowed eastward.

The Ogallala formation consists of medium-grained and coarse-grained sands and, in some places, of thin layers of gravel in what is called Mortar beds because the gravel is partly cemented by lime and is generally capped by

TABLE 10.—*Geologic materials in Kimball County, Nebr.*

System and epoch	Group or formation	Formation or member	Material
Quarternary:			
Recent		Recent	Eolian sands and loess.
Pleistocene		Peorian	Eolian silts and clays.
		Alluvium	Unconsolidated gravels, sands, and silts.
Tertiary:			
Pliocene	Ogallala	Kimball	Algal limestone, shale, and caliche sandstone.
		Sidney	Gravel and sand.
		Ash Hollow	Gravel, sand, silt, and some volcanic ash; "Mortar beds."
		Valentine	Sands.
Oligocene	White River	Brule	Massive silty clays with thin layers of volcanic ash and sands.

Figure 22.—**Brule outcrop along a streambank in left center. Ogallala material is above the Brule.**

impure limestone. The limestone is partly algal in origin. The Ogallala formation has been subdivided into the Valentine, Ash Hollow, Kimball, and Sidney members, or formations. The Valentine is the deepest member and consists of massive sand or sandstone. It is overlain by the Ash Hollow formation, which consists of ledge-forming hard and soft layers. The Ash Hollow formation is capped by the Kimball member, which consists of impure limestone and clay. In channel areas, the Sidney member occurs between the Kimball and Ash Hollow formations and consists of large amounts of sand and gravel.

The Brule formation (fig. 22) outcrops in narrow bands along the valley sides. No soils are mapped on the Brule formation in this county, but many soils of various textures are mapped on the Ash Hollow, Sidney, and Kimball formations. The Kimball formation is shown in figure 23.

The present valleys in Kimball County began to form when, after Tertiary time, they began to be cut into the surface of the Tertiary bedrock. The valleys were deepened during several periods in Pleistocene time. Periodically, they were filled with sediments washed from the uplands. The coarse gravel that occurs in remnants along the upper slopes of the valley of Lodgepole Creek probably accumulated between the early and middle parts of the Pleistocene epoch. The valleys, including the present flood plains, were probably lowered in late Pleistocene to Recent time.

Figure 23.—**Kimball formation.**

The soils along the streams generally have developed from the alluvial material that filled the valleys after they were first formed. In some places, the terraces are mantled with loess, eolian sand, or colluvial-alluvial wash from adjacent uplands. The soils along streams are loamy and sandy and range from deep to shallow. Most of the present flood plain is flooded annually, and small areas have high water tables that make the soils unsuited to cultivation.

Along the larger streams and on the lee side of ridges are sandy soils that have developed from sands reworked from Ogallala material and deposited by wind. These sands occur mostly in small areas, mainly southwest of Bushnell and just north of the valley of Lodgepole Creek.

Loessal material occurs on some terraces and in other areas throughout the uplands. The most extensive soils developed from wind-deposited silt are deep to moderately deep and silty or loamy. Small areas of shallow soils occur where thin deposits of loess were laid down over bedrock or gravel.

Climate

Kimball County has semiarid, continental climate. In summer, days are warm but nights are cool. Alternate cold and warm periods in winter cause much freezing and thawing of soils. Consequently, the surface layers tend to be loose and are more susceptible to erosion.

Climate is generally uniform in the county but, because of variations in slope and exposure, there are small local differences. The rainfall is slightly higher in the northeastern corner of the county than elsewhere.

The annual precipitation in Kimball County averages 16.5 inches. Wet and dry periods that last several years are common. Most of the zonal soils in the county have a horizon of calcium carbonate that forms mainly because rainfall is scarce. The soils are seldom wet below the living plant roots. Because the lime has not been leached, many young soils have free lime through the profile.

The small amount of water that moved through the soils carried particles of clay from the surface horizon to the subsoil, or underlying layer. When the movement of the water slowed, these particles were deposited. The clay accumulated in the subsoil and further slowed the water, causing an even greater rate of clay accumulation. Organic matter may also accumulate in the subsoil.

Strong winds have influenced the formation of some of the soils. Some effects of wind action can be seen in most soils in the county. The gently undulating topography of the Keith soils is, in part, a result of the effect of wind action. Many soils were formed from loessal parent material that was transported mainly by wind. In recent years, all soils have received small amounts of windblown materials that have been mixed with the surface soil. Because of wind erosion, some soils have lost materials.

Plant and animal life

Trees, plants, micro-organisms, earthworms, and various other forms of plant and animal life live on and in the soil and are active in the soil-forming processes. The changes that these biological forces bring about depend, among other things, on the kinds of life and the life processes peculiar to each. The kinds of plants and animals that live on and in the soil are determined by environmental factors, including climate, parent material, relief, age of the soil, and the associated organisms. The influence of the climate is most apparent, though not always most important, in determining the kinds of plants that grow on the well-drained, well-developed soils. In this way, climate exerts a powerful indirect influence on the morphology of soils.

The original vegetation on the moderately sandy and sandy soils in Kimball County consisted mainly of short and mid grasses and partly of tall grasses. Sedges, rushes, and water-tolerant grasses are dominant on the wet lands, and alkali-tolerant grasses, sedges, and forbs are dominant on the alkaline soils. Scattered pines and cedars grow on the rough lands along Rocky Hollow and Lodgepole Creek.

The soils of Kimball County are typical of grassland. Because of staining from the decay of organic matter over a long period of time, the surface soils are dark.

Little is known of the micro-organisms, earthworms, and other animals that live in soils of the area, but they are important in the formation of the soils.

Relief

Relief influences the development of soils in relatively small areas, chiefly by controlling the movement of water on the surface. The degree of slope, the shape of the surface, or other features of relief affect each soil that develops. Together with soil permeability, relief has much to do with runoff, internal drainage, and the moisture content of the soil.

Relief is very important where steep slopes cause rapid runoff. Little water penetrates the soil to affect soil forming, and the surface soil may be removed almost as fast as it is formed. Under these conditions, immature and very thin soils develop on steep slopes.

Soils on bottom lands and low terraces have little relief, for their surface generally is flat. They are not, therefore, affected by relief so much as are steep soils. The deposits have been in place for such a short time that relief has had little effect. Also, the flow of water in these soils is often controlled more by the movement of ground water and runoff from surrounding areas than it is by relief.

Time

Some materials that have been in place for only a short time have not been influenced enough by climate and vegetation to develop well-defined, genetically related horizons in their profile. Most soils of the first bottoms are made up of such materials. Soils of steep slopes have their materials constantly renewed and removed by geologic erosion and do not develop genetically related horizons. These two broad groups make up the younger soils of the county.

Some soils in Kimball County have been in place for a long period and are approaching an equilibrium with their environment. These soils have been in place long enough to develop genetic profiles, and horizons with some thickness.

Classification of Soils

In table 11 the soil series of Kimball County are placed in soil orders and great soil groups and some factors that have contributed to the morphology of the soils in the series are listed.

Soil orders

Soils are classified in three soil orders—zonal, azonal, and intrazonal. Zonal soils have formed where the parent materials have been in place for a long time and have not been subject to extreme conditions of relief or to extreme durability of the parent materials themselves. Zonal soils have well-developed soil characteristics that reflect the influence of the active factors of soil genesis, climate and living organisms.

The well-drained, well-developed soils in this county have formed under relatively similar conditions of climate and vegetation and are zonal soils. On these soils climate and vegetation have had the most influence, and relief and age have had the least. As a result, these soils have many properties in common, although they may have developed from various kinds of parent material.

In areas of the county where the parent materials have been in place for only a short time, the soils with only poorly defined or no genetic horizons have formed. Soils that are forming on recently transported materials are of this kind. These soils are young and have few or none of the properties of zonal soils and are called azonal soils. Because of their youth, their parent materials, or their relief, a profile with well-developed soil characteristics has not developed in azonal soils.

Some azonal soils are characterized by an A_1 horizon that is moderately dark colored and apparently moderately high in organic matter; by the absence of a zone of illuviation, or B horizon; and by parent material that is normally lighter colored than the A_1 horizon. Because of the absence of a B horizon, these soils are called A–C soils.

Other azonal soils on steep slopes are essentially A–C soils, because their materials are constantly renewed or are mixed and the changes brought about by climate and vegetation are slight. Here only a small quantity of water percolates through the soil, and much rapid runoff causes rapid geologic erosion.

On some nearly level areas in the county where both internal and external drainage are restricted or where geological erosion is very slow, soils have developed from materials that have been in place a long time. These soils have certain well-developed profile characteristics that zonal soils do not have. They are associated geographically with the zonal soils and are called intrazonal soils. Intrazonal soils are defined as soils with more or less well-developed soil characteristics that reflect the dominating influence of some local factor of relief or parent material over the normal effects of climate and vegetation. The properties of intrazonal soils in this area are generally the result of level relief.

