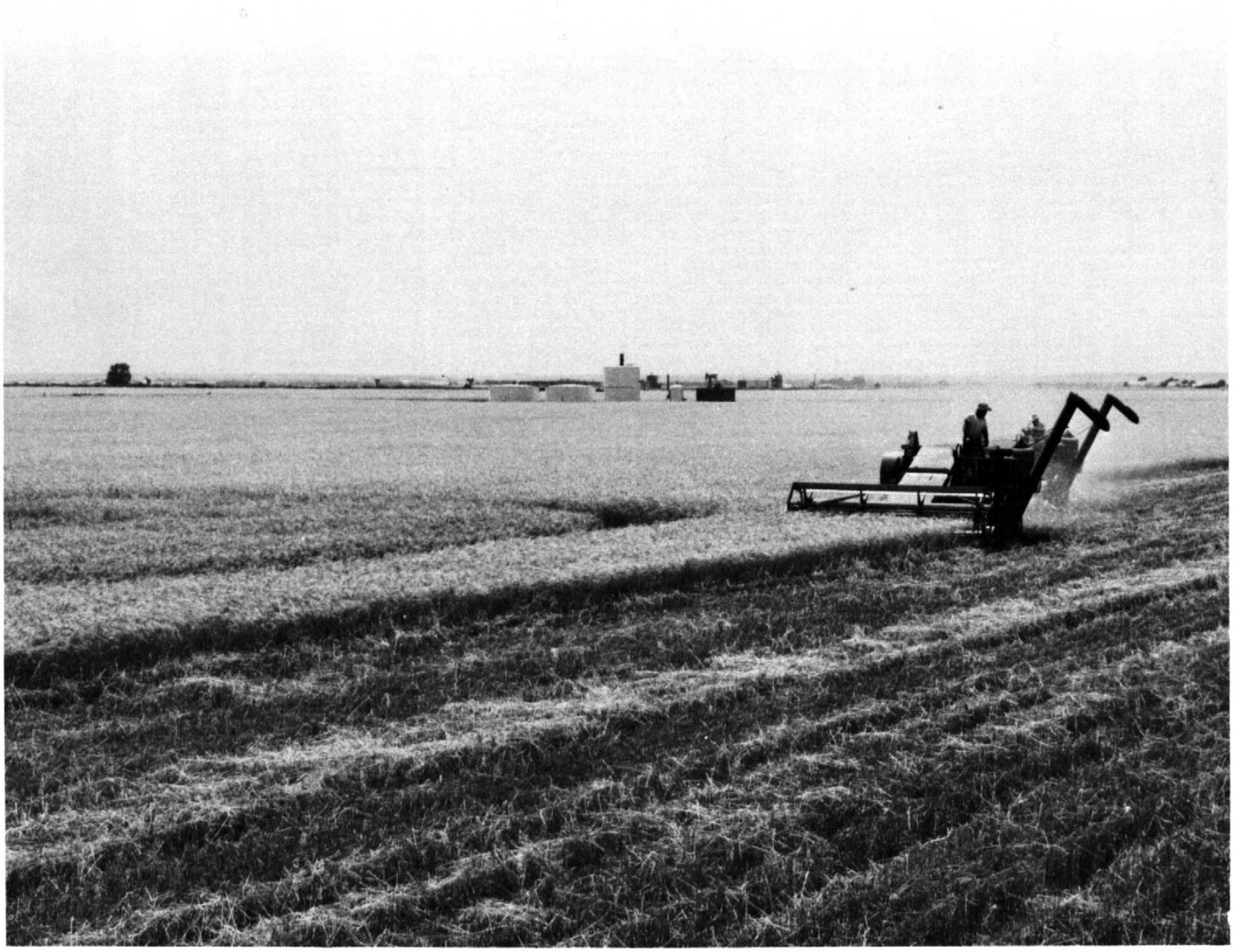
SOIL SURVEY OF

Ellis County, Kansas



United States Department of Agriculture
Soil Conservation Service
In cooperation with
Kansas Agricultural Experiment Station

Major fieldwork for this soil survey was done in the period 1961–68. Soil names and descriptions were approved in 1970. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1970. This survey was made cooperatively by the Soil Conservation Service and the Kansas Agricultural Experiment Station; it is part of the technical assistance furnished to the Ellis County Soil Conservation District.

Copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C., 20250.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and ranches; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Ellis County are shown on the detailed map on the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all of the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the windbreak suitability group and range site in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about the use and management of the soils from the soil descriptions and from the discussions of the capability units, the range sites, and the windbreak suitability groups.

Foresters and others can refer to the section "Windbreaks," where the soils of the county are grouped according to their suitability for trees.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Fish and Wildlife Management."

Ranchers and others can find, under "Range," groupings of the soils according to their suitability for range, and also the name of many of the plants that grow on each range site.

Community planners and others can read about soil properties that affect the choice of sites for dwellings, industrial buildings, schools, and parks in the section "Engineering Uses of the Soils."

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about how the soils were formed and how they are classified in the section "Formation and Classification of the Soils."

Students, teachers, and others can find information about soils and their management in various parts of the text.

Newcomers in Ellis County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "General Nature of the County."

Cover: **Wheat and oil production on Harney silt loam, 0 to 1 percent slopes. A small pothole is near center of photo.**

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SOIL SURVEY OF ELLIS COUNTY, KANSAS

BY ROBERT K. GLOVER, LARRY D. ZAVESKY, WILLIAM R. SWAFFORD, AND QUINTEN L. MARKLEY, SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH KANSAS AGRICULTURAL EXPERIMENT STATION

ELLIS COUNTY, located in the north-central part of Kansas (fig. 1), has an area of 576,000 acres, or about 900 square miles. Hays is the county seat. In 1970 the county had a population of 15,396.

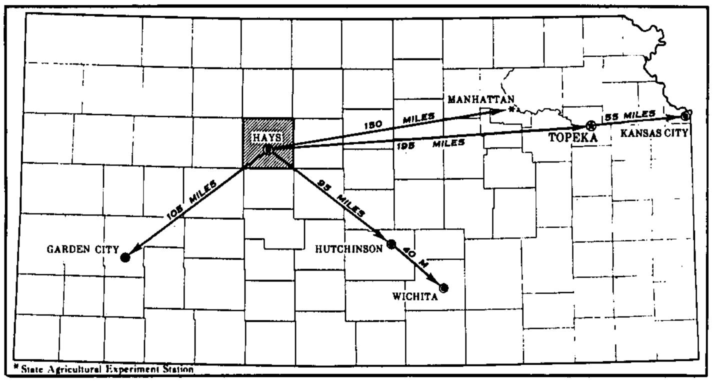

Figure 1.**—Location of Ellis County in Kansas.**

The farm income of the county is derived mainly from the sale of livestock and livestock products, wheat, and grain sorghum. Small amounts of alfalfa, barley, corn, rye, oats, and native hay are also produced. Beef cattle have increased in number in the last 10 years, as has the number of cattle fed out in feed yards. In 1966 there were 305,416 acres of cropland and 238,540 acres of pasture and range. The remaining 32,044 acres was woodland, cities, lakes, and roads (*11*).[1]

The average size of farms increased from 560 acres in 1959 to 640 acres in 1964. The farm income, though rather unsteady in total receipts since 1958, has changed in the proportion of income from field crops and from livestock. Of the total farm income in 1958, 67 percent was from field crops. Wheat earned half of the total farm income, and livestock earned 33 percent. In 1968, 45 percent of the total income was from field crops and 55 percent was from livestock. In that year wheat earned only 30 percent of the total farm income.

Although some farms still produce only field crops, most farms are now diversified to produce some livestock, mostly beef cattle. The number of dairy animals has declined in the county since 1958, but the amount of milk produced in the county exceeds the needs of the population, and the surplus is shipped to other areas.

[1] Italic numbers in parentheses refer to Literature Cited, p. 83.

Irrigation, although important to some individual farms, is practiced on only about 1.6 percent of the total cropland. Outside the Cedar Bluffs Irrigation District, irrigation is practiced only along major streams where water from streams or wells can be obtained. Most of the soils along the major streams are well suited to irrigation, but some are better suited than others. They have good potential if underground water can be located to irrigate them.

The climate of Ellis County is characterized by moderately low rainfall, rapid evaporation, and seasonal high winds. Most of the rainfall is in spring and summer, favoring the production of dryland wheat and grain sorghum. The distribution of rainfall during the growing period, however, limits or enhances the yield of these crops.

Oil production is the most important nonagricultural industry in the county. The assessed valuation indicates that oil production has been decreasing, however, since its peak in 1959.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Ellis County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different textures in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Harney and Mento, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Harney silt loam, 1 to 3 percent slopes, is one of several phases of the Harney series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this survey was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. One such kind of mapping unit is shown on the soil map of Ellis County: the soil complex.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Heizer-Armo complex is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Rough broken land is a land type in this county.

While a soil survey is in progress, soil scientists take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are also assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

Soil scientists observe how soils behave when used as a growing place for native and cultivated plants, and as material for structures, foundations for structures, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this to the slow permeability of the soil or to a high water table. They see that streets, road pavements, and foundations for houses are cracked on a named kind of soil and they relate this failure to the high shrink-swell potential of the soil material. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential uses.

After data have been collected and tested for the key, or benchmark, soils in a survey area, the soil scientists set up trial groups of soils. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. They then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Ellis County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in Ellis County are discussed in the following pages.

1. Roxbury-Eltree-Hord association

Deep, nearly level to strongly sloping, well-drained soils that have a loam to silty clay loam subsoil; on flood plains, stream terraces, and valley sides

This association is along the major streams of the county. The soils on the flood plains and terraces are nearly level to gently undulating, and the soils on the valley sides are nearly level to strongly sloping.

This association covers about 12 percent of the county. About 24 percent is Roxbury soils, 16 percent is Eltree soils, 11 percent is Hord soils, and 40 percent is minor soils (fig. 2).

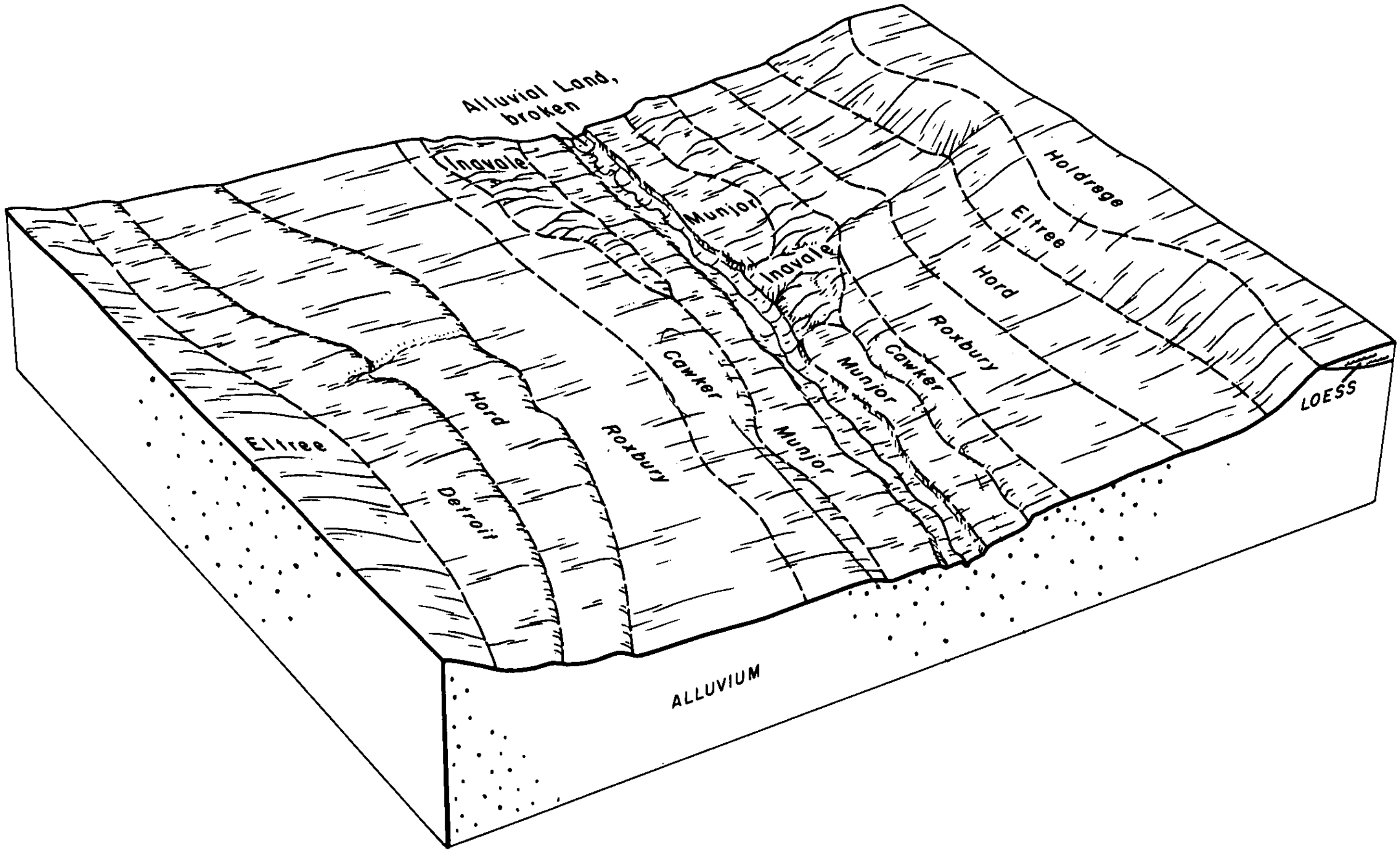

Figure 2.—**Pattern of soils and underlying material in the Roxbury-Eltree-Hord association.**

Roxbury soils are nearly level to gently undulating soils on terraces. The surface layer typically is grayish-brown silt loam about 24 inches thick. The next layer is grayish-brown light silty clay loam about 26 inches thick. It is underlain at a depth of about 50 inches by light brownish-gray light silty clay loam. Roxbury soils are calcareous and have high available water capacity.