Soils of each of the three orders—zonal, azonal, and intrazonal—may be derived from similar kinds of parent materials. In this area, the major differences of the soils in any one of these orders appear to be closely related to differences in the kinds of parent materials. The thickness of soil over the rock from which it was derived is partly

TABLE 11.—*Soil series classified according to soil orders and great soil groups and some characteristics that affect morphology*

Great soil group and series	Parent material	Relief	Drainage
ZONAL			
Chestnut:			
Altvan	Old alluvium and mixed eolian deposits	Nearly level to moderately steep	Well drained.
Chappell	Old alluvium and mixed sandy eolian deposits.	Nearly level to moderately steep	Well drained.
Cheyenne	Moderately sandy alluvium	Nearly level to gently sloping	Well drained.
Dix	Moderately sandy alluvium or gravel	Rolling to moderately steep	Excessively drained.
Goshen	Loess and silty alluvium	Nearly level to gently sloping	Well drained.
Keith	Loess	Nearly level to gently sloping	Well drained.
Parshall	Sandy alluvium	Nearly level to moderately steep	Well drained.
Rosebud	Weathered sandstone and siltstone	Nearly level to moderately steep	Well drained.
Tripp	Mixed loess and alluvium	Nearly level to moderately steep	Well drained.
Vebar	Weathered sandstone	Nearly level to moderately steep	Well drained.
INTRAZONAL			
Planosol:			
Scott	Loess	Nearly level depressions	Imperfectly drained.
AZONAL			
Lithosol:			
Canyon	Slightly weathered sandstone and limestone	Nearly level to steep	Well drained.
Regosol:			
Dwyer	Eolian sands over alluvium	Nearly level to gently sloping	Excessively drained.
Alluvial:			
Bayard	Colluvial-alluvial deposits	Gently sloping	Well drained.
Bridgeport	Colluvial-alluvial deposits	Nearly level to gently sloping	Well drained.
Glendive	Sandy alluvium	Nearly level	Moderately well drained.
Havre	Moderately sandy alluvium	Nearly level	Moderately well to well drained.

determined by the resistance of the rock to weathering, the volume of residue after weathering, and the rate of geological erosion. Some areas may have been influenced by the addition of loess or eolian sands.

Great soil groups in Kimball County

A great soil group consists of many soil series that have soils with major features in common. Every soil series in a great soil group has soils with the same number and kinds of definitive horizons, although these horizons may not be expressed in every profile to the same degree. Collectively, the members of a single great soil group have a wide range in many characteristics or properties. They may also have a wide range in fertility, tilth, moisture-holding capacity, susceptibility to erosion, and other qualities.

The great soil groups in Kimball County are Chestnut soils, Planosols, Lithosols, Regosols, and Alluvial soils.

CHESTNUT SOILS

The Chestnut soils are a zonal group of soils with dark-brown surface horizons that overlie lighter colored material which, in turn, overlies a horizon of lime accumulation at a depth of 1 to 4 feet. These soils developed under mixed tall, mid, and short grasses in a temperate to cool, subhumid to semiarid climate. In Kimball County the Altvan, Chappell, Cheyenne, Goshen, Keith, Parshall, Rosebud, and Tripp soils are Chestnut soils. Dix and Vebar soils are Chestnut soils intergrading to Regosols.

PLANOSOLS

The Planosols are an intrazonal group of soils that have leached (eluviated) surface horizons underlain by a compact claypan subsoil. They developed on nearly flat or depressed topography. Scott soils are the only Planosols in Kimball County.

LITHOSOLS

The Lithosols are an azonal group of soils that have no clearly expressed soil morphology. They have little or no evidence of soil development and consist mainly of a partly weathered mass of rock fragments or coarse sand and gravel. Canyon soils are the only Lithosols in Kimball County.

REGOSOLS

Regosols are moderately light colored azonal soils that are developing from thick unconsolidated deposits but do not have definite genetic horizons. In Kimball County the unconsolidated deposits are sands and loess on stream terraces and fans in valleys and on colluvial-alluvial slopes at the base of hills. In this county the Dwyer soils are Regosols.

ALLUVIAL SOILS

The Alluvial great soil group consists of azonal soils developing in alluvium that has been transported and deposited relatively recently. Except for the organic matter that has been added and has darkened the surface horizon, the materials that were deposited have had little or no modification by the soil-forming processes. In many soils the alluvium is stratified and is made up of material of various textures. In Kimball County the Bayard, Bridgeport, Glendive, and Havre soils are Alluvial soils. The Bayard and Bridgeport soils are Alluvial soils intergrading to Chestnut.

Mechanical and Chemical Analyses

This section consists of two main parts. In the first part is a discussion of the methods of analysis used in the field and laboratory and a table that lists the analytical data obtained. The second part describes profiles of some of the soils analyzed.

Field and Laboratory Methods

All samples used to obtain the data in table 12 were collected from carefully selected pits. The samples are considered representative of the soil material that is made up of particles less than three-quarters of an inch in diameter. Estimates of the fraction of the sample consisting of particles larger than three-quarters of an inch were made during the sampling. If necessary, the sample was sieved after it was dried and rock fragments larger than three-quarters of an inch in diameter were discarded. Then the material made up of particles less than three-quarters of an inch in diameter was rolled, crushed, and sieved by hand, and rock fragments larger than 2 millimeters in diameter were removed. The fraction that consists of particles between 2 millimeters and three-quarters of an inch in diameter was recorded on the data sheets and is listed in table 12 as the percentage greater than 2 millimeters.

The content given for the fractions that consist of particles larger than three-quarters of an inch and of particles between 2 millimeters and three-quarters of an inch is somewhat arbitrary. The accuracy of the data depends on the severity of the preparative treatment, which may vary with the objectives of the study. But it can be said that the two fractions contain relatively unaltered rock fragments that are larger than 2 millimeters in diameter and that they do not contain slakeable clods of earthy material.

Unless otherwise noted, all laboratory analyses are made on material that passes the 2-millimeter sieve and are reported on an oven-dry basis. In table 12, values for exchangeable sodium and potassium are for amounts of sodium and potassium that have been extracted by the ammonium acetate method minus the amounts that are soluble in the saturation extract.

Standard methods of the Soil Survey laboratory were used to obtain most of the data in table 12. Determinations of clay were made by the pipette method (*4, 5, 6*). The reaction of the saturated paste (1:1) and that of a 1:10 water suspension were measured with a glass electrode. Organic carbon was determined by wet combustion, using a modification of the Walkley-Black method (*7*). Nitrogen was determined by using a modification of procedure of the Association of Official Agricultural Chemists (*1*). The calcium carbonate equivalent was determined by measuring the volume of carbon dioxide evolved from soil samples treated with concentrated hydrochloric acid. The methods of the U.S. Salinity Laboratory were used to obtain the moisture tensions (*8*). The cation exchange capacity was determined by direct distillation of absorbed ammonia (*7*). To determine the extractable calcium and magnesium, calcium was separated as calcium oxalate and magnesium as magnesium-ammonium phosphate (*7*). Extractable sodium and potassium were determined on original extracts with a flame spectrophotometer. The saturation extract was obtained by using the methods of the U.S. Salinity Laboratory (*8*). Soluble sodium and potassium were determined on the saturation extract with a flame spectrophotometer.

In several of the determinations, the amounts of samples or chemicals used were varied from that given in the procedure to make the determination suitable for handling.

Profile Descriptions of Soils Analyzed

The profiles of the soils listed in table 12 are described in detail. Profiles of a Canyon loam and a Keith loam are described as typical of the Canyon series and of the Keith series in the subsection "Descriptions of Soils." Also in that subsection is a description of a profile of Rosebud loam, moderately deep. Profiles of Altvan loam, deep, and Rosebud loam, deep, are described in the following pages.

Profile of an Altvan loam, deep, located 2,160 feet east and 60 feet south of the NW. corner of sec. 31, T. 16 N., R. 58 W., in a cultivated field:

A_{1p} 0 to 6 inches, grayish-brown (10YR 5/2) loam; very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; very friable when moist; abrupt, smooth boundary.

A_{12} 6 to 8 inches, grayish-brown (10YR 5/2) loam; very dark grayish brown (10YR 3/2) when moist; weak, coarse, subangular blocky structure; very friable when moist; abrupt, smooth boundary.

B_1 8 to 12 inches, brown (10YR 5/3) heavy loam; dark brown (10YR 3/3) when moist; weak, coarse, subangular blocky structure; friable when moist; clear, smooth boundary.

B_{21} 12 to 18 inches, brown (10YR 5/3) clay loam; dark brown (10YR 3/3) when moist; compound weak, coarse, prismatic and moderate, fine and medium, subangular blocky structure; firm when moist; broken clay films on ped faces; clear, smooth boundary.

B_{22} 18 to 23 inches, pale-brown (10YR 6/3) heavy silt loam; brown (10YR 5/3) when moist; compound weak, coarse, prismatic and moderate, fine and medium, subangular blocky structure; friable when moist; abrupt, smooth boundary.

BC_{ca} 23 to 26 inches, very pale brown (10YR 7/3) silt loam; pale brown (10YR 6/3) when moist; weak, medium and coarse, subangular blocky structure; very friable when moist; disseminated lime in root channels and on structural faces; violent effervescence; clear, smooth boundary.

C_1 26 to 32 inches, very pale brown (10YR 7/3) loam; pale brown (10YR 6/3) when moist; weak, coarse, subangular blocky structure; very friable when moist; small amount of disseminated lime; violent effervescence; clear, wavy boundary.

D_1 32 to 35 inches, very pale brown (10YR 7/3) dirty gravel; about 75 percent is fine to coarse gravel; brown (10YR 5/3) when moist; violent effervescence; gradual, wavy boundary.

D_2 35 to 40 inches, Pleistocene gravel.

Fine and coarse gravel is scattered through the profile. Although structure for the B_{21} and B_{22} horizon are described the same, the B_{21} horizon is stronger in grade.

TABLE 12.—*Analytical data for*

[Analyses made at Soil Survey Laboratory, Soil Conservation

Soil	Horizon	Depth	Particle size distribution: Very coarse sand (2–1 mm.)	Coarse sand (1–0.5 mm.)	Medium sand (0.5–0.25 mm.)	Fine sand (0.25–0.10 mm.)	Very fine sand (0.10–0.05 mm.)	Silt (0.05–0.002 mm.)	Clay (<0.002 mm.)	Larger than 2 mm.	Texture
		Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
Altvan loam, deep: *Location:* 2,160 feet E. and 60 feet S. of NW. corner, sec. 31, T. 16 N., R. 58 W., (*Sample No.* S 57 Neb–53–12; *Laboratory No.* 5864–5872).	A_{1p}	0–6	16.6	[2] 13.8	[2] 5.4	[2] 4.4	[2] 11.4	34.1	14.3	11.8	Loam
	A_{12}	6–8	12.1	[2] 14.3	[2] 5.8	[2] 4.9	[2] 9.9	34.9	18.1	11.0	Loam
	B_1	8–12	4.2	[2] 10.5	[2] 5.6	[2] 5.9	[2] 12.6	38.7	22.5	6.4	Loam
	B_{21}	12–18	6.6	[2] 5.6	[2] 2.2	[2] 2.4	[2] 10.8	41.0	31.4	3.0	Clay loam
	B_{22}	18–23	2.3	[2] 2.4	[2] 1.1	[2] 1.6	[2] 15.3	50.6	26.7	1.5	Silt loam
	BC_{ca}	23–26	[3] .7	[3] 1.8	[2] 1.4	[2] 1.9	[2] 17.6	56.6	20.0	1.2	Silt loam
	C_1	26–32	[3] 2.7	[3] 4.5	[2] 2.9	[2] 3.1	[2] 17.8	47.3	21.7	5.3	Loam
	D_1	32–35	[3] 24.4	[3] 19.8	[2] 8.4	[2] 7.5	[2] 7.8	17.2	14.9	23.1	Coarse sandy loam.
	D_2	35–40	[3] 42.2	[3] 36.4	[2] 9.8	[2] 4.4	[2] .9	1.5	4.8	21.3	Coarse sand
Canyon loam, eroded: *Location:* 2,300 feet W. and 140 feet N. of SE. corner, sec. 27, T. 13 N., R. 56 W., (*Sample No.* S 57 Neb–53–9; *Laboratory No.* 5846–5849).	A_{1p}	0–4	[4] 7.8	[4] 11.4	[4] 9.7	[4] 16.7	[4] 19.1	22.3	13.0	4.4	Sandy loam
	AC	4–9	[4] 6.4	[4] 9.0	[4] 8.1	[4] 14.3	[4] 16.8	23.8	21.6	2.6	Sandy clay loam
	C	9–16	[4] 8.5	[4] 8.6	[4] 6.6	[4] 11.0	[4] 13.7	27.8	23.8	2.3	Sandy clay loam
	D_r	16–22	[5] 27.5	[5] 11.3	[5] 6.2	[5] 10.9	[5] 13.5	21.1	9.5	9.6	Coarse sandy loam.
Keith loam: *Location:* 1,320 feet S. and 30 feet W. of NE. corner, sec. 16, T. 16 N., R. 54 W., (*Sample No.* S 57 Neb–53–3; *Laboratory No.* 5810–5818).	A_{1p}	0–5	[6] 2.8	8.0	5.1	7.1	20.4	38.2	18.4	([7])	Loam
	A_{12}	5–7	1.8	5.1	3.7	5.2	20.3	42.5	21.4	1.3	Loam
	B_1	7–10	1.2	3.8	2.8	4.0	17.5	42.4	28.3	([7])	Clay loam
	B_{21}	10–18	.4	2.0	1.6	2.9	17.3	45.6	30.2	([7])	Clay loam
	B_{22}	18–23	.5	1.8	1.8	3.3	20.0	50.0	22.6	([7])	Silt loam or loam.
	C_{1ca}	23–32	.8	2.8	1.9	3.3	22.3	50.9	18.0	([7])	Silt loam or loam.
	C_2	32–40	.6	2.7	2.1	3.4	24.4	49.8	17.0	([7])	Loam
	C_3	40–57	1.6	7.6	5.2	7.3	29.3	36.6	12.4	([7])	Loam
	C_4	57–64	5.4	16.4	11.9	15.6	26.5	16.3	7.9	1.7	Sandy loam
Rosebud loam, deep: *Location:* 800 feet E. and 420 feet N. of SW. corner, sec. 9, T. 13 N., R. 53 W., (*Sample No.* S 57 Neb–53–1; *Laboratory No.* 5795–5802).	A_{1p}	0–6	4.5	6.8	4.2	5.6	16.1	43.9	18.9	4.6	Loam
	A_{12}	6–8	5.6	6.9	4.0	5.6	15.0	43.5	19.4	4.8	Loam
	B_1	8–11	4.1	7.1	4.3	5.5	11.0	40.6	26.5	2.8	Loam
	B_2	11–20	1.3	2.8	2.4	3.4	12.5	44.4	33.2	--------	Clay loam
	B_{3ca}	20–23	[8] .8	[3] 2.2	[3] 2.4	[3] 3.7	[3] 15.6	46.7	28.6	([7])	Clay loam
	C_1	23–28	[8] 1.0	[3] 3.6	[3] 3.7	[3] 5.9	[3] 19.3	45.3	21.2	3.2	Loam
	C_2	28–34	[8] 4.9	[3] 10.9	[3] 9.1	[3] 12.1	[3] 18.9	29.7	14.4	45.7	Fine sandy loam.
	D	34–45	[8] 35.7	[3] 18.4	[3] 8.1	[3] 6.7	[3] 6.1	8.1	16.9	2.6	Coarse sandy loam.
Rosebud loam, moderately deep: *Location:* 1,900 feet W. and 135 feet N. of SE. corner sec. 4, T. 13 N., R. 55 W., (*Sample No.* S 57 Neb–53–5; *Laboratory No.* 5828–5833).	A_{1p}	0–4	[6] 2.1	10.2	8.2	9.8	15.1	35.5	19.1	([7])	Loam
	B_2	4–11	1.0	5.7	6.2	8.6	14.7	33.5	30.3	([7])	Clay loam
	BC_{ca}	11–15	[8] .9	[8] 5.3	[8] 5.5	[8] 8.0	[8] 16.6	34.2	29.5	--------	Clay loam
	C_1	15–19	[8] 2.2	[8] 9.9	[8] 7.8	[8] 11.5	[8] 18.7	27.5	22.4	([7])	Sandy clay loam.
	C_2	19–23	[4] 6.0	[4] 15.4	[4] 11.2	[4] 13.9	[4] 15.6	20.5	17.4	4.5	Sandy loam
	D_1	23–30	[4] 12.6	[4] 17.3	[4] 13.2	[4] 15.6	[4] 11.1	13.8	16.4	20.1	Sandy loam

[1] Method of analysis provided distillation of absorbed ammonia after leaching to remove extractable cations.

[2] Concretions of manganese estimated to make up 0 to 25 percent of the particles.

[3] Concretions of manganese and calcium carbonate estimated to make up 25 to 50 percent of the particles.

[4] Concretions of calcium carbonate estimated to make up 25 to 50 percent of the particles.

selected soil profiles

Service, Lincoln, Nebr. Dashes indicate values not determined]

Chemical analysis												Exchangeable sodium percentage
Reaction (pH)		Organic carbon	Nitrogen	Electrical conductivity ($ECx10^3$ millimhos per cm. at 25° C.)	$CaCO_3$ equivalent	Cation exchange capacity (NH_4AC)[1]	Extractable cations					
1:1	1:10						Ca	Mg	N	Na	K	
		Percent	*Percent*		*Percent*	*Meq./100 gm.*	*Meq./100 gm.*	*Meq./100 gm.*	*Meq./100 gm.*	*Meq./100 gm.*	*Meq./100 gm.*	
6.6	7.2	1.12	0.094	0.5	<1	13.9	8.4	2.2	3.1	<0.1	1.8	<1
6.7	7.2	.77	.074	.6	<1	14.2	9.2	3.0	2.4	<.1	1.2	<1
7.0	7.4	.52	.055	.6	<1	16.5	10.4	4.1	2.0	<.1	1.3	<1
7.1	7.8	.56	.062	.5	7	24.2	15.0	6.8	2.0	<.1	2.1	<1
7.7	8.4	.58	.073	.7	5	26.2	17.8	8.2	.8	.1	2.6	<1
8.3	9.1	.61	.075	.7	7	23.2	---	---	---	.1	2.6	<1
8.5	9.2	.37	---	.7	14	18.6	---	---	---	.2	2.4	1
8.5	9.3	.22	---	.8	16	11.0	---	---	---	.2	1.5	2
8.7	9.4	.02	---	.8	1	4.5	---	---	---	.1	.7	2
8.0	8.5	1.60	.145	.7	5	15.1	---	---	---	<.1	1.2	<1
7.9	8.6	1.75	.188	.7	19	15.8	---	---	---	<.1	.5	<1
8.0	8.7	1.05	.133	.6	27	14.1	---	---	---	<.1	.3	<1
8.1	8.9	.39	.050	.6	35	11.4	---	---	---	<.1	.6	<1
6.8	7.3	.92	.076	.6	<1	15.3	10.3	2.9	3.5	<.1	1.8	<1
6.7	7.2	.87	.080	.6	<1	17.3	11.1	3.2	3.9	<.1	1.8	<1
7.0	7.4	.54	.058	.6	<1	21.4	14.0	4.9	2.4	.1	2.0	<1
7.3	7.8	.45	.049	.6	<1	25.8	16.1	6.8	2.8	.2	2.8	1
7.9	8.5	.42	.051	.8	<1	24.8	16.3	7.0	.8	.5	3.2	2
8.6	9.4	.25	.023	.8	8	19.3	---	---	---	1.0	3.1	5
8.9	9.6	.17	---	.9	9	17.6	---	---	---	1.7	3.2	8
9.1	9.7	.05	---	1.1	4	14.2	---	---	---	2.1	2.6	13
9.1	9.7	.02	---	1.2	3	9.2	---	---	---	1.3	1.4	12
7.6	8.1	1.27	.109	.8	<1	16.8	13.3	2.1	4.7	<.1	2.1	<1
7.3	7.7	1.20	.102	.7	<1	16.6	12.1	2.4	4.3	<.1	1.9	<1
7.3	7.7	.65	.064	.6	<1	9.1	12.9	4.1	3.2	<.1	2.0	<1
7.6	8.0	.52	.060	.6	<1	26.3	17.2	7.2	2.8	.2	2.8	1
8.3	9.0	.74	.091	.8	9	23.8	---	---	---	.3	3.0	1
8.5	9.2	.35	.038	.8	12	18.6	---	---	---	.4	2.7	2
8.7	9.4	.12	---	.9	8	13.3	---	---	---	.5	2.1	3
8.8	9.3	.05	---	1.0	8	13.3	---	---	---	.8	2.0	5
7.8	8.3	1.17	.111	.7	<1	17.4	16.7	1.1	1.6	<.1	1.6	<1
7.5	8.0	.79	.080	.6	1	25.2	20.2	4.2	2.4	<.1	1.3	<1
8.2	8.7	1.02	.104	.6	18	19.4	---	---	---	<.1	1.2	<1
8.2	9.0	.41	.043	.6	17	14.7	---	---	---	<.1	1.3	<1
8.3	9.1	.21	.020	.6	12	12.5	---	---	---	<.1	1.4	<1
8.5	9.2	.16	.014	.7	17	10.1	---	---	---	<.1	1.2	<1

[5] Concretions of calcium carbonate estimated to make up 50 percent of the particles.