Eltree soils are nearly level to strongly sloping soils on high terraces and valley sides. The surface layer is grayish-brown silt loam about 26 inches thick. The upper part of the subsoil is grayish-brown heavy silt loam about 9 inches thick. The lower part of the subsoil is light brownish-gray light silty clay loam about 14 inches thick. The underlying material is pale-brown light silty clay loam. Eltree soils are calcareous and have high available water capacity.

Hord soils are nearly level to gently undulating soils on terraces. The surface layer is very dark grayish-brown silt loam about 18 inches thick. The upper part of the subsoil is dark grayish-brown light silty clay loam about 10 inches thick. The lower part of the subsoil is light brownish-gray light silty clay loam about 15 inches thick. The underlying material is pale-brown heavy silt loam. Hord soils have high available water capacity.

Minor soils in this association are Alluvial land, broken, and Anselmo, Boel, Detroit, Holdrege, Inavale, McCook, Munjor, New Cambria, and Wann soils. The channels and banks of Big Creek are occupied by Alluvial land, broken. Inavale, McCook, and Munjor soils are on the flood plains and low terraces near the channels of streams, and Detroit and New Cambria soils are on the higher terraces. Sloping Anselmo and Holdrege soils are associated with Eltree soils on valley side slopes. The somewhat poorly drained Boel and Wann soils are in areas that have a fluctuating water table.

Water erosion is a hazard on the sloping soils, and soil blowing is a hazard on fields left bare of vegetation. The soils on the flood plains and low terraces are subject to flooding.

Most of this association is cultivated. Some areas of the sandy, wet, or strongly sloping soils are in native grass. The arable soils of this association are among the most desirable for crops in the county, and the potential production is high for wheat, sorghum, and alfalfa.

The soils in this association have good potential for irrigation if water is available. Some areas are irrigated.

2. *Mento-Brownell-Wakeen association*

Deep and moderately deep, nearly level to strongly sloping, well-drained soils that have a very gravelly loam to silty clay loam subsoil; on uplands

This association is on uplands that are dissected by

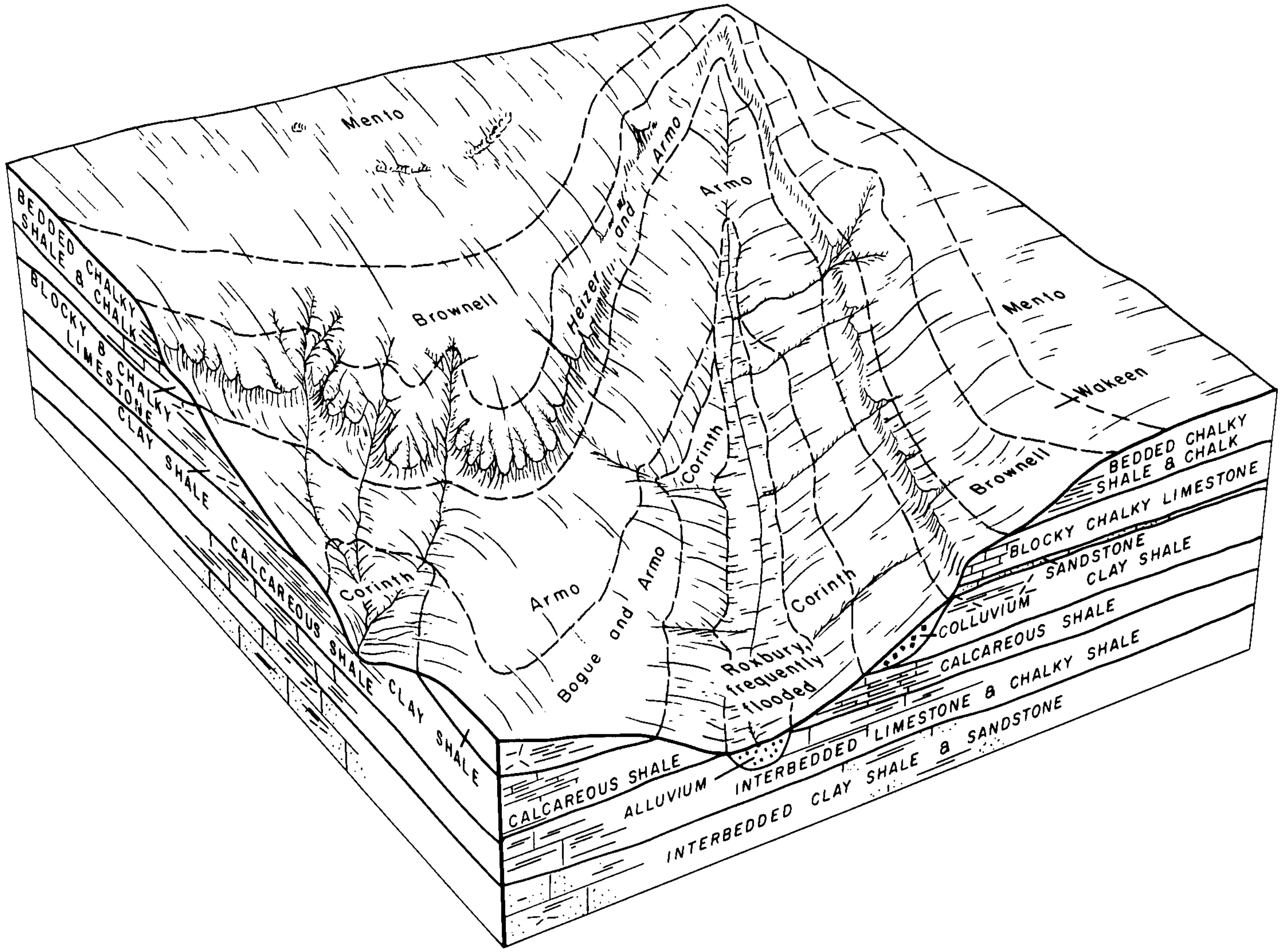

***Figure 3.*—Pattern of soils and underlying material in the Mento-Brownell-Wakeen association.**

drainageways. The areas along the drainageways are gently sloping to strongly sloping.

This association covers about 23 percent of the county. About 37 percent is Mento soils, 31 percent is Brownell soils, 10 percent is Wakeen soils, and 22 percent is of minor soils (fig. 3).

Mento soils are deep, nearly level to sloping soils on uplands. The surface layer is typically dark grayish-brown silt loam about 9 inches thick. The subsoil is 22 inches thick. The upper part is grayish-brown heavy silty clay loam about 6 inches thick; the next layer is grayish-brown, calcareous heavy silty clay loam about 6 inches thick; and the lower layer is pale-brown, calcareous silty clay loam about 10 inches thick. The underlying material is 36 inches thick. The upper part of the underlying material is pale-brown, calcareous light silty clay loam about 10 inches thick; and the lower part is 26 inches of white, calcareous clay loam that has many fragments of chalk or limestone of sand and gravel size. Below is bedded chalky limestone. Mento soils have high available water capacity.

Brownell soils are moderately deep, gently sloping to strongly sloping soils on uplands. The surface layer is typically very dark gray gravelly loam about 7 inches thick. The subsoil is dark-gray very gravelly loam about 8 inches thick that contains common chalky limestone fragments ½ inch to 2 inches in diameter. The underlying material is very pale brown channery loam about 15 inches thick that contains many coarse chalky limestone fragments 3 to 6 inches in diameter. Bedded chalky limestone is at a depth of 30 inches. Brownell soils have low available water capacity and are calcareous throughout.

Wakeen soils are moderately deep, gently sloping to strongly sloping soils on uplands. The surface layer is typically 17 inches thick. The upper part is dark grayish-brown silt loam about 5 inches thick; the middle part is dark grayish-brown light silty clay loam about 5 inches thick; and the lower 7 inches is grayish-brown silty clay loam. The subsoil is very pale brown silty clay loam 12 inches thick. The underlying material is very pale brown silty clay loam 7 inches thick. Thinly bed-

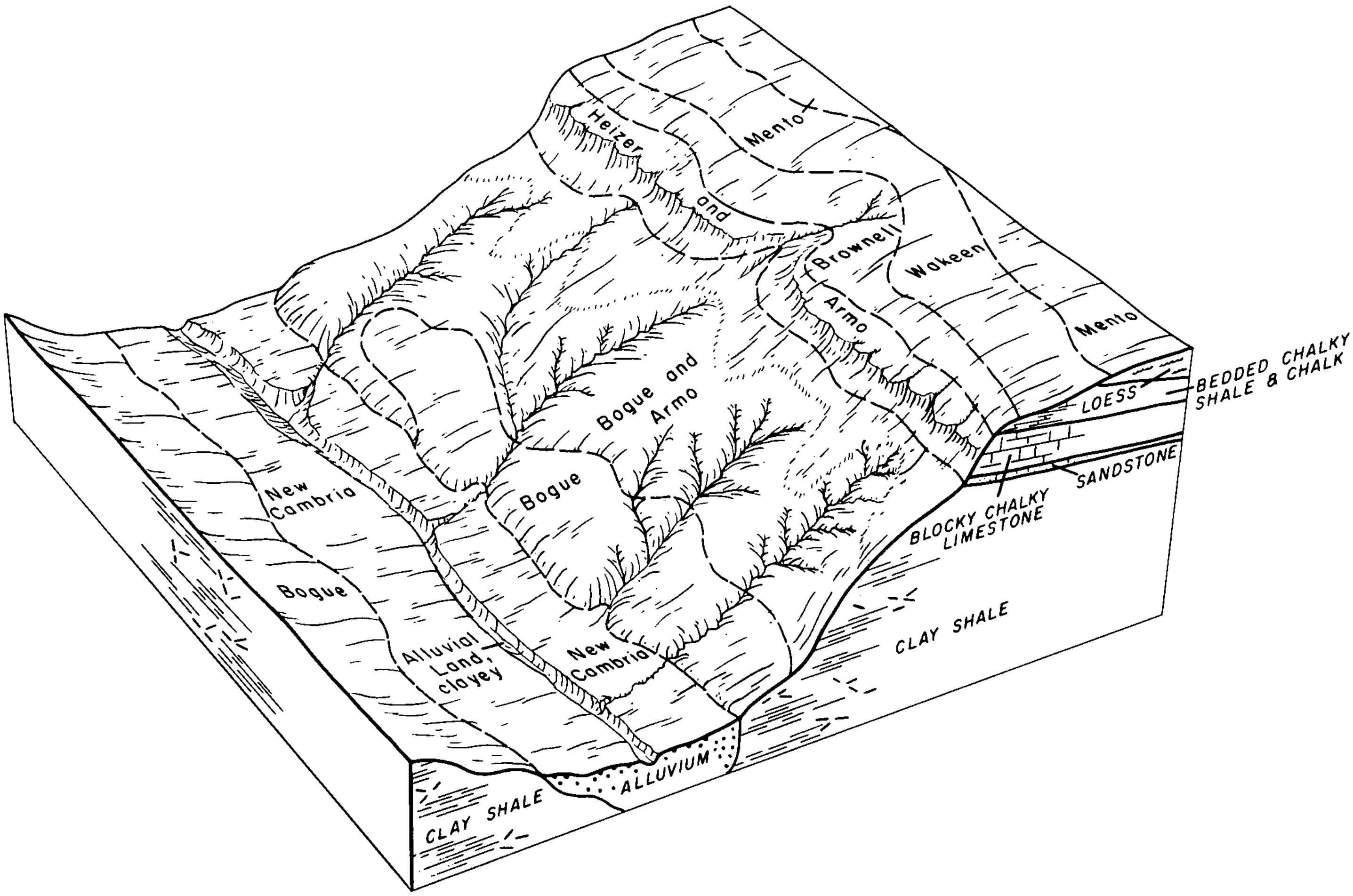

***Figure 4.*—Pattern of soils and underlying material in the Armo-Bogue-Heizer association.**

ded, brownish-yellow chalk bedrock is at a depth of about 36 inches. Wakeen soils are calcareous and have moderate available water capacity.

Minor soils in this association are Alluvial land, wet, and Armo, Bogue, Corinth, Harney, Heizer, and Roxbury soils. Harney soils are on the higher crests near Mento soils. Armo, Bogue, and Corinth soils are below the Brownell soils but above the floors of drainageways. Heizer soils are in steep areas below Mento, Brownell, and Wakeen soils. Roxbury soils are on the floors of the drainageways where a water table is not present. The Roxbury soils are frequently flooded. Alluvial land, wet, is on the floors of drainageways where a water table is present.

Water erosion is a hazard on the sloping soils, and soil blowing is a hazard on fields left bare of vegetation. Iron chlorosis is a management concern if sorghum is planted on Wakeen and Armo soils, because of the high lime content. Overgrazing is the main management concern on range.

About 55 percent of this association is in wheat and sorghum. The other 45 percent is native range, to which the soils are well suited.

3. Armo-Bogue-Heizer association

Deep to shallow, gently sloping to moderately steep, well drained and moderately well drained soils that have a channery loam to clay subsoil or substratum; on uplands

This association is on uplands. Many drainageways and small streams dissect the landscape.

This association covers about 14 percent of the county. About 46 percent is Armo soils, 19 percent is Bogue soils, 10 percent is Heizer soils, and 25 percent is minor soils and land types (fig. 4).

Armo soils are deep, well-drained, gently sloping to strongly sloping soils. They are mostly sloping to strongly sloping and are on side slopes below Heizer soils and above Bogue soils. The surface layer is typically dark grayish-brown heavy loam in the upper 10 inches and grayish-brown silt loam in the lower 5 inches. The subsoil is pale-brown light clay loam about 13 inches thick. The upper 13 inches of the underlying material is pale-brown light clay loam, and the next 10 inches is pale-brown silt loam. The lower layer of the underlying material, below a depth of about 51 inches, is a bed of fine and medium gravel that contains loam in about 30 percent of the interstices. Armo soils are calcareous and have high available water capacity.

Bogue soils are moderately deep, moderately well drained, sloping to moderately steep soils. The surface layer is gray clay about 6 inches thick. The subsoil is

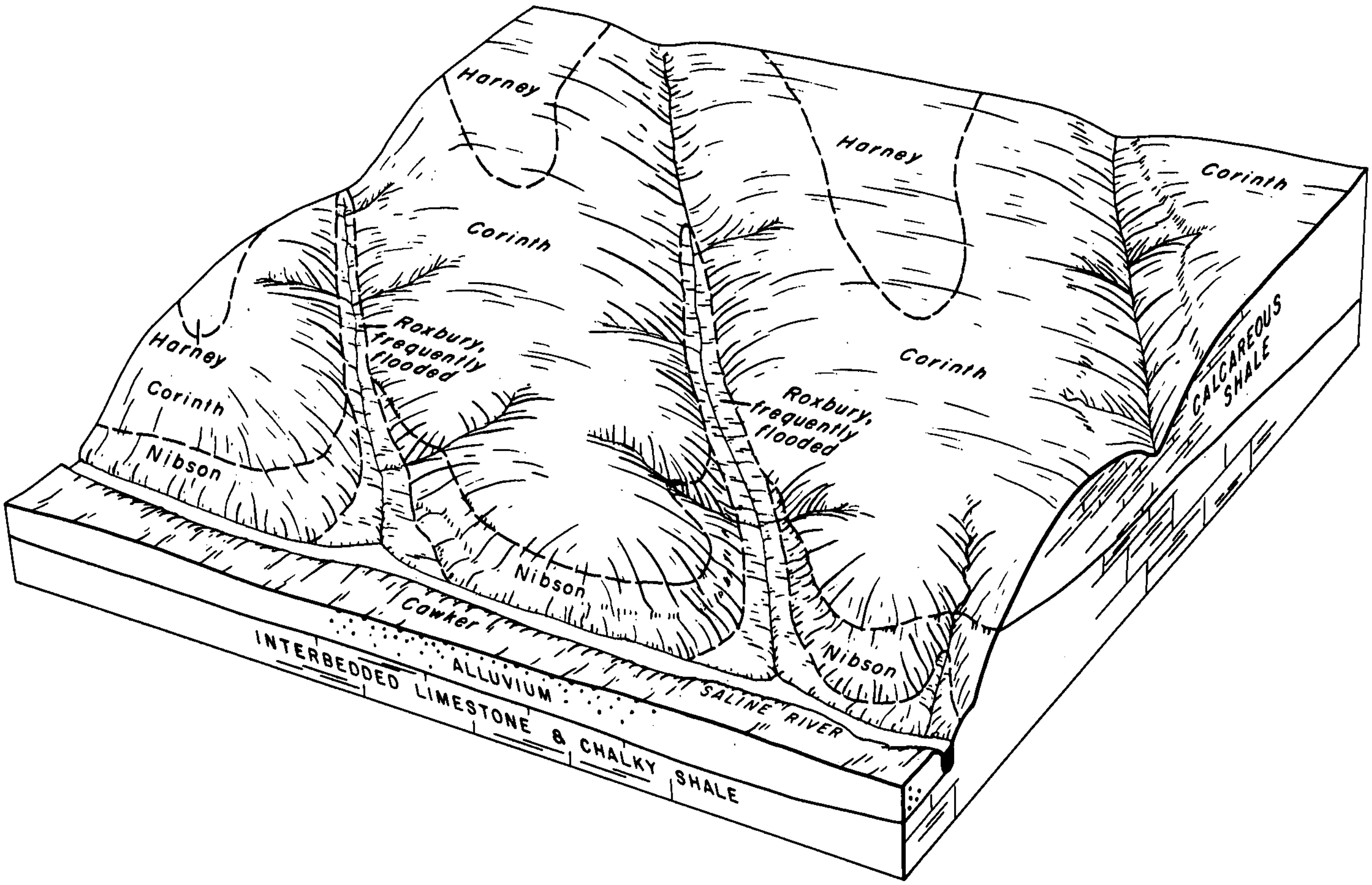

Figure 5.—**Pattern of soils and underlying material in the Corinth-Harney association.**

gray clay 11 inches thick. The underlying material is gray clay in the upper 6 inches and dark-gray, weathered clay shale in the lower 9 inches. Clay shale is at a depth of about 32 inches. Bogue soils have low available water capacity.

Heizer soils are shallow, well-drained, strongly sloping to moderately steep soils. Steep limestone bluffs are in some areas. The surface layer is dark-gray gravelly loam about 6 inches thick. The next layer is gray channery loam 3 inches thick. The underlying material is light brownish-gray channery loam about 5 inches thick. Below this is white chalky limestone. Heizer soils are calcareous and have very low available water capacity.

Minor soils and land types in this association are Alluvial land, clayey; Hilly land; Brownell, Corinth, Harney, Mento, New Cambria, Roxbury, and Wakeen soils; and shallow soils that have a texture similar to that of Bogue soils. Alluvial land, clayey, is on the floors of intermittent drainageways that drain areas of Bogue soils. New Cambria and Roxbury soils are on the floors of the larger drainageways. The Roxbury soils are frequently flooded. Hilly land is on the valley walls adjacent to streams. Harney soils are in a complex with Armo soils. Corinth soils are below Bogue soils on uplands, and the shallow clays are intermixed with Bogue soils. Brownell, Mento, and Wakeen soils are above the Armo and Heizer soils.

Erosion is a hazard in all cultivated areas and in areas of range that are overgrazed. Overgrazing is the main management concern in areas used as range.

About 95 percent of this association is used for range. A few areas of gently sloping to sloping Armo soils on uplands are used for wheat and grain sorghum, but most of the cultivated areas produce livestock forage.

4. *Corinth-Harney association*

Moderately deep and deep, nearly level to strongly sloping, well-drained soils that have a silty clay loam to silty clay subsoil; on uplands

This association is on ridgetops, hill crests, and side slopes on uplands.

This association covers about 4 percent of the county. About 71 percent is Corinth soils, 17 percent is Harney soils, and 12 percent is minor soils (fig. 5).

Corinth soils are moderately deep, gently sloping to strongly sloping soils on uplands. The surface layer is grayish-brown silty clay loam about 9 inches thick. The subsoil is 13 inches thick. The upper layer is light brownish-gray heavy silty clay loam 7 inches thick, and the lower layer is light yellowish-brown heavy silty

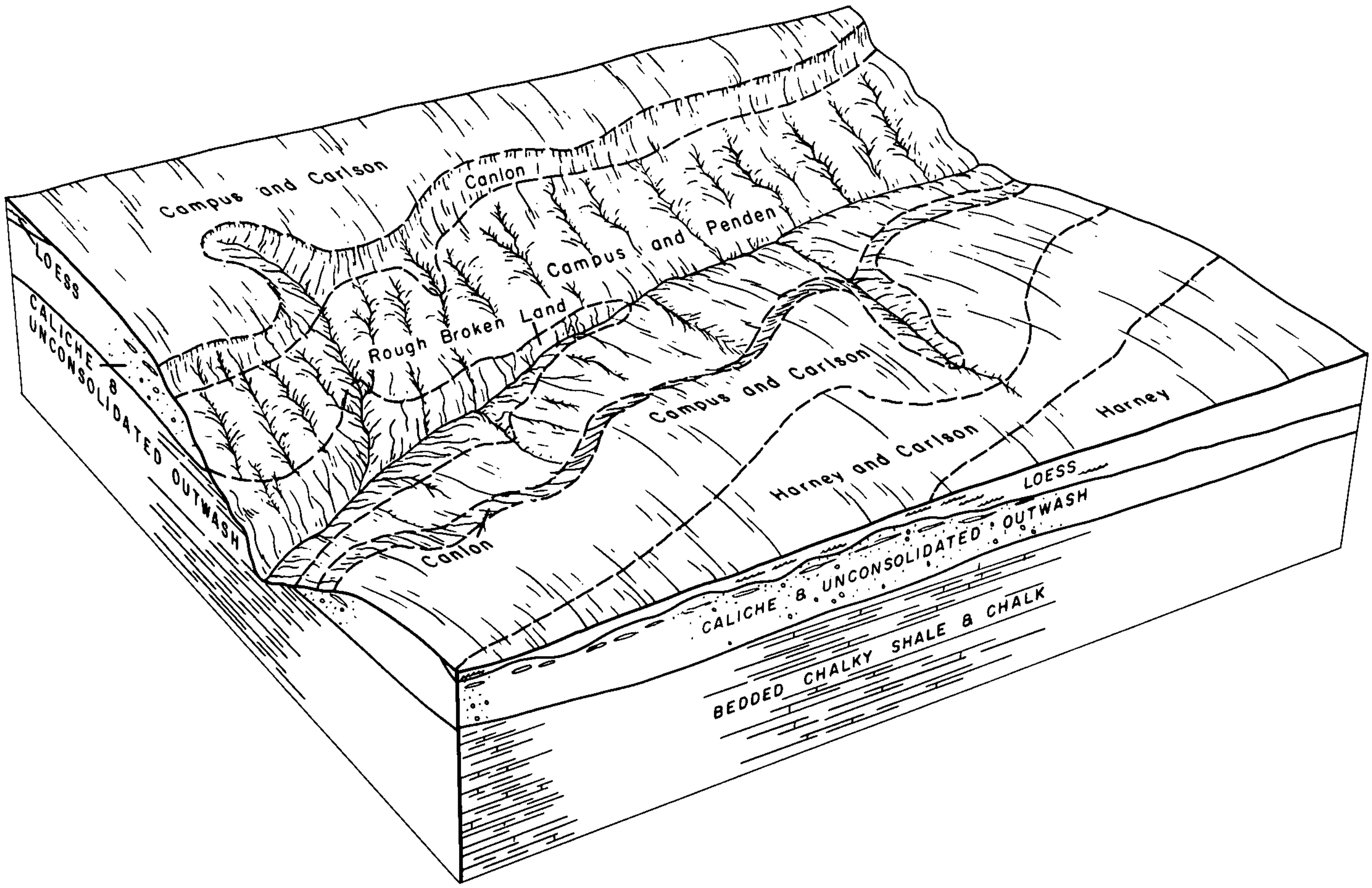

Figure 6.—**Pattern of soils and underlying material in the Campus-Harney-Carlson association.**

clay loam 6 inches thick. The underlying material is 8 inches of brownish-yellow heavy silty clay loam that is underlain by light yellowish-brown, platy, calcareous shale. Cornith soils are calcareous and have moderate available water capacity.

Harney soils are deep, nearly level to sloping soils on uplands. The surface layer is 10 inches thick. The upper 6 inches is dark grayish-brown silt loam, and the lower 4 inches is dark grayish-brown light silty clay loam. The subsoil is about 30 inches thick. The upper 9 inches is grayish-brown heavy silty clay loam; the next 11 inches is grayish-brown light silty clay; and the lower 10 inches is light brownish-gray, calcareous heavy silty clay loam. The underlying material is light brownish-gray, calcareous light silty clay loam. Harney soils have high available water capacity.

Minor soils in this association are Bogue, Nibson, and Roxbury soils. Roxbury soils are frequently flooded and occur on the floor of intermittent drainageways and small creeks that incise the uplands. Bogue soils are above Corinth soils, and Nibson soils are below Corinth soils.

Water erosion is a hazard on the sloping soils, and soil blowing is a hazard on all fields left bare of vegetation. Iron chlorosis is a concern on Corinth soils if sorghum is planted, because of the high lime content of these soils. Overgrazing is the main concern on range.

About 70 percent of this association is cultivated. Wheat and sorghum are the main crops. The strongly sloping soils are mostly in native grass.

5. *Campus-Harney-Carlson association*

Moderately deep and deep, nearly level to moderately steep, well-drained soils that have a loam to silty clay subsoil or substratum; on uplands

This association is on tablelands, ridgetops, and side slopes that are cut by widely spaced intermittent drainageways.

This association covers about 7 percent of the county. About 35 percent is Campus soils, 20 percent Harney soils, 12 percent is Carlson soils, and 33 percent is minor soils (fig. 6).

Campus soils are moderately deep, sloping to strongly sloping soils on ridgetops and side slopes and along drainageways. The surface layer is dark grayish-brown loam, about 9 inches thick, that contains many caliche fragments 1/4 to 1 inch in diameter. The next layer is light-gray clay loam, about 10 inches thick, that has many caliche fragments 1/4 to 1 inch in diameter. The underlying material is white loam, about 14 inches thick, that has many caliche fragments 1/4 to 1 inch in diameter. White, partly consolidated caliche is at a depth of about 33 inches. Campus soils are calcareous and have low available water capacity.

Harney soils are deep. They are nearly level to gently sloping soils on tablelands and sloping soils on side slopes above drainageways. The surface layer is about 10 inches thick. The upper part is dark grayish-brown silt loam 6 inches thick, and the lower part is dark grayish-brown light silty clay loam 4 inches thick. The subsoil is about 30 inches thick. The upper 9 inches is grayish-brown heavy silty clay loam; the next 11 inches is grayish-brown light silty clay; and the lower 10 inches is light brownish-gray, calcareous heavy silty clay loam. The underlying material is light brownish-gray, calcareous light silty clay loam. Harney soils have high available water capacity.