[6] Particles are organic matter.

[7] Trace.

[8] Concretions of calcium carbonate estimated to make up 0 to 25 percent of the particles.

Profile of a phase of Rosebud loam, deep, located 800 feet east and 420 feet north of SE. corner, sec. 9, T. 13 N., R. 53 W., in a cultivated field:

A_{1p} 0 to 6 inches, grayish-brown (10YR 5/2) loam; very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; very friable when moist; abrupt, smooth boundary.

A_{12} 6 to 8 inches, grayish-brown (10YR 5/2) loam; very dark grayish brown (10YR 3/2) when moist; weak, coarse, subangular blocky structure; friable when moist; clear, smooth boundary.

B_1 8 to 11 inches, grayish-brown (10YR 5/2) loam; very dark grayish brown (10YR 3/2) when moist; compound prismatic and weak, medium, subangular blocky structure; firm when moist; broken clay films on ped faces; abrupt, smooth boundary.

B_2 11 to 20 inches, pale-brown (10YR 6/3) clay loam; dark brown (10YR 3/3) when moist; compound weak, coarse, prismatic and moderate, fine and medium, subangular blocky structure; firm when moist; continuous clay films on ped faces; clear, smooth boundary.

B_{3ca} 20 to 23 inches, light brownish-gray (10YR 6/2) clay loam; grayish brown (10YR 5/2) when moist; weak, coarse, subangular blocky structure; friable when moist; strong effervescence; clear, smooth boundary.

C_1 23 to 28 inches, light-gray (10YR 7/2) loam; light brownish gray (10YR 6/2) when moist; weak, medium, subangular blocky structure; friable when moist; disseminated lime in root channels and along structural faces; violent effervescence; clear, smooth boundary.

C_2 28 to 34 inches, light-gray (10YR 7/2) fine sandy loam; brown (10YR 5/3) when moist; massive; friable when moist; disseminated lime in root channels; violent effervescence; clear, smooth boundary.

D 34 to 45 inches, pink (7.5YR 7/4) weathered Tertiary silts; brown (10YR 5/3) when moist; contains a high proportion of fragments of granitic gravel and sandy limestone.

In all horizons there are krotovinas, 1 to 2 inches in diameter. The krotovinas in the lower horizons are filled with dark-colored material that was transported from the surface horizons.

General Nature of Kimball County

This section is provided mainly for those who are not familiar with the county. It gives general information about the county and rather detailed information about climate.

Physiography, Drainage, and Vegetation

Kimball County is a moderately rolling plain divided by the valley of Lodgepole Creek. This valley is sharply defined and extends across the county in an east-west direction. It is 1 to 2 miles wide and about 200 feet deep. On each side of the valley are broad areas of undulating tableland.

The county is a constructional plain that was built up by deposits of rock debris, which washed from the Rocky Mountain region to the west. The two areas of upland are both called the tableland or the divides. They have similar topography.

Because many shallow drainageways are close to each other, the county is slightly rolling in most places. Some areas are nearly level. In their upper courses, the drainageways, or draws, are broad, shallow depressions that have no continuous channels. Along the lower courses of the larger draws are steep slopes or bluffs that are rugged and barren in a few places. The floors of the larger draws are fairly wide and nearly level. They are partly filled with sand.

Small, isolated buttes or hills with level tops and rounded knolls rise above the upland plain. In only a few places are these flat landforms more than 50 feet above the general level of the surrounding areas. Also scattered in the tableland are many slight basins or depressions without drainage outlets. These basins are shallow and range from less than an acre to as much as 1,000 acres in size.

The elevation of the county ranges from about 4,800 to 5,300 feet above sea level. The plain slopes eastward. Lodgepole Creek, a tributary of the South Platte River, is the principal drainage channel and the only stream of importance in the county. A small area in the extreme northern part of the county is drained by Rocky Hollow, which runs northeastward. Short tributary branches occur throughout the upland. The county is adequately drained except in the small depressions and on some of the low bottom lands along Lodgepole Creek. The general direction of the drainage is eastward, the direction of the general slope of the plain.

Kimball County is in what is commonly called shortgrass country and is practically treeless. The only native trees in the county are cottonwood, boxelder, ash, willow, juniper, and stunted pine. These trees are along the streams and draws. The juniper and the stunted pine are on the rougher and more broken land along the larger streams and draws.

Climate and Its Effect on Crop Yields [5]

The climate of Kimball County is distinctly continental. Humidity and precipitation are low, and most of the rainfall comes in summer. At times high winds cause serious soil blowing. The temperature fluctuates greatly from season to season, from day to day, and according to time of the day. The risk of hail is as great in Kimball County as it is any other place in the United States. Sunshine is abundant. Because the county is at an elevation of about 5,000 feet, summer nights are cool and the climate generally is healthful and stimulating. Table 13 lists the average monthly, seasonal, and annual temperature and precipitation at Kimball, Nebr.

Precipitation

The moisture that falls as rain, snow, or hail in Kimball County comes from the Gulf of Mexico and the South Atlantic Ocean. Moisture from the Pacific Ocean is blocked by the high mountain ranges to the west. Much of the moisture that moves northward from the Gulf of Mexico and the South Atlantic Ocean falls as precipitation to the east of Kimball County. Much more rain, therefore, falls in the Corn Belt than falls in Kimball County.

On the other hand, the high elevation of Kimball County tends to increase precipitation. The easterly flow of air cools and expands as it travels up the sloping terrain toward this county. This same upland flow makes air at lower levels unstable or buoyant, a condition that favors showers, thunderstorms, and hail in summer.

[5] This subsection was written by WENDELL C. JOHNSON, Soil Conservation Service.

TABLE 13.—*Temperature and precipitation at Kimball, Kimball County, Nebr.*

[Elevation, 4,725 feet]

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Driest year (1893)	Wettest year (1905)	Average snowfall
	° F.	° F.	° F.	*Inches*	*Inches*	*Inches*	*Inches*
December	28. 9	75	−34	0. 56	0. 85	0	5. 9
January	26. 8	73	−36	. 41	. 10	. 65	4. 3
February	28. 4	75	−30	. 59	. 65	1. 20	6. 2
Winter	28. 0	75	−36	1. 56	1. 60	1. 85	16. 4
March	35. 5	82	−20	1. 03	. 50	1. 87	8. 5
April	45. 5	95	−6	2. 09	. 74	5. 57	6. 5
May	55. 0	99	8	2. 67	1. 28	4. 04	1. 8
Spring	45. 3	99	−20	5. 79	2. 52	11. 48	16. 8
June	65. 2	108	28	2. 49	. 61	4. 10	. 1
July	71. 8	110	37	2. 30	. 99	3. 48	(3)
August	70. 2	104	26	1. 81	. 96	2. 38	0
Summer	69. 1	110	26	6. 60	2. 56	9. 96	. 1
September	61. 0	102	11	1. 18	. 10	1. 57	. 3
October	48. 9	94	0	. 86	(3)	. 73	2. 2
November	36. 5	80	−22	. 52	. 10	(3)	4. 3
Fall	48. 8	102	−22	2. 56	. 20	2. 30	6. 8
Year	47. 8	110	−36	16. 51	6. 88	25. 59	40. 1

[1] Average temperature based on a 63-year record, through 1953; highest temperature on a 61-year record and lowest temperature on a 60-year record, through 1952.

[2] Average precipitation based on a 67-year record, through 1955; wettest and driest years based on a 67-year record, in the period 1888–1955; snowfall based on a 53-year record, through 1952.

[3] Trace.

Thunderstorms occur in Kimball County on an average of about 50 days in a year. This average is about the same as in Richardson County in the extreme southeastern part of Nebraska, even though the annual precipitation in Richardson County is nearly twice as much as it is in Kimball County.

The curve in figure 24 is plotted to show changes in normal weekly precipitation at Kimball, Nebr., for a 12-month period. For example, the average rainfall in a week that begins on May 1 is 0.6 inch, which is read from the scale on the left of the graph. The amounts of precipitation listed on the left are for 1-week periods; thus, the normal precipitation for a month is the total of the precipitation in the weeks of the month. Figure 24 was adapted from analyses made under the North Central Regional Project NC–26, Weather and Agricultural Production.