Carlson soils are deep, nearly level to sloping soils on uplands. The surface layer is dark-gray silt loam about 8 inches thick. The subsoil is about 15 inches thick. The upper 4 inches is dark grayish-brown silty clay loam; the next 6 inches is brown heavy silty clay loam, and the lower 5 inches is grayish-brown, calcareous silty clay loam. The underlying material is very pale brown, calcareous clay loam. Carlson soils have high available water capacity.

Minor soils in this association are Armo, Canlon, Penden, and Mento soils; Rough broken land; Alluvial land, wet; and Roxbury silt loam, frequently flooded. Canlon soils are downslope from Campus soils and are associated with outcrops of caliche. Penden soils are strongly sloping to moderately steep and are downslope from Canlon and Campus soils on side slopes. Mento soils are on the ridgetops on tablelands near Harney and Carlson soils. Rough broken land and Armo soils are below Campus and Penden soils. Roxbury silt loam, frequently flooded, and Alluvial land, wet, are on floors of intermittent drainageways.

Water erosion is a hazard on the sloping cultivated soils, and soil blowing is a hazard on soils left bare of vegetation. Overgrazing is the main management concern on range. Overgrazed range is susceptible to soil blowing and water erosion. Iron chlorosis is a concern where sorghum is planted on the Campus soils, because Campus soils have a high lime content, which reduces the availability of iron in the soil.

About 45 percent of this association is cultivated. The principal crops are wheat and sorghum. The remaining 55 percent of the acreage is strongly sloping to moderately steep and is used for range. The deep soils of this association have good potential for irrigation if water is available.

6. *Harney-Carlson-Armo association*

Deep, nearly level to strongly sloping, well-drained soils that have a clay loam to silty clay subsoil; on uplands

This association is nearly level to gently sloping in broad areas on uplands and gently sloping to strongly sloping on sides of widely spaced drainageways that dissect these areas.

The soil association covers 32 percent of the county. About 66 percent is Harney soils, 14 percent is Carlson soils, 13 percent is Armo soils, and 7 percent is minor soils (fig. 7).

Harney soils are nearly level to sloping. A few small depressions occur where the soils are nearly level. The surface layer is about 10 inches thick. The upper 6 inches is dark grayish-brown silt loam, and the lower 4 inches is dark grayish-brown light silty clay loam; the subsoil is 30 inches thick. The upper 9 inches is grayish-brown heavy silty clay loam; the next 11 inches is grayish-brown light silty clay; and the lower 10 inches is light brownish-gray, calcareous heavy silty clay loam. The underlying material is light brownish-gray calcareous light silty clay loam. Harney soils have high available water capacity.

Carlson soils are nearly level to sloping. The surface layer is dark-gray silt loam about 8 inches thick. The subsoil is about 15 inches thick. The upper 4 inches is dark grayish-brown silty clay loam; the next 6 inches is brown heavy silty clay loam; and the lower 5 inches is grayish-brown, calcareous silty clay loam. The underlying material is very pale brown, calcareous clay loam. Carlson soils have high available water capacity.

Armo soils are gently sloping on tablelands and sloping to strongly sloping along intermittent drainageways. The surface layer is typically dark grayish-brown heavy loam in the upper 10 inches and grayish-brown silt loam in the lower 5 inches. The subsoil is pale-brown light clay loam about 13 inches thick. The upper 13 inches of the underlying material is pale-brown light clay loam; the next 10 inches is pale-brown silt loam; and the lower part is a bed of fine and medium gravel that has 30 percent of the interstices filled with loam. Armo soils are calcareous and have high available water capacity.

Minor soils in this association are Roxbury silt loam, frequently flooded, and Hord silt loam. The Roxbury soil is on the flood plains of the intermittent drainageways and small streams. The Hord soil is above the Roxbury soil.

Water erosion is a hazard on the sloping soils, and soil blowing is a hazard on fields left bare of vegetation. Iron chlorosis, because of the high lime content of the Armo soils, lowers the production of sorghum. Overgrazing is the main management concern on range.

About 85 percent of this association is cultivated. Some areas of the strongly sloping soils are in native grass. The arable soils of this association are among the most desirable upland soils for crops in the county. The potential production is high for wheat and sorghum. Alfalfa can also be grown. These soils have a good potential for irrigation if water is available, and some areas are irrigated.

7. *Harney-Wakeen-Nibson association*

Deep to shallow, nearly level to strongly sloping, well drained and somewhat excessively drained soils that have a silty clay loam and silty clay subsoil; on uplands

This association is nearly level to sloping on tablelands and gently sloping to strongly sloping on sides of drainageways that incise these tablelands.

This association covers 8 percent of the county. About 43 percent is Harney soils, 19 percent is

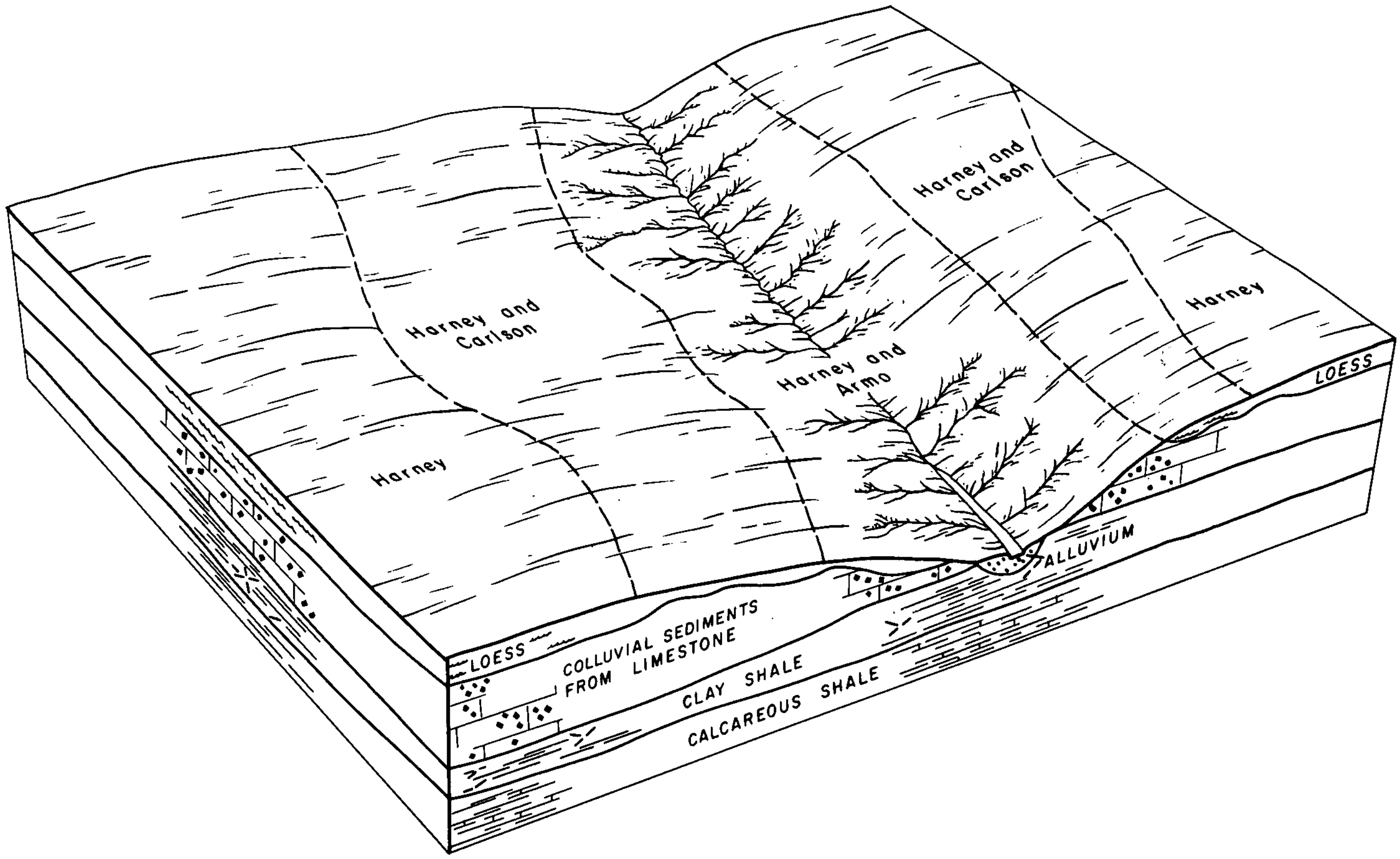

Figure 7.—**Pattern of soils and underlying material in the Harney-Carlson-Armo association.**

Wakeen soils, 17 percent is Nibson soils, and 21 percent is minor soils (fig. 8).

Harney soils are deep, well-drained, nearly level to sloping soils on uplands. The surface layer is about 10 inches thick. The upper 6 inches is dark grayish-brown silt loam, and the lower 4 inches is dark grayish-brown light silty clay loam. The subsoil is 30 inches thick. The upper 9 inches is grayish-brown heavy silty clay loam; the next 11 inches is grayish-brown light silty clay; and the lower 10 inches is light brownish-gray, calcareous heavy silty clay loam. The underlying material is light brownish-gray, calcareous light silty clay loam. Harney soils have high available water capacity. About 60 percent of the acreage of these soils is underlain by chalky limestone bedrock at a depth of 3 to 5 feet and is highly calcareous below the subsoil.

Wakeen soils are moderately well drained, gently sloping to strongly sloping soils on uplands. The surface layer is about 17 inches thick. The upper part is dark grayish-brown silt loam about 5 inches thick, the next 5 inches is dark grayish-brown light silty clay loam, and the lower part is grayish-brown silty clay loam about 7 inches thick. The subsoil is very pale brown silty clay loam 12 inches thick. The underlying material is about 7 inches of very pale brown silty clay loam that is underlain by bedded brownish-yellow chalk at a depth of about 36 inches. Wakeen soils are calcareous and have moderate available water capacity.

Nibson soils are shallow, somewhat excessively drained, sloping to strongly sloping soils on sides of drainageways. The surface layer is dark grayish-brown heavy silt loam about 7 inches thick. The subsoil is 7 inches thick. The upper part is grayish-brown silty clay loam 3 inches thick, and the lower part is light yellowish-brown silty clay loam 4 inches thick. The underlying material is 5 inches of pale-yellow weathered shale and limestone of silty clay loam texture. Below this is pale-yellow shale and limestone. Nibson soils are calcareous and have very low available water capacity.

Minor soils in this association are Armo and Mento soils, Hilly land, and Roxbury silt loam, frequently flooded. Armo soils are below the Nibson soils in the larger drainageways. Mento soils are intermingled with Harney and Wakeen soils on tablelands and are nearly level to gently sloping. Hilly land is on valley sides below the Nibson soils. Roxbury silt loam, frequently flooded, is on the floor of small streams and intermittent drainageways.

Water erosion is a hazard in sloping, cultivated areas, and soil blowing is a hazard in cultivated areas

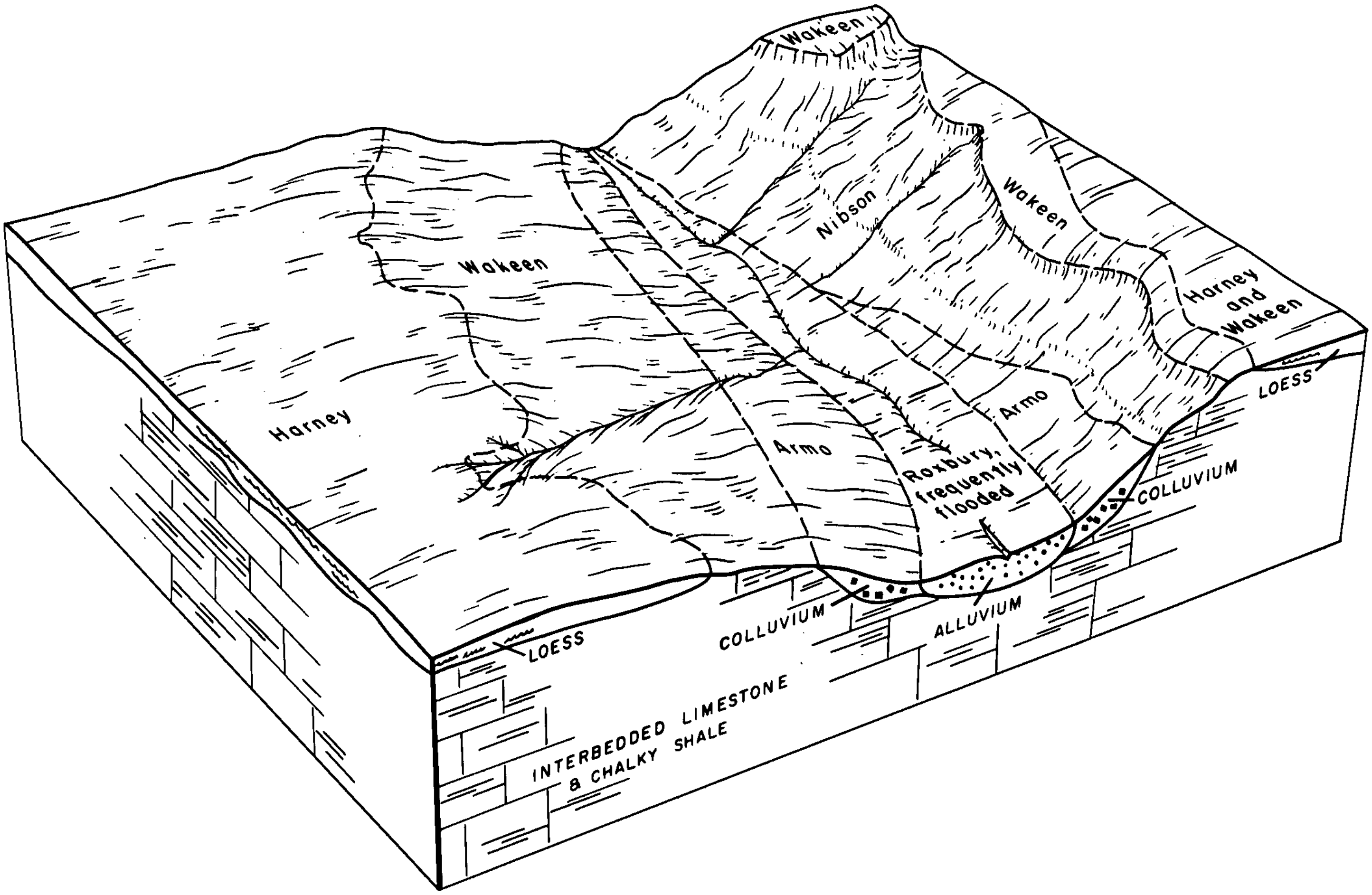

Figure 8.—**Pattern of soils and underlying material in the Harney-Wakeen-Nibson association.**

left bare of vegetation. Overgrazing is the main concern on range.

About 65 percent of this association is cultivated. Wheat and sorghum are the principal crops. The remaining 35 percent is in native grass and is used as range. Most areas of the Nibson soils are used for range.

Descriptions of the Soils

This section describes the soil series and mapping units in Ellis County. Each soil series is described in detail, and then, briefly, each mapping unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. The profile described in the series is representative for mapping units in that series. If the profile of a given mapping unit is different from the one described for the series, these differences are stated in describing the mapping unit, or they are differences that are apparent in the name of the mapping unit. Color terms are for dry soil unless otherwise stated.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Hilly land for example, does not belong to a soil series, but nevertheless is listed in alphabetic order along with the soil series.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit, range site, and windbreak suitability group in which the mapping unit has been placed. The page for the description of each capability unit or other interpretative group can be learned by referring to the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each map-

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

Soil	Area	Extent	Soil	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Alluvial land, broken	3,438	0.6	Harney-Carlson silt loams, 1 to 3 percent slopes	46,151	8.0
Alluvial land, clayey	2,952	.5	Harney-Wakeen silt loams, 0 to 1 percent slopes	1,826	.3
Alluvial land, wet	608	.1	Harney-Wakeen silt loams, 1 to 3 percent slopes	16,083	2.8
Anselmo fine sandy loam, 2 to 6 percent slopes	951	.2	Heizer-Armo complex	15,518	2.7
Armo loam, 1 to 3 percent slopes	7,096	1.2	Hilly land	6,424	1.1
Armo loam, 3 to 7 percent slopes	33,095	5.7	Holdrege silt loam, 0 to 1 percent slopes	1,191	.2
Armo loam, 3 to 7 percent slopes, eroded	2,521	.4	Holdrege silt loam, 1 to 3 percent slopes	3,043	.5
Armo loam, 7 to 15 percent slopes	27,070	4.7	Hord silt loam	7,002	1.2
Boel fine sandy loam	889	.1	Inavale loamy sand	3,538	.6
Bogue clay, 3 to 8 percent slopes	7,308	1.3	McCook fine sandy loam	929	.2
Bogue-Armo complex	19,029	3.3	McCook silt loam	5,807	1.0
Brownell gravelly loam, 2 to 10 percent slopes	35,014	6.1	Mento silt loam, 0 to 1 percent slopes	737	.1
Campus-Carlson complex, 3 to 7 percent slopes	12,167	2.1	Mento silt loam, 1 to 3 percent slopes	21,079	3.7
Campus-Penden complex, 5 to 15 percent slopes	10,203	1.8	Mento silty clay loam, 1 to 3 percent slopes, eroded	2,698	.5
Canlon complex	1,875	.3	Mento soils, 3 to 7 percent slopes, eroded	15,940	2.8
Corinth silty clay loam, 1 to 3 percent slopes	564	.1	Munjor sandy loam	3,495	.6
Corinth silty clay loam, 3 to 7 percent slopes	4,607	.8	New Cambria silty clay	1,748	.3
Corinth silty clay loam, 7 to 15 percent slopes	11,427	2.0	Nibson silt loam, 5 to 12 percent slopes	5,267	.9
Crete silty clay loam, 0 to 1 percent slopes	7,872	1.4	Roxbury silt loam	16,662	2.9
Crete silty clay loam, thin surface variant, 0 to 1 percent slopes	520	.1	Roxbury silt loam, frequently flooded	27,575	4.8
Detroit silt loam	3,782	.7	Rough broken land	4,106	.7
Eltree silt loam, 0 to 1 percent slopes	2,039	.4	Wakeen silt loam, 1 to 3 percent slopes	5,876	1.0
Eltree silt loam, 1 to 3 percent slopes	6,403	1.1	Wakeen silt loam, 1 to 3 percent slopes, eroded	619	.1
Eltree silt loam, 3 to 7 percent slopes	5,337	.9	Wakeen silt loam, 3 to 7 percent slopes	10,272	1.8
Eltree silt loam, 7 to 15 percent slopes	1,329	.2	Wakeen silt loam, 5 to 15 percent slopes, eroded	1,929	.3
Harney silt loam, 0 to 1 percent slopes	43,164	7.5	Wann loam	3,361	.6
Harney silt loam, 1 to 3 percent slopes	35,907	6.2	Rivers	2,744	.5
Harney silt loam, 3 to 7 percent slopes	10,145	1.8	Borrow pits	112	(1)
Harney silty clay loam, 2 to 5 percent slopes, eroded	20,031	3.5			
Harney-Armo complex, 3 to 7 percent slopes, eroded	21,920	3.8	Total	576,000	100.0
Harney-Carlson silt loams, 0 to 1 percent slopes	5,005	.9			

[1] Less than 0.05 percent.

ping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*9*).

Alluvial Land

Alluvial land consists of sediment deposited by streams on flood plains. Its properties are variable. Areas are variously suitable for range, recreation, and wildlife habitat.

Alluvial land, broken (Ab).—This land type is on the channel and banks of Big Creek. The banks are moderately steep and broken in most places, but some banks are vertical. The soil on the banks is loamy. The narrow flood plain along the channel consists of nearly level to gently sloping loamy soils and sandbars. Areas range from 100 to 300 feet in width. The channel is 25 to 65 feet wide.

Included with this land type in mapping were small areas of Roxbury, McCook, and Hord soils.

Alluvial land, broken, has limited use for grazing. The vegetation varies from one area to another. Western wheatgrass, Virginia wildrye, Canadian wildrye, switchgrass, and annual grasses and weeds are the principal range forage. American elm, Siberian elm, cottonwood, green ash, and a few mulberry and hackberry trees are scattered along the channel.

Flooding is a hazard to use. The channel and banks are susceptible to erosion. Water for livestock is available from the creek. Other uses are recreation and wildlife habitat. Capability unit VIIw–1; range site and windbreak suitability group not assigned.

Alluvial land, clayey (0 to 2 percent slopes) (Ac).—This land type consists of nearly level to gently undulating clayey soils on narrow flood plains along meandering intermittent streams. The streams drain areas of soils that formed in material weathered from clay shale. In places these clayey soils have layers of sandy or gravelly material below a depth of 2 feet. The soils are calcareous within 15 inches of the surface. Areas range from 100 to 500 feet in width.

Included with this land type in mapping were some small areas of Bogue and New Cambria soils.

Most areas are in native grass and are well suited to grazing. The soils are subject to flooding, and the areas are cut up by meandering, shallowly entrenched to deeply entrenched stream channels. Most of the adjoining soils are sloping to moderately steep and are not suited to cultivation.

The practices effective in producing adequate forage for livestock are proper rate of stocking, deferred grazing, rotation grazing, cross fencing, and properly distributing salt and water. Suitable sites for water impoundment are generally available. Capability unit VIw–1; Clay Lowland range site; windbreak suitability group 1.

Alluvial land, wet (0 to 1 percent slopes) (Ad).—This land type consists of clayey, loamy, and sandy soils that formed in alluvium. The clayey and loamy soils range from shallow to deep over sand. In about 20 to 30 percent of the soils, the water table fluctuates between the surface and a depth of 2 feet. These soils have a black surface layer, mottling around root channels, and more prominent mottles in the lower layers. In about 40 to 50 percent of the area of the soils, the water table fluctuates between depths of 2 and 4 feet. These soils are mottled only in the lower layers. In the remaining 25 to 30 percent of the area, the water table is below a depth of 4 feet.

Included with this land type in mapping were some small areas of Roxbury silt loam, frequently flooded.

The soils in this mapping unit are well suited to grazing and wildlife habitat. Most areas support an excellent growth of tall grasses, but the wetter areas support mostly cattails, rushes, and sedges.

Among the practices needed to maintain good range is a proper rate of stocking. Fencing for separate use and management is beneficial. Capability unit Vw–1; Wetland range site; windbreak suitability group not assigned.

Anselmo Series

The Anselmo series consists of deep, well-drained soils that formed in moderately coarse textured outwash. These gently sloping to sloping soils are on valley sides or old high terraces.

In a representative profile the surface layer is dark grayish-brown fine sandy loam about 10 inches thick. The subsoil is dark-brown and brown, very friable sandy loam 15 inches thick. The underlying material is brown sandy loam in the upper part and pale-brown loamy sand in the lower part.

Permeability is moderately rapid, and available water capacity is moderate. Most areas of these soils are cultivated, but some of the most sloping areas are in native grass.

Representative profile of Anselmo fine sandy loam, 2 to 6 percent slopes, in a cultivated field, 1,500 feet east and 150 feet south of the northwest corner of sec. 21, T. 11 S., R. 16 W.:

A1—0 to 10 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, granular structure; slightly hard, very friable; common fine roots; slightly acid; gradual, smooth boundary.

B21—10 to 16 inches, dark-brown (10YR 4/3) sandy loam, dark brown (10YR 3/3) moist; weak, fine, subangular blocky structure; slightly hard, very friable; common fine roots; neutral; gradual, smooth boundary.

B22—16 to 25 inches, brown (10YR 5/3) light sandy loam, dark brown (10YR 4/3) moist; weak, medium; subangular blocky structure; slightly hard, very friable; few fine roots; mildly alkaline; gradual, smooth boundary.

C1—25 to 35 inches, brown (10YR 5/3) sandy loam, dark brown (10YR 4/3) moist; massive; slightly hard, friable; few fine roots; mildly alkaline; gradual, smooth boundary.

C2—35 to 60 inches, pale-brown (10YR 6/3) loamy sand, brown (10YR 5/3) moist; massive; soft, very friable; weakly effervescent; mildly alkaline.

The solum ranges from 15 to 40 inches in thickness. The A1 horizon ranges from 7 to 14 inches in thickness and from loamy fine sand to loam in texture. It ranges from very dark grayish brown to grayish brown in color. The B horizon ranges from 8 to 30 inches in thickness and from sandy loam to fine sandy loam in texture. The C horizon ranges from sandy loam to loamy sand. It is calcareous below a depth of 30 inches and is weakly to strongly effervescent.

Anselmo soils are in positions on the landscape similar to those of Eltree and Holdrege soils. They are leached of lime to a greater depth, are coarser textured in all horizons, and have a thinner A horizon than Eltree soils. They are coarser textured in all horizons than Holdrege soils and formed in outwash rather than in loess.

Anselmo fine sandy loam, 2 to 6 percent slopes (Ae).—This soil has convex slopes.

Included with this soil in mapping were some areas of soils that are similar to this Anselmo soil but are calcareous between depths of 15 and 30 inches. Also included were small areas of Armo, Eltree, Harney, and Roxbury soils; small areas of Hilly land that has slopes of about 6 percent; and small eroded areas, which are shown on the soil map by a symbol.

Runoff is slow to moderate. Water erosion is a hazard, and soil blowing also is a hazard if the soil is dry and lacks a plant cover. Inadequate rainfall is a limitation to all crops.

About 75 percent of the acreage of this soil is cultivated. Wheat and sorghum are the main dryland crops. Minimum tilling, stubble mulching, contouring, and terracing are effective. This soil is suitable for land leveling for flood or sprinkler irrigation. Capability unit IIIe–3; Sandy range site; windbreak suitability group 2.

Armo Series

The Armo series consists of deep, calcareous, well-drained soils that formed in medium-textured local colluvium derived from chalky limestone (fig. 9). These gently sloping to strongly sloping soils are on side slopes and tablelands and along drainageways on uplands.

In a representative profile the surface layer is about 15 inches thick. The upper 10 inches is dark grayish-brown heavy loam, and the lower 5 inches is grayish-brown silt loam. The subsoil is pale-brown, friable light clay loam about 13 inches thick. The upper 13 inches of the underlying material is pale-brown light clay loam; thin lenses of loamy sand make up about 25 percent of this horizon. The next part of the underlying material is pale-brown silt loam but is about 40 percent interbedded strata of gravelly loamy sand in which the sand particles are mostly chalk. Below a depth of about 51 inches is a bed of fine and medium gravel in which 30 percent of the interstices are filled with loam.

Permeability is moderate, and available water capacity is high. Most areas of the gently sloping and sloping soils are cultivated. Most areas of the strongly sloping soils are in native grass.

Representative profile of Armo loam, 3 to 7 percent slopes, in native grass, 1,400 feet east and 3,500 feet north of the southwest corner of sec. 28, T. 11 S., R. 17 W.:

A1—0 to 10 inches, dark grayish-brown (10YR 4/2) heavy loam, very dark brown (10YR 2/2) moist; weak,

Figure 9.—**Profile of an Armo loam.**

thin, platy structure in upper 2 inches parting to moderate, fine and medium, granular; slightly hard, friable; many fine grass roots; few fragments of chalk 2 millimeters to 2 centimeters in diameter; strongly effervescent; mildly alkaline; gradual, smooth boundary.