From figure 25 can be found the probability of receiving more or less than a given amount of precipitation in any 2-week period during the growing season. For example, draw a vertical line from 5 at the bottom of figure 25 to the point where it intersects the July 26 curve, and from this point, draw a horizontal line to the left to the precipitation scale. You will find that in 1 year in 5 Kimball

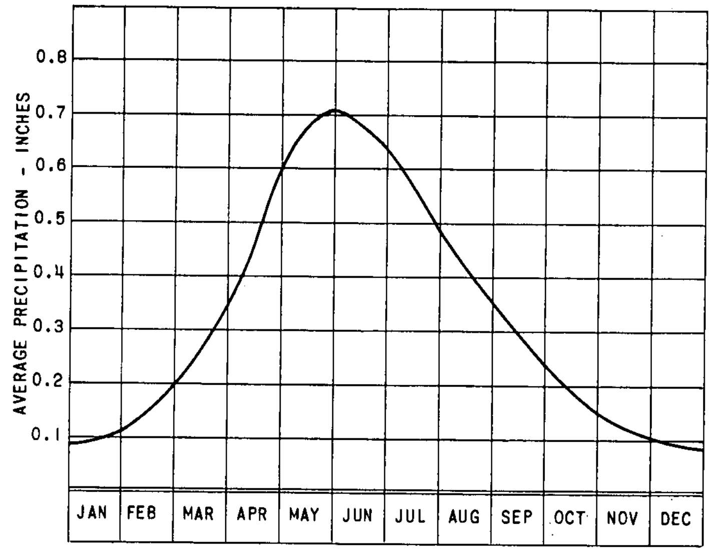

***Figure 24.*—Changes in normal weekly precipitation at Kimball, Nebr., for a 12-month period.**

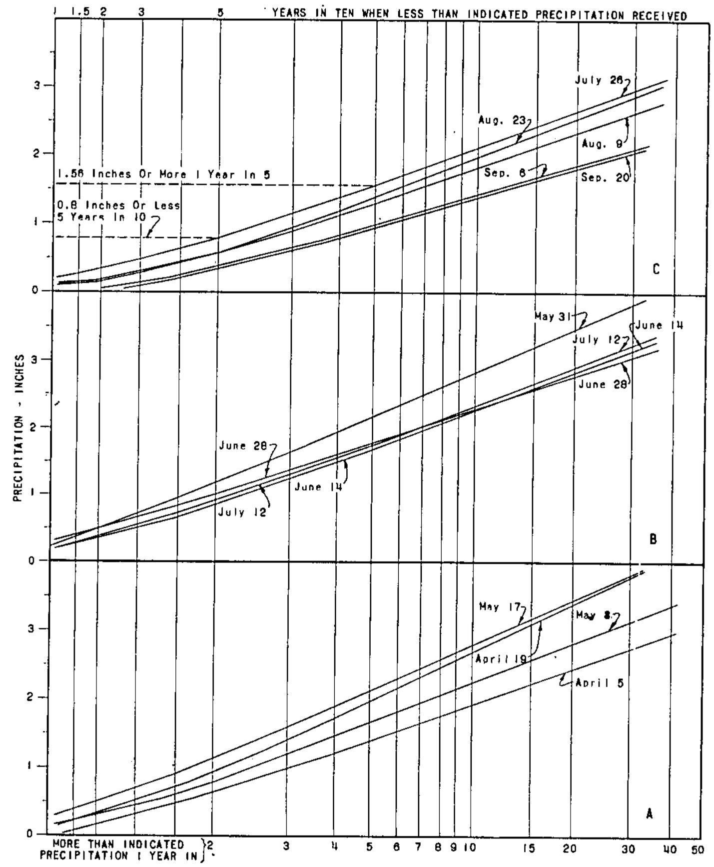

***Figure 25.*—Probability of receiving various amounts of precipitation at Kimball, Nebr., during 2-week periods that begin at indicated dates between April 5 and September 20.**

will probably receive 1.56 inches or more of rain during the 2-week period that begins July 26. Now draw a vertical line downward from 5 on the top scale to the point where it intersects the July 26 curve, and then draw

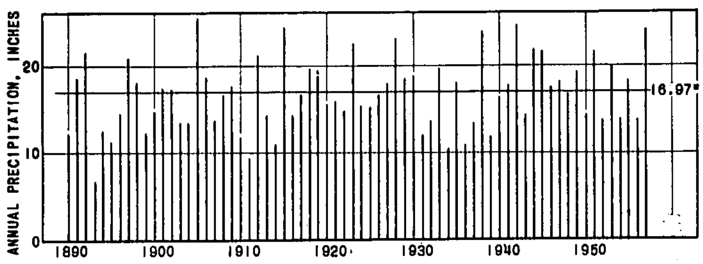

Figure 26.—**Precipitation at Kimball, Nebr., by year, in the period 1890 to 1957.**

a horizontal line to the left. You will see that 5 years in 10 the rainfall for this 2-week period will probably be 0.80 or less.

Periods of consecutive wet and dry years tend to occur (fig. 26). Periods of dry years occurred from 1890 to 1903, 1908 to 1916, and from 1931 to 1939 in the great drought in the 1930's. Wet periods occurred from 1915 to 1930 and from 1938 to 1953. More years have below-normal than above-normal amounts of precipitation. In general, annual precipitation in the Great Plains increases in variability from east to west and from north to south.

Hail

About 10 percent of the thunderstorms in Kimball County are accompanied by hail. Kimball County is in an area that has a great number of days with hail. Also, in a small area around Kimball County the season during which hailstorms occur is longer than elsewhere. Most hailstorms come in June. The storms generally occur in the afternoon when heating of the air by contact with the surface of the ground is greatest. Elevation also influences the likelihood of hail.

The wide fluctuation from year to year in hail damage to wheat in Kimball County is shown in figure 27. The estimates of hail damage used as a basis for this figure were obtained from data compiled by insurance companies. Hail losses have varied from virtually none in 1935 to 50 percent of the crop in 1953. The average loss from 1924 through 1954 was 11.24 percent of the crop.

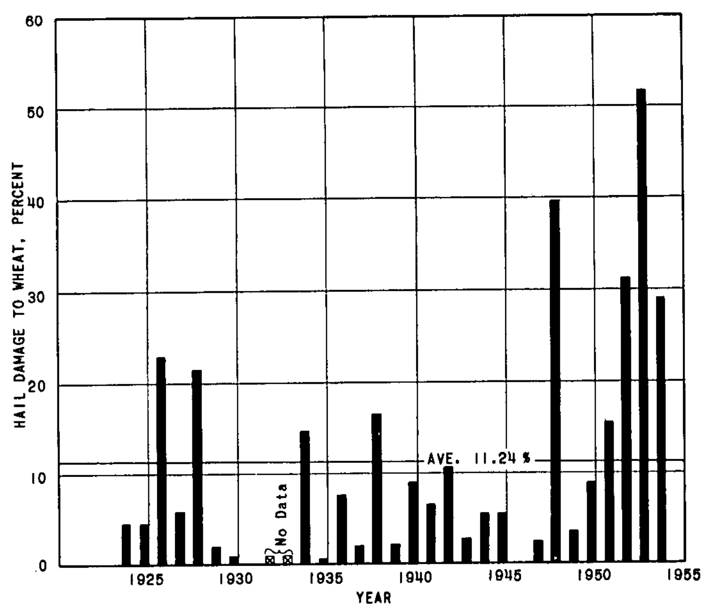

Figure 27.—**Percentage of the wheat crop damaged by hail in Kimball County, 1924–1954.**

Hail risk is greater in years when the precipitation in spring is abundant. Figure 27 shows that, in 9 of the years between 1924 and 1954, hail damage was above average. In 7 of these 9 years, the precipitation in June was above the average of 2.80 inches; the average precipitation of these 7 years was 3.87 inches.

Temperature

Because it is at high elevations, Kimball County has a short growing season. Its average growing season is 137 days, which is much shorter than that in parts of eastern Nebraska at about the same latitude as Kimball County but at lower elevations. The growing season at Omaha is 189 days, and that at Grand Island, in Hall County, is 160 days. Summer in Kimball County is so cool that some varieties of grain sorghum cannot mature. New hybrid varieties that are suited to the area are being developed.

The average date of the last killing frost in spring is May 14, and that of the first killing frost in fall is September 27. The following lists subfreezing temperatures and the average dates of their last occurrence in spring and their first occurrence in fall at Kimball, Nebr.:

Temperature in ° F.	*Last in spring*	*First in fall*
32	May 14	Sept. 27
28	May 3	Oct. 6
24	April 23	Oct. 17
20	April 13	Oct. 24
16	April 3	Nov. 2

The risk of frost after any date in spring and before any date in fall can be determined from figure 28. For example, figure 28 shows that there will probably be frost after May 10 in 6 years of every 10. The risk of frost during the growing season at other dates in spring and in fall also can be determined.

The highest temperature that has been recorded at Kimball is 110° F., and the lowest is −36° F. Because of the high elevations, summers are rather cool. At Kimball, the average number of days per year with temperature higher than 90° is only 20, whereas at Omaha this average is 30 days, and along the Kansas-Nebraska border, the average is 60 days. Because the radiation of heat is rapid after sundown, summer nights are pleasant.

The average number of days with minimum temperatures below zero is 15, about the same as at Omaha and Grand Island. Winter temperatures are frequently moderated by chinook winds that blow from the west down the eastern slope of the Rocky Mountains and warm the air by compression. The average number of days per year when freezing and thawing occur is high along the eastern slope of the Rocky Mountains. This average is about 125 days

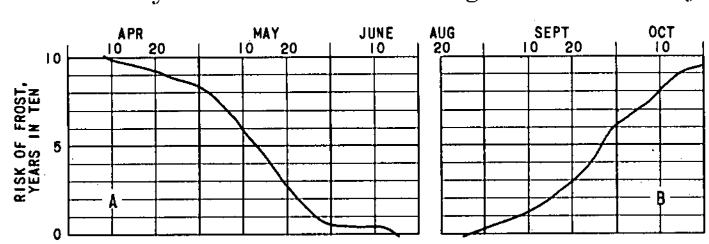

Figure 28.—**Risk of frost: *A*, after any date in spring; *B*, before any date in fall.**

in Kimball County, as compared to 100 days at Omaha. Freezing and thawing affect wind erosion because they loosen the soil and make it more susceptible to blowing.

From May through August, the prevailing winds are from the southeast, and the rest of the year they are from the northwest. Winds are strongest in spring and weakest in summer. Although they are relatively strong, winds are not so strong as they are in the eastern part of the Nebraska Panhandle. Because temperatures vary quite widely during the day, wind velocities during the day vary also. Gusty winds occur in the afternoon. Wind erosion is a problem in some years; it was a great problem in 1955.

Rainfall and wheat production

Since Kimball County is semiarid, drought is always a threat to the dryland farmer. Sparse rainfall and the wind erosion usually limit crop production.

The first farmers in the county turned to other methods after their attempts to raise cultivated crops were unsuccessful. The early attempts were unsuccessful because methods were used that were suited to the more humid regions to the east and there were several dry years in the 1890's. After 1920, use of summer fallowing to conserve moisture increased rapidly. Now, about one-half of the total area of the county is in wheat or fallow for wheat, a crop which the early settlers believed could not be grown profitably. During the 17-year period extending from 1940 to 1956, the seeded acreage of wheat averaged 149,700 acres and the summer fallow averaged 147,500 acres.

Because the occurrence of the rainfall and hail is erratic, annual yields of wheat in the county have fluctuated widely. Yields varied from a low 80,000 bushels to a high of 3,700,000 bushels in the period of 1931 to 1957. In recent years wheat has been raised almost entirely on summer fallowed land.

Curves in figure 29 show the average yield of wheat per seeded acre and the percentage of the wheat crop abandoned in Kimball County for the period extending from 1931 through 1957. Abandonment of acreage sown to wheat has ranged from 10 percent or less in 1941 to more than 75 percent in 1937. The average abandonment for the period between 1931 and 1957 was 24 percent in Kimball County, compared to 15 percent for the State of Nebraska as a whole.

Direct comparison of average annual rainfall in this county with that in other counties can be misleading. Elevation, kind of soil, and tillage practices must also be considered. Temperatures are cooler at higher elevations and the effectiveness of the rainfall is greater because evaporation and plant transpiration are less when it is cold than when it is hot. Also, coarse-textured soils lose less moisture through evaporation than do the more clayey soils. Fallowing also affects the supply of moisture. During a fallow year, about 65 percent of the precipitation is lost through evaporation and about 25 percent is conserved as soil moisture available to plants at wheat planting time. Without fallowing, considerably less moisture is conserved.

Differences in effective rainfall can be shown by comparing this county with Cimarron County in the extreme western end of the Oklahoma Panhandle. Cimarron County has about the same average annual precipitation as Kimball County but has about 700 feet less elevation. Even though hail loss is only about 60 percent as much as that in Kimball County, average yields in Cimarron County are less. Between 1919 and 1955, the average yield of wheat in Cimarron County was 6.5 bushels per seeded acre, whereas between 1931 and 1957, the average yield in Kimball County was 12.7 bushels per acre.

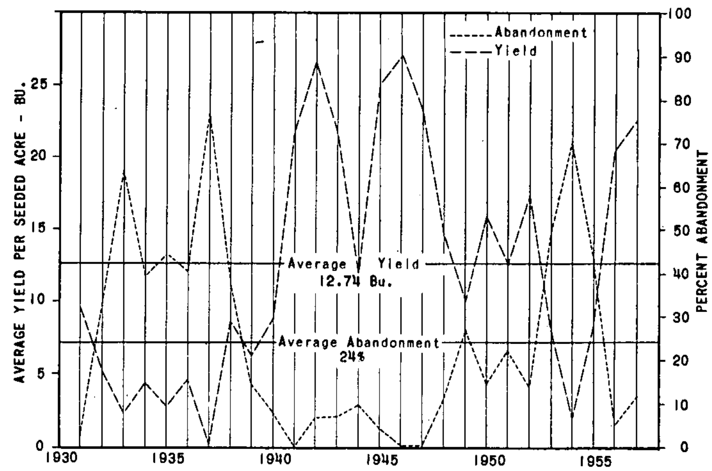

Figure 29.—**Annual yields of wheat per seeded acre in Kimball County and percentages of wheat crop abandoned, 1931–1957.**

Yields in Cimarron County, Okla., are smaller because temperatures are higher and less moisture is conserved by fallowing. In the past decade, only about 60 percent of the wheat land in Cimarron County has been left fallow. Less fallowing is done in Cimarron County because the soils are more clayey than those in Kimball County and therefore are not so well suited to this practice.

The amount of moisture during the fallow season drastically affects the chance of getting a crop. Planting with a fallow-season moisture of less than 25 inches is extremely risky.

Settlement, Transportation, Industry, and Culture

Kimball County was organized in 1888 from part of Cheyenne County. The county was settled mainly by native Americans from eastern Nebraska, Iowa, and Illinois. Kimball, in the central part of the county, is the principal town and the county seat. The other principal towns are Bushnell and Dix.

The main line of the Union Pacific Railroad west of Omaha passes through the central part of the county. U.S. Highway 30 also crosses the county from east to west, and State Highway 29 crosses from north to south. An airport at Kimball is used mostly by private planes.

Oil was discovered in Kimball County in 1951, and by 1958, the county was the largest oil producer in the State. A large gas plant in the southern part of the county processes natural, propane, and butane gases. Much of the crude oil is sent through pipelines for refining outside the county. Serving the oil industry in the county are supply, contracting, and maintenance companies.

Large elevators in the towns handle wheat and other grains. A dairy in Kimball is supplied by the milk produced on many farms. Most of the homes in the county have telephones and electricity.

Two lakes in the county provide fishing, boating, and other recreational facilities.

Public schools serve all parts of the county. Most schools are consolidated, and pupils are transported to and from school in buses. In the three towns are churches of many denominations.

Agriculture

This subsection discusses the history of agriculture in Kimball County and conservation farming, crops, and livestock.

History

Around 1868, the first permanent settlements were made in Kimball County and the Union Pacific Railroad was extended through the county. The early settlers established ranches and raised livestock, mainly cattle.

Farming began on a small scale about 1884, when the Union Pacific Railroad began to sell its land and some public land was opened to settlement and preemption. Wheat and corn were the main crops, but they were not profitably grown. The varieties of those crops planted and the methods of cultivation were not suited to the climate and the soil, and prices were low. After several years of dry weather and poor crops in the early 1890's, farming was practically replaced by ranching. Ranching continued to be the dominant enterprise until about 1905.

After 1905, public lands were bought rapidly as a result of a Federal law that made homesteads available in tracts of 640 acres. Large cattle ranches were broken up, and farming increased. Many homesteaders, however, farmed for only a short time and then sold their land to speculators. By 1916, only about 6 percent of the county was cultivated.

During World War I, the ranchers in Kimball County planted many acres of their rangeland to wheat and other food crops. By the end of the war, about half of the county had been cultivated and winter wheat was the main crop. The planting of wheat in a large total acreage continued after the war. In 1927 about 84,000 acres were in wheat, and by 1952 the acreage in wheat had increased to almost 190,000 acres.

Conservation farming

In 1920 a start was made in conservation farming in Kimball County when summer fallowing was tried. The farmers, however, had trouble finding the best way to conserve moisture by that method. Several dry years in the 1930's and a severe drought in 1937 caused much soil blowing and damage to crops. Feed and seed were scarce. During the drought in 1937, practices of soil conservation were demonstrated, including listing on the contour, seeding native grasses in listed furrows, contour furrowing the rangeland, and stripcropping.

Interest in the conservation of soil and water continued in the 1940's. Meetings were held, and soil conserving practices were established on farms to demonstrate value of the practices. A soil conservation district was organized in the winter of 1948–49, and technicians of the Soil Conservation Service were assigned to assist the district. With the help of the district, many farmers began to terrace their land, to farm on the contour, to plant crops in strips alternating with strips of fallow, to stubble mulch the fields, and to use other practices for conserving soil and water.

Crops

Table 14 lists the acres of principal crops harvested in Kimball County in 1929, 1939, 1949, and 1954 as reported by the U.S. Census of Agriculture.

Wheat is expected to continue as the main crop in the county unless the demand for other crops increases or unless high-value crops are introduced. Corn, beans, potatoes, sugar beets, and alfalfa are generally irrigated. The acreage in those crops is limited by the area in the county suited to irrigation. Oats, barley, rye, and grain sorghum are grown, mainly as substitutes for wheat, and forage sorghum is grown for supplemental and winter feed for livestock.

TABLE 14.—*Acres of principal crops harvested in stated years*

Crop	1929	1939	1949	1954
Winter wheat threshed or combined	129, 908	103, 710	[1] 140, 102	[1] 62, 147
Corn for all purposes	9, 371	6, 199	1, 537	1, 540
Small grains threshed or combined:				
Oats	5, 944	775	5, 476	1, 350
Barley	36, 237	2, 370	13, 941	5, 543
Rye	910	957	443	1, 371
Sorghum harvested for grain	---------	169	27	2, 918
Sorghum cut for silage, hay or fodder	521	5, 766	2, 881	3, 068
Irish potatoes for home use or for sale	5, 050	3, 136	[2] 2, 093	[3] 763
Sugar beets harvested for sugar	728	430	23	---------
All hay	6, 904	6, 654	7, 700	15, 979
Alfalfa and alfalfa mixtures cut for hay	3, 267	502	1, 658	2, 321

[1] Includes summer wheat.
[2] Does not include acreage for farms with less than 15 bushels harvested.
[3] Does not include acreage for farms with less than 20 bushels harvested.

Livestock

Table 15 lists the livestock on farms in Kimball County in 1930, 1940, 1950, 1954, as reported by the U.S. Census.

The need for horses has decreased because farming has become more mechanized. A few horses probably will be kept for handling cattle and for pleasure. Most of the sheep are grazed on wheat pasture. The sheep vary in number from year to year, depending on the amount of pasture available.