A3—10 to 15 inches, grayish-brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) moist; weak, coarse, subangular blocky to weak, medium, granular structure; hard, friable; common fine grass roots; few chalk fragments as in horizon above; strongly effervescent; mildly alkaline; gradual, smooth boundary.

B2—15 to 28 inches, pale-brown (10YR 6/3) light clay loam, yellowish brown (10YR 5/4) moist; weak, fine, granular structure; slightly hard, friable; few fine grass roots; violently effervescent; moderately alkaline; gradual, wavy boundary.

C1ca—28 to 41 inches, pale-brown (10YR 6/3) light clay loam, yellowish brown (10YR 5/4) moist; massive; very hard, friable; few fine grass roots; few nests of worm casts and granules; thin lenses of lighter colored coarse loamy sand make up 25 percent of horizon; common soft masses of calcium carbonate 5 to 15 millimeters in diameter; violently effervescent; moderately alkaline; gradual, wavy boundary.

C2—41 to 51 inches, pale-brown (10YR 6/3) silt loam, yellowish brown (10YR 5/4) moist; massive; hard, friable; few fine roots; strata of gravelly loamy sand make up about 40 percent of horizon; sand particles and pebbles mostly chalk; violently effervescent; moderately alkaline; clear, wavy boundary.

IIC3—51 to 60 inches, bed of fine and medium gravel; 30 percent of interstices filled with loam; most pebbles are chalk.

The solum ranges from 20 to 40 inches in thickness. The profile is calcareous throughout in most places, but in a few places it is noncalcareous to a depth of 7 inches. The A1 horizon ranges from 7 to 20 inches in thickness and is loam, silt loam, or silty clay loam. It ranges from brown to very dark grayish brown in color. The B horizon ranges from 10 to 20 inches in thickness and from loam to light clay loam in texture. It ranges from very pale brown to grayish brown in color. The C horizon is silt loam to light clay loam irregularly stratified with layers of coarse loamy sand and gravelly loamy sand. The sand and gravel is mostly chalk fragments, which make up 15 to 40 percent of the material below the B2 horizon.

Armo loam, 3 to 7 percent slopes, eroded, has an A horizon that is less than 7 inches thick, but the soil is included in the Armo series.

Armo soils are near Eltree, Bogue, Wakeen, Heizer, Nibson, Harney, and Crete soils. They have a thinner A horizon, are less silty, and contain more chalky sand and gravel below the B horizon than Eltree soils. They are less clayey and are deeper to bedrock than Bogue soils and are deeper to bedded chalk and limestone than Wakeen, Nibson, and Heizer soils. They lack the clayey B2t horizon of Harney and Crete soils and have a higher concentration of carbonate in the A and B horizons.

Armo loam, 1 to 3 percent slopes (Am).—This soil is on erosional uplands on tablelands, on side slopes, and in scattered areas near the middle and lower parts of broad ridges. Slopes are plane to convex. This soil has a profile similar to the one described as representative for the series, but the surface layer is neutral and is about 17 inches thick, and the surface layer and subsoil contain less chalky sand and gravel.

Included with this soil in mapping were small areas of Eltree, Penden, Carlson, and Harney soils. Also included were small eroded areas, which are shown on the soil map by a symbol.

Runoff is medium. Water erosion is the main hazard, but soil blowing also is a hazard if the soil is left bare. Iron chlorosis is a management concern if sorghum is planted on these soils, because of the high lime content.

About 90 percent of the acreage of this soil is cultivated. Wheat and sorghum are the main crops, but a small amount of alfalfa is also grown. About 10 percent of this soil is in native grass and is used for range. A small acreage is irrigated. Terracing and contour farming help to control water erosion. Good management of crop residue through stubble mulching helps to reduce soil blowing, increase the intake of water, and maintain good tilth. Capability unit IIe–4; Limy Upland range site; windbreak suitability group 3.

Armo loam, 3 to 7 percent slopes (An).—This soil is on erosional uplands, on ridges, on side slopes, and along drainageways of the uplands. Slopes are plane to convex. This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of Eltree, Penden, Harney, Wakeen, Bogue, and Brownell soils. Also included were small eroded areas, rock outcrops, and sandy spots, which are shown on the soil map by a symbol.

Runoff is medium to rapid. Water erosion is the main hazard, but soil blowing also is a hazard if the soil is left bare for any extended period, such as for summer fallow or between crops. Iron chlorosis affects production of sorghum, because of the high content of lime in the soil.

About 60 percent of this soil is cultivated. Wheat and sorghum are the main crops, but some alfalfa is also grown. About 40 percent of this soil is in native grass and is used for range. Terracing, contour farming, and stubble mulching help to control water erosion. Good management of crop residue, by keeping it on the surface, helps to reduce soil blowing, increase the intake of water, and maintain organic-matter content and good tilth. Capability unit IIIe–6; Limy Upland range site; windbreak suitability group 3.

Armo loam, 3 to 7 percent slopes, eroded (Ao).—This soil is on knolls and along drainageways. It has a profile similar to the one described as representative for the series, but the surface layer is about 5 inches thick. In many places the surface layer is a mixture of the original surface layer and the subsoil. In some places the soil lacks gravel and sand in the underlying material.

Included in mapping were some small areas of Eltree, Penden, Bogue, Brownell, Corinth, and Wakeen soils and of Hilly land.

Runoff is rapid. Water erosion is the main management concern, but soil blowing also is a hazard if the soil is left bare. Iron chlorosis may affect sorghum planted on this soil, because of the high lime content.

About 75 percent of this soil is cultivated, and wheat and sorghum are the main crops. Most of the rest formerly was cultivated but has been reseeded to grass. The soil is better suited to tame or native grasses than to most other crops because of the eroded condition and the hazard of further erosion. Terracing, contour farming, and stubble mulching or good residue management help to reduce erosion, increase the intake of water, and improve tilth. Seeding to tame or native grasses or grass-legume mixtures helps to control erosion. Capability unit IVe–4; Limy Upland range site; windbreak suitability group 3.

Armo loam, 7 to 15 percent slopes (Ar).—This soil is on sides of small valleys, on knolls, and on narrow ridgetops. It has a profile similar to the one described as representative for the series, but the surface layer is about 10 inches thick and the subsoil is about 10 inches thick.

Included in mapping were some small areas of Penden, Eltree, Bogue, Brownell, Campus, Corinth, Heizer, New Cambria, and Wakeen soils; Hilly land; Roxbury silt loam, frequently flooded; and Armo loam, 3 to 7 percent slopes, eroded. Also included were small eroded spots and rock outcrops, which are shown on the soil map by a symbol.

Runoff is rapid, and water erosion is a hazard. Continued overgrazing can result in severe water erosion.

Most of this soil is in native grass and is used for range. The soil is well suited to native grasses but must be managed to prevent continued overgrazing and to maintain the desirable species. Management practices must include proper rate of stocking, deferred grazing, and rotation grazing. Suitable sites for stock-water impoundments are generally available. Capability unit VIe–1; Limy Upland range site; windbreak suitability group 3.

Boel Series

The Boel series consists of deep, somewhat poorly drained soils that formed in coarse-textured alluvium. These soils are on flood plains along permanent streams. They are nearly level to gently undulating.

In a representative profile the surface layer is dark grayish-brown fine sandy loam about 10 inches thick. The next layer is grayish-brown,, very friable loamy sand about 7 inches thick that has a few faint mottles in the lower part. The upper 26 inches of the underlying material is light-gray loamy sand mottled with strong brown and reddish brown. This material is underlain, at a depth of 43 inches, by light-gray silt loam that contains thin strata of fine sandy loam and loamy fine sand and is saturated with water most of the time.

Permeability is moderately rapid above the water table, which fluctuates between depths of 2 and 6 feet during most growing seasons. Available water capacity is low. Most areas of these soils are in native range or hay meadow and are well suited to these uses.

Representative profile of Boel fine sandy loam, in native grass, 3,080 feet south and 2,380 feet east of the northwest corner of sec. 10, T. 11 S., R. 20 W.:

A1—0 to 10 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark brown (10YR 2/2) moist; weak, medium, granular structure; soft, very friable; many fine to coarse roots; strongly effervescent; mildly alkaline; gradual, smooth boundary.

AC—10 to 17 inches, grayish-brown (10YR 5/2) loamy sand, very dark grayish brown (10YR 3/2) moist; few, faint, brown mottles in lower half of horizon; single grained; loose, very friable; many fine and medium roots; strongly effervescent; mildly alkaline; gradual, smooth boundary.

C1—17 to 43 inches, light-gray (10YR 7/2) light loamy sand, pale brown (10YR 6/3) moist; common, distinct, medium, strong-brown (7.5YR 5/6) and reddish-brown (5YR 5/4) mottles; single grained; loose when dry and moist; few fine roots; strongly effervescent; mildly alkaline; gradual, smooth boundary.

IIC2—43 to 60 inches, light-gray (10YR 6/1) silt loam, gray (10YR 5/1) moist; massive; few thin strata that are more clayey or more coarse; saturated with water most of the time; few, small, soft carbonate concretions; violently effervescent; moderately alkaline.

The A1 horizon ranges from very dark gray to grayish brown in color. It is dominantly fine sandy loam, but it is silt loam, loam, or sand in some places. Reaction ranges from neutral to moderately alkaline. The AC horizon has a color that is between those of the A and C horizons, and it ranges from light sandy loam to loamy sand in texture. Distinct mottling occurs at a depth of less than 40 inches. The C horizon ranges from loamy sand to coarse sand. The IIC2 horizon is absent in some places.

Boel soils are near Munjor and Wann soils. They are coarser textured in the A and C horizons and are not so well drained as Munjor soils. They have a coarser texture than Wann soils, especially below the A horizon.

Boel fine sandy loam (0 to 2 percent slopes) (Bf).—This soil is nearly level to gently undulating and is on flood plains adjacent to permanent streams. The water table generally fluctuates between depths of 2 and 6 feet, but it is at a depth of 1 to 2 feet during cool, excessively wet periods.

Included with this soil in mapping were small areas of Wann, Munjor, Inavale, and McCook soils.

Wetness caused by the high water table and flooding is a limitation to the use of this soil.

Most areas of this soil are in native grass and are used for range or hay meadow. This soil is among the soils best suited to range. Proper rate of stocking, deferred grazing, and rotation grazing help to maintain good range condition. Fencing of areas for separate management is desirable. Capability unit IIIw–2; Subirrigated range site; windbreak suitability group 1.

Bogue Series

The Bogue series consists of moderately deep, modertely well drained soils that formed in material weathered from clay shale. These soils are sloping to moderately steep and are on uplands.

In a representative profile the surface layer is gray clay about 6 inches thick. The subsoil is gray, extremely firm clay about 11 inches thick. The underlying material is about 15 inches thick. The upper 6 inches is gray clay, and the lower 9 inches is dark-gray weathered clay shale that is underlain by clay shale at a depth of 32 inches (fig. 10).

Permeability is very slow, and available water capacity is low. Most areas of these soils are in native grass and are used for range.

Representative profile of Bogue clay, 3 to 8 percent slopes, in native grass, 1,550 feet east and 450 feet south of the northwest corner of sec. 17, T. 12 S., R. 16 W.:

A1—0 to 6 inches, gray (5Y 5/1) clay, dark gray (5Y 4/1) moist; weak, very thick, platy structure parting to weak, medium, subangular blocky; very hard, very firm; many fine grass roots; few fragments of calcite; moderately alkaline; gradual, smooth boundary.

B1—6 to 10 inches, gray (5Y 5/1) clay, dark gray (5Y 4/1) moist; few, fine, distinct, very dark (5Y 3/1) moist mottles on vertical ped faces; weak, coarse, blocky structure; extremely hard, extremely firm; common fine grass roots; few fine fragments of calcite or chalk; mildly alkaline; gradual, wavy boundary.

B2—10 to 17 inches, gray (5Y 5/1) clay, dark gray (5Y 4/1) moist and very dark gray (2.5Y 3/1) moist in equal parts in fine indefinite pattern; few, fine, distinct, dark yellowish-brown (10YR 4/4, moist) mottles; weak, coarse, blocky structure; extremely hard, extremely firm; common fine grass roots; few slickenside faces intersect and are inclined 20 to 30 degrees from horizontal; moderately alkaline; gradual, wavy boundary.