TABLE 15.—*Number of livestock on farms in stated years*

Livestock	1930	1940	1950	1954
Cattle and calves	7, 437	[1] 6, 711	11, 940	13, 386
Sheep and lambs	5, 619	[2] 8, 865	9, 622	9, 962
Hogs and pigs	7, 756	[3] 1, 092	1, 436	860
Horses and mules	2, 058	[1] 982	462	312
Chickens	[1] 33, 803	[3] 26, 750	[3] 24, 198	[3] 25, 097

[1] Over 3 months old.
[2] Over 6 months old.
[3] Over 4 months old.

Glossary

Aggregate, soil. Many fine soil particles held together in a single mass or cluster, such as a prism, block, crumb, or granule.

Alluvial soil. A soil developed in alluvium, which consists of soil materials deposited on land by streams.

Association, soil. An area made up of a few or many soils that are in a characteristic geographic pattern. The soils in an association may be similar, or they may differ widely in important characteristics.

Azonal soils. A group of soils that lack well-developed profile characteristics because of their youth, or because relief or the parent material has prevented a normal soil profile from developing.

Bottom lands. The flood plain of a stream, part of which may be flooded at infrequent intervals.

Calcareous soil. Soil that contains enough calcium carbonate, mixed in many places with magnesium carbonate, to cause bubbles to form when treated with dilute hydrochloric acid. Soil that is alkaline in reaction because of the presence of calcium carbonate.

Colluvium. Mixed deposits of soil material and rock fragments near the base of rather steep slopes. Colluvium is moved downhill by force of gravity and, to some extent, by soil creep, frost action, and local wash.

Complex, soil. An intricate mixture of small areas of different soils that are mapped as one unit because the individual areas of the different soils are too small to be mapped as separate units on a map of the scale used.

Consistence, soil. The nature of soil material expressed by the resistance of the individual particles to separation from one another (cohesion), or expressed by the ability of a soil mass to undergo a change in shape without breaking (plasticity). Consistence varies with the moisture content. Thus, a soil aggregate or clod may be hard when dry and plastic when wet. Common terms for consistence are—

Friable. When moist, soil material is easily crushed by hand and coheres when pressed together. Friable soils are easily tilled.

Firm. When moist, soil material crushes under moderate pressure but resistance is distinctly noticeable. Firm soils are likely to be difficult to till.

Hard. When dry, soil material is moderately resistant to pressure; it can be broken in the hands without difficulty but is barely breakable between thumb and forefinger.

Loose. Soil material is noncoherent when moist or dry. Loose soils are generally coarse textured and are easily tilled.

Plastic. When wet, soil material retains an impressed shape and resists being deformed. Plastic soils are high in clay and are difficult to till.

Soft. Soil material is weakly coherent and fragile; when dry, it breaks to powder or individual grains under slight pressure.

Flood plain. The nearly level areas along stream courses that are subject to overflow.

Great soil group (soil classification). A broad group of soils that have common internal soil characteristics.

Horizon, soil. A layer of soil, approximately parallel to the soil surface, with characteristics produced by soil-forming processes.

Horizon A.—The horizon at the surface. From this horizon the soluble minerals and clay have been removed by percolating water. The major A horizon may be subdivided into A_1 the part that is dark colored because of the presence of organic matter, and A_2, the part that is leached and light colored.

Horizon B.—The horizon in which clay or other material has accumulated. It may be subdivided into B_1, B_2, or B_3 horizons.

Horizon C.—The material immediately under the true soil. It is presumed to be similar in chemical, physical, and mineral composition to the material from which at least a part of the overlying soil developed.

Inclusions. Small areas of soil within the borders of a mapped soil that differ from the mapped soil and are too small to map separately.

Intrazonal soil. Any one of the great groups of soils having more or less well-developed soil characteristics that reflect the dominating influence of some local factor of relief or parent material over the normal influences of the climate and vegetation.

Loess. Geological deposit of fairly uniform, fine material, mostly silt, presumably transported by wind.

Mapping unit, soil. Any soil, miscellaneous land type, soil complex, or group of undifferentiated soils shown on the detailed soil map and identified by a symbol.

Mottled. Marked with spots of color and usually associated with poor drainage. Descriptive terms for mottles are: Contrast—*faint, distinct,* and *prominent;* abundance—*few, common,* and *many;* and size—*fine, medium,* and *coarse.* The size measurements are: *Fine,* commonly less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* commonly between 5 and 15 millimeters (about 0.2 to 0.6 inch) along the greatest dimension; and *coarse,* commonly more than 15 millimeters (about 0.6 inch) along the greatest dimension.

Munsell color notation. A method of designating soil color by a combination of letters and numbers, such as 10YR 3/4. The use of the Munsell notation is explained in the "Soil Survey Manual" (*9*).

Ped. An individual natural soil aggregate such as a crumb, a prism, or a block, in contrast to a clod, which is a mass of soil formed after digging or other disturbance.

Permeability, soil. That quality of the soil that enables it to transmit water and air.

Phase, soil. A subdivision of a soil type having variations in characteristics not significant to the classification of a soil in its natural landscape but significant to use and management of the soil. The variations are chiefly in such external characteristics as relief, stoniness, or erosion.

Planosol. An intrazonal group of soils with eluviated surface horizons underlain by claypans or fragipans and developed on nearly level or gently sloping uplands in humid and subhumid climates.

Profile, soil. A vertical section of the soil through all the horizons and extending into the parent material.

Range sites. A kind of rangeland that differs from other rangeland in its ability to produce significantly different kinds or amounts of climax, or original, vegetation. A significant difference is one large enough to require different grazing or management to maintain or improve the condition of the range.

Range condition. The present state of the vegetation in relation to the climax vegetation for that site.

Reaction, soil. The degree of acidity or alkalinity of a soil mass, expressed in either pH values or in words, as follows:

	pH		*pH*
Extremely acid	below 4.5	Neutral	6.6–7.3
Very strongly acid	4.5–5.0	Mildly alkaline	7.4–7.8
Strongly acid	5.1–5.5	Moderately alkaline	7.9–8.4
Medium acid	5.6–6.0	Strongly alkaline	8.5–9.0
Slightly acid	6.1–6.5	Very strongly alkaline	9.1 and higher.

Regosol. An azonal group of soils that are without definite genetic horizons and are on deep unconsolidated deposits or soft rocky deposits.

Runoff. The amount of water removed by flow over the surface of the soil and the rapidity of this flow. The amount and rapidity of runoff are affected by factors such as texture, structure, and porosity of the surface soil; the vegetative covering; the prevailing climate; and the slope. Relative degree of runoff is expressed in six classes as follows: *Very rapid, rapid, medium, slow, very slow,* and *ponded.*

Series, soil. A group of soils that have genetic horizons similar, except for the texture of the surface soil, as to differentiating characteristics and arrangement in the soil profile, and developed from a particular type of parent material. A series may include two or more soil types that differ from one another in the texture of the surface soil.

Soil. (1) The natural medium for the growth of land plants. (2) A dynamic natural body on the surface of the earth in which plants grow, composed of mineral and organic materials and living forms. (3) The collection of natural bodies occupying parts of the earth's surface that support plants and that have properties due to the integrated effect of climate and living matter acting upon parent material, as conditioned by relief, ove periods of time. A soil is an individual three-dimensional body on the surface of the earth, unlike the adjoining bodies.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active.

Structure, soil. The aggregation of primary soil particles into compound particles, or clusters of primary particles, which are separated from adjoining aggregates by surfaces of weakness. Soil structure is classified according to *grade, class,* and *type.*

Grade. Distinctness of aggregation. Expresses the differential between cohesion within aggregates and adhesion between aggregates. Terms: *Structureless* (single grain or massive), *weak, moderate,* and *strong.*

Class. Size of soil aggregates. Terms: *Very fine* or *very thin, fine* or *thin medium, coarse* or *thick,* and *very coarse* or *very thick.*

Type. Shape and arrangement of individual natural soil aggregates. Terms: *Platy, prismatic, columnar, blocky, subangular blocky, granular,* and *crumb.* (Example of grade, class, and type: Moderate, coarse, subangular blocky.)

Texture, soil. Size of the individual particles making up the soil mass. The relative amounts of particles of different size classes, called sand, silt, and clay, determine texture. A coarse-textured soil is one high in content of sand; a fine-textured one contains a large proportion of clay.

Clay. Small mineral soil grains, less than 0.002 millimeter (0.000079 inch) in diameter. Soil material that contains 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Silt. Small mineral soil grains ranging from 0.05 millimeter (0.002 inch) to 0.002 millimeter (0.000079 inch) in diameter. Includes all soil material that contains 80 percent or more silt and less than 12 percent clay.

Sand. Small rock or mineral fragments that have diameters ranging from 0.05 millimeter (0.002 inch) to 2.0 millimeters (0.079 inch). The term sand is also applied to soils that contain 90 percent or more of sand.

Type, soil. A subdivision of the soil series based on texture of the surface soil.

Woodland site. A group of soils that produce the same kinds and amounts of forest products and need similar management.

Zonal soil. A soil with well-developed soil characteristics that reflect the influence of the active factors of soil genesis—climate and living organisms, chiefly vegetation.

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GUIDE FOR MAPPING UNITS

[See table 1, p. 7, for approximate acreage and proportionate extent of each soil; table 2, p. 28, for estimated yields under dryland farming; table 3, p. 33, for estimated yields under irrigation; and table 9, facing p. 58, for engineering interpretations]

Map symbol	*Mapping unit*	*Page*	*Dryland capability unit*	*Page*	*Irrigated capability unit*	*Page*	*Range site*	*Page*	*Woodland site*	*Page*
AfAW	Altvan fine sandy loam, deep, 1 to 3 percent slopes.	8	IIIe-3	26		--	Sandy	34	Sandy	37
Aa	Altvan loam, deep, 0 to 1 percent slopes.	8	IIIc-1 [1]	25		--	Silty	34	Silty to Clayey.	36
AaAW	Altvan loam, deep, 1 to 3 percent slopes.	8	IIIe-1 [2]	25		--	Silty	34	Silty to Clayey.	36
AaBW	Altvan loam, deep, 3 to 5 percent slopes.	9	IIIe-1	25		--	Silty	34	Silty to Clayey.	36
AaCW	Altvan loam, deep, 5 to 9 percent slopes.	9	IVe-1	26		--	Silty	34	Silty to Clayey.	36
3AAW	Altvan loam, moderately deep, 1 to 3 percent slopes.	9	IIIe-1	25		--	Silty	34	Silty to Clayey.	36
3ABW	Altvan loam, moderately deep, 3 to 5 percent slopes.	9	IVe-1	26		--	Silty	34	Silty to Clayey.	36
3ACW	Altvan loam, moderately deep, 5 to 9 percent slopes.	9	IVe-1	26		--	Silty	34	Silty to Clayey.	36
BfBW	Bayard fine sandy loam, 1 to 5 percent slopes.	10	IIIe-3	26	IIIe-3	32	Sandy	34	Sandy	37
BhA	Bridgeport loam, 1 to 3 percent slopes	10	IIIe-1 [2]	25	IIe-1	31	Silty	34	Silty to Clayey.	36
BhB	Bridgeport loam, 3 to 5 percent slopes	10	IIIe-1	25	IIIe-1	32	Silty	34	Silty to Clayey.	36
CcBW	Canyon loam, 0 to 5 percent slopes	11	VIs-4	27		--	Shallow	34	Shallow	37
CcB3	Canyon loam, 0 to 5 percent slopes, eroded.	11	VIs-4	27		--	Shallow	34	Shallow	37
CRC	Canyon-Rosebud loams, 5 to 9 percent slopes.	11	VIs-4	27		--	Shallow	34	Shallow	37
CRC3	Canyon-Rosebud loams, 5 to 9 percent slopes, eroded.	11	VIs-4	27		--	Shallow	34	Shallow	37
CcD	Canyon loam, 9 to 20 percent slopes	11	VIs-4	27		--	Shallow	34	Shallow	37
CnBW	Canyon sandy loam, 0 to 5 percent slopes.	11	VIs-4	27		--	Shallow	34	Shallow	37
CVC	Canyon-Vebar sandy loams, 5 to 9 percent slopes.	11	VIs-4	27		--	Shallow	34	Shallow	37
CnD	Canyon sandy loam, 9 to 20 percent slopes.	11	VIs-4	27		--	Shallow	34	Shallow	37
C-C	Canyon complex, 0 to 9 percent slopes	11	VIIs-3	27		--	Very shallow	34	Not suited to trees.	37
C-D	Canyon complex, 9 to 20 percent slopes	11	VIIs-3	27		--	Very shallow	34	Not suited to trees.	37
ChAW	Chappell sandy loam, 1 to 3 percent slopes	12	IVe-3	26		--	Sandy	34	Sandy	37
ChBW	Chappell sandy loam, 3 to 5 percent slopes	12	VIe-3	27		--	Sandy	34	Sandy	37
ChC	Chappell sandy loam, 5 to 9 percent slopes	12	VIe-3	27		--	Sandy	34	Sandy	37
Cy	Cheyenne loam, 0 to 1 percent slopes	13	IIIc-1	25	IIs-5	32	Silty	34	Silty to Clayey	36
CyA	Cheyenne loam, 1 to 3 percent slopes	13	IIIe-1	25	IIe-1	31	Silty	34	Silty to Clayey	36
DxC	Dix loams, 3 to 9 percent slopes	13	VIs-4	27		--	Shallow	34	Shallow	37
DxD	Dix complex, 9 to 20 percent slopes	13	VIs-4	27		--	Shallow	34	Shallow	37
Dy	Dwyer loamy sand	14	IVe-5	26		--	Sands	34	Sandy	37
Gd	Glendive fine sandy loam	14	IIIe-3	26	IIe-3	31	Sandy	34	Sandy	37
Go	Goshen loam, 0 to 1 percent slopes	15	IIc-1	25		--	Silty	34	Silty to Clayey	36
GoA	Goshen loam, 1 to 3 percent slopes	15	IIIe-1 [2]	25		--	Silty	34	Silty to Clayey	36
Gv	Gravelly land	15	VIIs-3	27		--	Very shallow	34	Not suited to trees.	37
He	Havre silt loam	16	IIc-1	25	I-1	31	Silty	34	Silty to Clayey	36
Ke	Keith loam, 0 to 1 percent slopes	17	IIIc-1 [1]	25		--	Silty	34	Silty to Clayey	36
KeAW	Keith loam, 1 to 3 percent slopes	17	IIIe-1 [2]	25		--	Silty	34	Silty to Clayey	36
KeBW	Keith loam, 3 to 5 percent slopes	17	IIIe-1	25		--	Silty	34	Silty to Clayey	36
Lx	Loamy alluvial land	17	VIw-2	27		--	Overflow	34	Moderately Wet.	37
Pn	Parshall sandy loam, deep, 0 to 1 percent slopes.	17	IIIe-3	26	IIe-3	31	Sandy	34	Sandy	37
PnBW	Parshall sandy loam, deep, 1 to 5 percent slopes.	17	IIIe-3	26	IIIe-3	32	Sandy	34	Sandy	37
PnCW	Parshall sandy loam, deep, 5 to 9 percent slopes.	17	IVe-3	26	IVe-3	32	Sandy	34	Sandy	37
3Pn	Parshall sandy loam, moderately deep, 0 to 1 percent slopes.	17	IVe-3	26	IIIe-3	32	Sandy	34	Sandy	37
3PnB	Parshall sandy loam, moderately deep, 1 to 5 percent slopes.	18	IVe-3	26	IVe-3	32	Sandy	34	Sandy	37

See footnotes at end of table.

GUIDE FOR MAPPING UNITS—Continued

Map symbol	Mapping unit	Page	Dryland capability unit	Page	Irrigated capability unit	Page	Range site	Page	Woodland site	Page
Rw	Riverwash	18	VIIIs-1	27	----	----	----	----	Not suited to trees.	37
Rv	Rock land	18	VIIs-3	27	----	----	Very shallow	34	Not suited to trees.	37
Rb	Rosebud loam, deep, 0 to 1 percent slopes.	19	IIIc-1 [1]	25	----	----	Silty	34	Silty to Clayey.	36
RbAW	Rosebud loam, deep, 1 to 3 percent slopes.	19	IIIe-1 [2]	25	----	----	Silty	34	Silty to Clayey.	36
RbBW	Rosebud loam, deep, 3 to 5 percent slopes.	19	IIIe-1	25	----	----	Silty	34	Silty to Clayey.	36
RbCW	Rosebud loam, deep, 5 to 9 percent slopes.	19	IVe-1	26	----	----	Silty	34	Silty to Clayey.	36
RbD	Rosebud loam, 9 to 15 percent slopes	19	VIe-1	27	----	----	Silty	34	Silty to Clayey.	36
3RbW	Rosebud loam, moderately deep, 0 to 1 percent slopes.	19	IIIc-1	25	----	----	Silty	34	Silty to Clayey.	36
3RAW	Rosebud loam, moderately deep, 1 to 3 percent slopes.	19	IIIe-1	25	----	----	Silty	34	Silty to Clayey.	36
3RBW	Rosebud loam, moderately deep, 3 to 5 percent slopes.	19	IVe-1	26	----	----	Silty	34	Silty to Clayey.	36
3RCW	Rosebud loam, moderately deep, 5 to 9 percent slopes.	19	IVe-1	26	----	----	Silty	34	Silty to Clayey.	36
Sx	Sandy alluvial land	20	VIs-4	27	----	----	Shallow	34	Shallow	37
Se	Scott silt loam	20	VIw-2	27	----	----	Overflow	34	Moderately Wet.	37
Tr	Tripp fine sandy loam, 0 to 1 percent slopes.	21	IIIe-3	26	IIe-3	31	Sandy	34	Sandy	37
TrA	Tripp fine sandy loam, 1 to 3 percent slopes.	21	IIIe-3	26	IIe-3	31	Sandy	34	Sandy	37
TrBW	Tripp fine sandy loam, 3 to 5 percent slopes.	21	IIIe-3	26	IIIe-3	32	Sandy	34	Sandy	37
Ta	Tripp loam, 0 to 1 percent slopes	21	IIc-1	25	I-1	31	Silty	34	Silty to Clayey.	36
TaAW	Tripp loam, 1 to 3 percent slopes	21	IIIe-1 [2]	25	IIe-1	31	Silty	34	Silty to Clayey.	36
TaBW	Tripp loam, 3 to 5 percent slopes	21	IIIe-1	25	IIIe-1	32	Silty	34	Silty to Clayey.	36
TaCW	Tripp loam, 5 to 9 percent slopes	21	IVe-1	26	IVe-1	32	Silty	34	Silty to Clayey.	36
VrAW	Vebar sandy loam, 0 to 3 percent slopes.	22	IIIe-3	26	----	----	Sandy	34	Sandy	37
VrBW	Vebar sandy loam, 3 to 5 percent slopes.	22	IVe-3	26	----	----	Sandy	34	Sandy	37
VrCW	Vebar sandy loam, 5 to 9 percent slopes.	22	IVe-3	26	----	----	Sandy	34	Sandy	37
VrD	Vebar sandy loam, 9 to 15 percent slopes.	22	VIe-3	27	----	----	Sandy	34	Sandy	37
Wx	Wet alluvial land	22	Vw-1	27	----	----	Wet Land	34	Wet	37

[1] These soils are in capability unit IIc-1 (dryland) in the Keith-Rosebud soil association (see General Soil Map).

[2] These soils are in capability unit IIc-1 (dryland) in the Keith-Rosebud soil association (see General Soil Map).

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