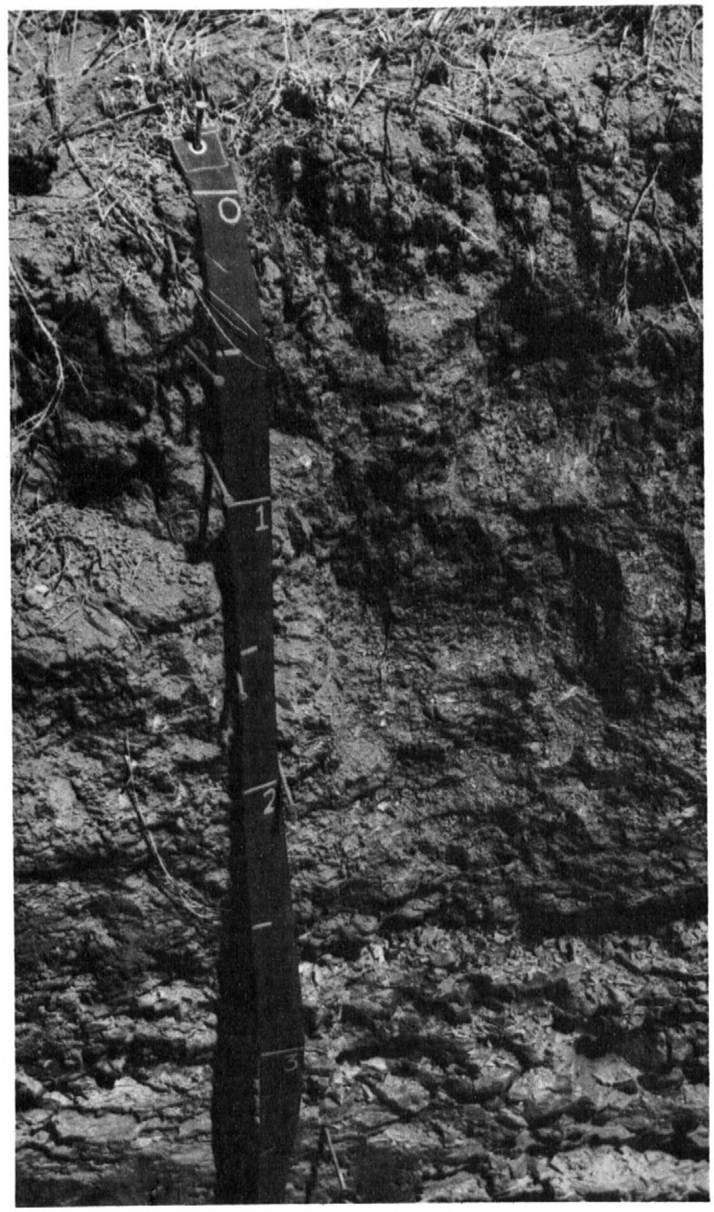

Figure 10.—**Profile of Bogue clay.**

C1—17 to 23 inches, gray (5Y 5/1) clay, dark gray (5Y 4/1) and black (5Y 2/1) moist in equal parts in medium indefinite pattern; moderate, thin, platy structure; extremely hard, extremely firm; few fine roots; common small shale fragments of yellowish brown (10YR 5/6) moist and few horizontal and oblique strata 5 to 10 millimeters thick of yellowish brown (10YR 5/4) moist; very strongly acid; gradual, smooth boundary.

C2—23 to 32 inches, dark gray (5Y 4/1) weathered clay shale, common horizontal strata 1 to 2 centimeters thick of yellowish brown (10YR 5/7) and black (5Y 2/1) moist; moderate, medium, platy structure; extremely hard, extremely firm; very few roots; very strongly acid; gradual, smooth boundary.

R—32 to 57 inches, clay shale that has the same colors as in the C2 horizon; no roots observed; few oblique fractures or joints; very strongly acid.

The solum is typically 15 to 17 inches in thickness but ranges from 12 to 23 inches. Depth to shale is typically 28 to 33 inches but ranges from 20 to 40 inches. The solum ranges from neutral to moderately alkaline, and the C and R horizons range from medium acid to very strongly acid.

Bogue soils are near Armo, Corinth, Heizer, and New Cambria soils and Alluvial land, clayey. They contain more clay and are shallower to clay shale bedrock than Armo and New Cambria soils and Alluvial land, clayey. They are about the same depth to bedrock as Corinth soils but contain more clay throughout and contain less carbonates. Bogue soils are deeper and contain more clay throughout the profile than Heizer soils.

Bogue clay, 3 to 8 percent slopes (Bg).—This soil is on erosional uplands. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of New Cambria, Bogue, Armo, and Corinth soils; Alluvial land, clayey; and areas of soils similar to Bogue soils but less than 20 inches deep over unweathered clay shale.

Runoff is rapid. Water erosion is the main hazard, but soil blowing also is a hazard if range is overgrazed for extensive periods.

Most areas of this soil are in native grass and are used as range. The soil is difficult to revegetate in eroded areas. Proper rate of stocking, deferred grazing, and rotation grazing are effective in producing adequate forage for livestock and in controlling erosion. Fencing for better use of range is desirable. Suitable sites for water impoundment are available. Capability unit VIe–2; Blue Shale range site; windbreak suitability group 4.

Bogue-Armo complex (5 to 25 percent slopes) (Bo).—This complex is in gently rolling to hilly areas on uplands that are dissected by drainageways. About 40 percent of this complex is Bogue clay, and 30 percent is Armo loam. The rest is Corinth soils; Alluvial land, clayey; and soils similar to Bogue clay but less than 20 inches deep over clay shale.

Runoff is rapid. Water erosion is the main hazard, but soil blowing also is a hazard where the range has been overgrazed for several years.

This complex is mostly in native grass and is used for range. Stocking at a proper rate and fencing for better use of range through rotation or deferred grazing are effective in controlling erosion and producing adequate forage for livestock. Suitable sites are available for the impoundment of water. Both soils in capability unit VIIs–1; Bogue soils in Blue Shale range site and windbreak suitability group 4; Armo soils in Limy Upland range site and windbreak suitability group 3.

Brownell Series

The Brownell series consists of moderately deep, well-drained soils that formed in gravelly and channery local outwash derived from chalky limestones. These soils are on knolls, ridges, and side slopes on uplands (fig. 11).

Figure 11.—**Profile of Brownell gravelly loam.**

In a representative profile the surface layer is very dark gray gravelly loam about 7 inches thick. The subsoil is dark-gray, friable very gravelly loam about 8 inches thick. It is porous and contains common chalky limestone fragments ½ inch to 2 inches in diameter. The underlying material is very pale brown channery loam 15 inches thick. It has many coarse fragments of soft chalky limestone 3 to 6 inches in diameter. Loamy material fills the interstices. Chalky limestone is at a depth of about 30 inches.

Permeability is moderate, and available water capacity is low. Most areas of these soils are in native grass and are used for range.

Representative profile of Brownell gravelly loam, 2 to 10 percent slopes, in native grass, 600 feet east and 180 feet north of the southwest corner of sec. 32, T. 11 S., R. 17 W.:

A1—0 to 7 inches, very dark gray (10YR 3/1) gravelly loam, very dark brown (10YR 2/2) moist; strong, fine and medium, granular structure; slightly hard, friable; many fine and medium roots; porous; common worm casts; violently effervescent; moderately alkaline; gradual, smooth boundary.

B2—7 to 15 inches, dark-gray (10YR 4/1) very gravelly loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; slightly hard, friable; many fine and medium roots; porous; common worm casts; common chalky limestone fragments ½ inch to 2 inches in diameter; violently effervescent; moderately alkaline; gradual, smooth boundary.

C1—15 to 30 inches, very pale brown (10YR 8/4) channery loam, very pale brown (10YR 8/3) moist; weak, coarse, subangular blocky structure; slightly hard, friable; few fine roots; porous; few worm casts; many coarse fragments of soft chalky limestone 3 to 6 inches in diameter, loamy material fills interstices between fragments; violently effervescent; moderately alkaline; abrupt boundary.

R—30 to 60 inches, very pale brown (10YR 8/3) chalky limestone.

The solum is typically 12 to 18 inches in thickness but ranges from 10 to 20 inches. The A horizon ranges from 4 to 10 inches in thickness and from loam to gravelly loam in texture. The A horizon ranges from very dark gray to grayish brown in color. The B horizon ranges from gravelly loam to channery loam. The content of gravel and channery fragments ranges from 50 to 65 percent, and the fragments range from ½ inch to 4 inches in diameter. The C horizon ranges from very gravelly loam to channery loam and is 50 to 80 percent gravelly and channery fragments 1 inch to 6 inches in diameter. Depth to chalky limestone ranges from 20 to 40 inches.

Brownell soils are near Heizer, Wakeen, and Mento soils. They are deeper to chalky limestone than Heizer soils. They contain more gravel and channery fragments than Wakeen soils. They are shallower over chalky limestone than Mento soils and lack the B2t horizon of those soils.

Brownell gravelly loam, 2 to 10 percent slopes (Br).—This soil is on erosional uplands, knolls, ridgetops, and side slopes.

Included with this soil in mapping were small areas of Wakeen, Heizer, Mento, and Armo soils. Also included were small areas of soils that are similar to Brownell soils but that have a surface layer of light brownish gray and rock outcrops, which are shown on the soil map by a symbol.

Runoff is rapid. Water erosion and soil blowing are hazards if the range is overgrazed for long periods.

Most areas of this soil are in native grass. The soil is better suited to native grass and grazing than to most other uses. Proper rate of stocking, deferred grazing, rotation grazing, and proper placement of salt and water help to maintain and improve native range. Suitable sites for water impoundment are available. Capability unit VIe-3; Limy Upland range site; windbreak suitability group 3.

Campus Series

The Campus series consists of moderately deep, calcareous, well-drained soils that formed in caliche and unconsolidated outwash. These soils are sloping to strongly sloping and are on ridgetops and side slopes and along drainageways on uplands.

In a representative profile the surface layer is dark grayish-brown loam about 9 inches thick. It contains many fragments of caliche ¼ to 1 inch in diameter. The next layer is light-gray, friable light clay loam about 10 inches thick and has many caliche fragments ¼ to 1 inch in diameter. The underlying material is white loam about 14 inches thick and has many caliche fragments ¼ to 1 inch in diameter and common masses of segregated lime. About 25 to 50 percent, by volume, of this layer is lime. White caliche and unconsolidated outwash is at a depth of about 33 inches. This material is hard when dry.

Permeability is moderate, and available water capacity is low. Most of the strongly sloping areas and 40 percent of the sloping areas are in native grass. The other 60 percent of the sloping areas are cultivated.

Representative profile of Campus loam in an area of Campus-Carlson complex, 3 to 7 percent slopes, in a cultivated field 2,590 feet east and 100 feet north of the southwest corner of sec. 7, T. 12 S., R. 20 W.:

A1—0 to 9 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; slightly hard, friable; few fine roots; many open pores; common worm casts; many caliche fragments ¼ to 1 inch in diameter; violently effervescent; moderately alkaline; gradual, smooth boundary.

AC—9 to 19 inches, light-gray (10YR 7/2) light clay loam, grayish brown (10YR 5/2) moist; moderate, fine, granular structure; slightly hard, friable; few fine roots; common open pores, few worm casts; many caliche fragments ¼ to 1 inch in diameter; violently effervescent; moderately alkaline; gradual, smooth boundary.

Cca—19 to 33 inches, white (10YR 8/2) loam, light gray (10YR 7/2) moist; massive; hard, friable; many open pores; many caliche fragments ¼ to 1 inch in diameter and common masses of segregated lime; violently effervescent; moderately alkaline; diffuse, wavy boundary.

R—33 to 60 inches, white (10YR 8/2), partially consolidated caliche; loam in fractures and between pebbles and fragments of caliche; hard.

The A1 horizon ranges from sandy loam to silty clay loam in texture and from dark gray to brown in color. The A1 horizon generally is calcareous throughout, but it is noncalcareous to a depth of 7 inches in a few places. The depth to caliche ranges from 20 to 40 inches.

Campus soils are near Canlon, Penden, and Carlson soils. They are deeper to caliche than Canlon soils. They are less clayey and shallower to caliche than Penden soils. They are less clayey than Carlson soils and lack the B2t horizon of those soils.

Campus-Carlson complex, 3 to 7 percent slopes (Cc).—This complex is on erosional uplands. About 55 percent is Campus soils, 26 percent is Carlson soils, and 19 percent is included soils. The Campus soils occur on knolls and ridgetops and the Carlson soils occur on ridgetops and along shallow drainageways. A Campus soil in this complex has the profile described as representative for the Campus series.

Included with these soils in mapping were small areas of Canlon soils and areas of soils that are similar to Campus soils except for having a lighter colored surface layer. Also included were small areas of soils similar to Carlson soils, except that the material below the subsoil is less than 20 percent lime, by volume, and small eroded spots and rock outcrops, which are shown on the soil map by a symbol.

Runoff is rapid. Water erosion is the main hazard, but soil blowing also is a hazard if the soil is left bare.

About 80 percent of this complex is in wheat and sorghums, and the other 20 percent is in native grass and is used for range. Use of contour farming, terraces, and waterways helps to control water erosion (fig. 12). Stubble mulching helps to reduce water erosion and soil blowing, increases the intake of water, and helps to maintain good tilth. Iron chlorosis is a management concern if sorghum is planted on Campus soils, because of the high lime content in the soil. Both soils in capability unit IVe–2; Campus soils in Limy Upland range site and windbreak suitability group 3; Carlson soils in Loamy Upland range site and windbreak suitability group 2.

Campus-Penden complex, 5 to 15 percent slopes (Cd).—This complex is on erosional uplands. It is on sides of small valleys and in drainageways. In most places Campus soils occur above the Penden soils on the side slopes. About 44 percent of this complex is Campus soils, 35 percent is Penden soils, and 21 percent is included soils.

Included with these soils in mapping were small areas of Harney and Canlon soils and Roxbury silt loam, frequently flooded. Also included were small areas of rock outcrops, which are shown on the soil map by a symbol.

Runoff is rapid. Water erosion and soil blowing are hazards in overgrazed areas.

All of this complex is in native grass and is used for range. A few areas that were formerly cultivated have been reseeded to native grasses. Proper rate of stocking, deferred grazing, and rotation grazing help to maintain or improve range. Fencing and proper placement of salt and water for more uniform grazing is desirable. Suitable sites for water impoundments are available in most areas. Capability unit VIe–1; Limy Upland range site; windbreak suitability group 3.

Canlon Series

The Canlon series consists of shallow, well-drained soils that formed in residuum derived from caliche. These soils are sloping to moderately steep and are on narrow ridgetops and sides of ridges above or below ledges of outcropping caliche.

In a representative profile the surface layer is grayish-brown loam about 4 inches thick. It is calcareous and contains a few scattered fragments of caliche. The next layer is light-gray, friable loam about 4 inches thick. It is calcareous and contains many fragments of caliche 1/4 inch to 1 1/2 inches in diameter. The underlying material is white loam about 5 inches thick. It is calcareous and contains many small to large fragments of caliche. Below is white caliche.

Permeability is moderate, and available water capacity is very low. All of the acreage of these soils is in native grass and is used for range.

A representative profile of Canlon loam, in native grass, in an area of Canlon complex, 100 feet north and 2,700 feet east of the southwest corner of sec. 4, T. 12 S., R. 20 W.:

A1—0 to 4 inches, grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; slightly hard, friable; many fine and medium roots; few nests of worm casts; a few scattered fragments of caliche; calcareous, violently effervescent; moderately alkaline; clear, smooth boundary.

AC—4 to 8 inches, light-gray (10YR 6/1) loam, gray (10YR 5/1) moist; weak, fine and medium, granular structure; slightly hard, friable; common fine and medium roots; few worm casts; many fragments of caliche 1/4 inch to 1 1/2 inches in diameter; calcareous, violently effervescent; moderately alkaline; clear, smooth boundary.

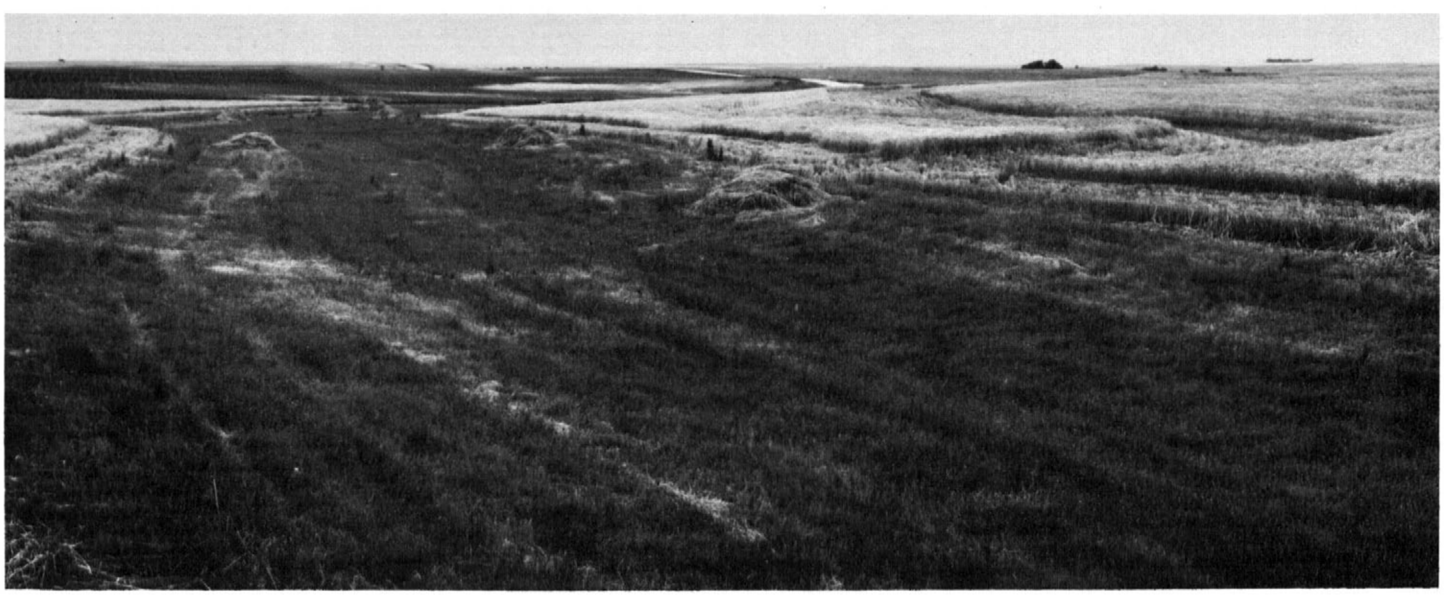

Figure 12.—**Grassed waterway in drainageway on Campus-Carlson complex, 3 to 7 percent slopes.**

C—8 to 13 inches, white (10YR 8/2) loam, light gray (10YR 7/2) moist; massive; hard, friable; few fine roots; many small to large fragments of caliche; most of the fine material is lime; calcareous, violently effervescent; moderately alkaline; abrupt boundary.
R—13 to 60 inches, white (10YR 8/2) caliche.

The A1 horizon ranges from dark grayish brown to very pale brown in color and from 3 to 6 inches in thickness. It ranges from fine sandy loam to silt loam in texture. In most places the soil is calcareous throughout, but the A1 horizon is noncalcareous in a few places. Reaction is mildly alkaline or moderately alkaline. The AC horizon is intermediate in color and texture between those of the A and C horizons. The C horizon ranges from light brownish gray to very pale brown in color and from fine sandy loam to silt loam in texture.

Canlon soils are near Campus, Penden, and Carlson soils. They are shallower to caliche than Campus, Penden, and Carlson soils. They are less clayey than Penden and Carlson soils. They lack the B2t horizon of Carlson soils.

Canlon complex (5 to 25 percent slopes) (Ce).—This complex is on a narrow rim of a bluff of outcropping caliche. About 42 percent is Canlon loam, 20 percent is Campus loam, and 38 percent is included soils.

Included with these soils in mapping were small areas of Penden soils; outcrops of caliche; Alluvial land, wet; and loamy alluvial soils in small drainageways. Also included are soils similar to Canlon soils except that the surface layer is 7 inches or more in thickness and dark grayish brown or darker in color. There is also a small acreage of soils that have caliche at a depth of less than 10 inches.

Runoff is rapid. Water erosion and soil blowing are hazards if the range is overgrazed.

All of the complex is in native grass and is used for range. A few small areas formerly cultivated have been reseeded to native grass. Proper rate of stocking, deferred grazing, and rotation grazing help to maintain and improve range. Suitable sites for water impoundment are available in most places. Both soils in capability unit VIIs–2; Canlon soils in Shallow Limy range site and windbreak suitability group 4; Campus soils in Limy Upland range site and windbreak suitability group 3.

Carlson Series

The Carlson series consists of deep, well-drained soils that formed in thin deposits of moderately fine textured loess over highly calcareous loamy colluvium derived from chalky limestone and calcareous unconsolidated outwash. These soils are nearly level to sloping and are on broad tablelands, ridgetops, and side slopes on uplands.

In a representative profile the surface layer is dark-gray silt loam about 8 inches thick. The subsoil is about 15 inches thick. The upper 4 inches is dark grayish-brown, firm silty clay loam; the next 6 inches is brown, firm heavy silty clay loam; and the lower 5 inches is grayish-brown, firm, calcareous silty clay loam. The underlying material is very pale brown, calcareous clay loam.

Permeability is moderately slow, and available water capacity is high. About 90 percent of the acreage of these soils is cultivated. The remaining 10 percent, most of which is sloping, is in native grass and is used for range.

Representative profile of Carlson silt loam, in a cultivated field, in an area of Harney-Carlson silt loams, 1 to 3 percent slopes, 600 feet east and 2,040 feet north of the southwest corner of sec. 8, T. 12 S., R. 20 W.:

A1—0 to 8 inches, dark-gray (10YR 4/1) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, granular structure; hard, friable; few fine roots; few open pores; neutral; clear, smooth boundary.
B1—8 to 12 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, subangular blocky structure; hard, firm; few fine roots; few nests of worm casts; few open pores; mildly alkaline; clear, smooth boundary.
B2t—12 to 18 inches, brown (10YR 5/3) heavy silty clay loam, dark brown (10YR 4/3) moist; moderate, medium, subangular blocky structure; hard, firm; few fine roots; few open pores; moderately alkaline; clear, wavy boundary.
B3ca—18 to 23 inches, grayish-brown (10YR 5/2) light silty clay loam, dark grayish brown (10YR 4/2) moist; weak, medium, subangular blocky structure; hard, firm; few fine roots; few open pores; common lime-

Figure 13.—Harney-Carlson silt loams, 1 to 3 percent slopes, are on upper terraces. Campus loam is on terrace ridge in foreground.

***Figure 14.*—Profile of Corinth silty clay loam, 3 to 7 percent slopes.**

stone fragments minute to ½ inch in diameter; weakly effervescent; moderately alkaline; clear, smooth boundary.

Cca—23 to 60 inches, very pale brown (10YR 8/3) clay loam, light yellowish brown (10YR 6/4) moist; weak, coarse, prismatic structure; hard, friable; common open pores; a few soft lime masses; violently effervescent; moderately alkaline.

The solum ranges from 18 to 36 inches in thickness. Depth to free carbonates in the form of films, threads, or soft masses ranges from 17 to 24 inches. The A horizon ranges from loam to silty clay loam in texture and from dark gray to brown in color. The B2t horizon ranges from dark grayish brown to light yellowish brown in color and from clay loam to light silty clay in texture. The Cca horizon generally ranges from loam to silty clay loam, but in some places it is loamy sand or sandy loam. It ranges from light brownish gray to very pale brown in color.

Carlson soils are near Canlon, Campus, Harney, and Armo soils. They are more clayey than Campus and Armo soils and contain a B2t horizon that those soils lack. They have a higher concentration of lime below the B2t horizon than Harney soils. They are deeper than Canlon and Campus soils.

In this county Carlson soils are mapped only in complexes with Campus and Harney soils (fig. 13).

Corinth Series

The Corinth series consists of moderately deep, well-drained soils that formed in material weathered from calcareous shale. These soils are gently sloping to strongly sloping and are on ridgetops and sides of ridges on uplands.

In a representative profile the surface layer is grayish-brown silty clay loam about 9 inches thick. The subsoil is 13 inches thick. The upper 7 inches is light brownish-gray, firm heavy silty clay loam; and the lower 6 inches is light yellowish-brown, firm heavy silty clay loam. The underlying material is 8 inches of brownish-yellow heavy silty clay loam that is underlain by light yellowish-brown, platy, calcareous shale. The shale contains numerous seams of gypsum (fig. 14).

Permeability is moderately slow, and available water capacity is moderate. Most areas of the gently sloping and sloping soils are cultivated. Most areas of the strongly sloping soils are in native grass and are used for range.

Representative profile of Corinth silty clay loam, 3 to 7 percent slopes, in native grass, 1,640 feet west and 3,090 feet north of the southeast corner of sec. 10, T. 12 S., R. 16 W.:

A11—0 to 5 inches, grayish-brown (2.5Y 5/2) silty clay loam; dark grayish brown (10YR 4/2) moist; moderate, fine, granular structure; hard, firm; numerous roots; few worm casts; few flat pieces of calcite; strongly effervescent; mildly alkaline; clear, smooth boundary.

A12—5 to 9 inches, grayish-brown (2.5Y 5/3) silty clay loam, dark grayish brown (2.5Y 4/3) moist; moderate, fine and very fine, subangular blocky structure; hard, firm; many roots; few worm casts; few flat pieces of calcite; violently effervescent; moderately alkaline; gradual, smooth boundary.

B21—9 to 16 inches, light brownish-gray (2.5Y 6/3) heavy silty clay loam, dark grayish brown (2.5Y 4/3) moist; moderate, fine and very fine, subangular blocky structure; very hard, firm; many roots; few worm casts; few flat pieces of calcite; violently effervescent; moderately alkaline; gradual, smooth boundary.

B22—16 to 22 inches, light yellowish-brown (2.5Y 6/3) heavy silty clay loam, olive brown (2.5Y 4/3) moist; moderate, fine, subangular blocky structure; very hard, firm; few roots, soft, platy fragments of calcareous shale; few flat pieces of calcite; violently effervescent; moderately alkaline; gradual, smooth boundary.

C—22 to 30 inches, brownish-yellow (10YR 6/6) heavy silty clay loam, yellowish brown (10YR 5/6) moist; weak, fine, subangular blocky structure; very hard, firm; several, soft, platy fragments of calcareous shale; several flat pieces of calcite; few roots; violently effervescent; moderately alkaline; gradual, smooth boundary.

R—30 to 47 inches, mixed light yellowish-brown (10YR 6/4) and brown (10YR 4/3), weathered, platy shale, yellowish brown (10YR 5/4) and brown (10YR 4/3) moist; few roots; numerous thin seams of light-gray (N 7/0) gypsum.

The soil ranges from 15 to 30 inches in thickness. Depth to unweathered calcareous shale is typically 26 to 34 inches but ranges from 20 to 40 inches. The profile is calcareous throughout in most places but is noncalcareous to a depth of 6 inches in some places. The A horizon is grayish brown to light brownish gray. It generally is silty clay loam, but in some places it is silt loam or clay loam. The B horizon ranges from brown to light yellowish brown in color. It is silty clay loam or silty clay that ranges from 35 to 45 percent in content of clay but typically has a clay content of 37 to 43 percent. The C horizon is brownish yellow or olive yellow in color and silty clay loam or silty clay in texture.

Corinth soils are near Harney, Bogue, Nibson, and New Cambria soils and Roxbury soils. They are shallower and have a lighter colored surface layer than Harney, New Cambria, and Roxbury soils. They are deeper to shale and contain more clay than Nibson soils. They contain less clay and more free carbonates than Bogue soils.

Corinth silty clay loam, 1 to 3 percent slopes (Cm).—This soil is on ridgetops and sides of ridges on uplands. It has a profile similar to the one described as representative for the series, but the surface layer is slightly thicker.

Included with this soil in mapping were small areas of Harney soils. Also included were areas of soils similar to Corinth soils except that the surface layer and subsoil formed in loess and are noncalcareous.

Runoff is medium. Water erosion is the main hazard, but soil blowing also is a hazard if the soil is left bare. Iron chlorosis is a concern if sorghum is planted, because of the high lime content in the soil.

Most areas of this soil are cultivated. Wheat and sorghum are the main crops. Terraces, waterways, and contour farming help to control water erosion. Good management of crop residue through stubble mulching helps to reduce soil blowing, increase the intake of water, and maintain good tilth. A small acreage of this soil is in native grass and is used for range. Capability unit IIIe–9; Limy Upland range site; windbreak suitability group 3.

Corinth silty clay loam, 3 to 7 percent slopes (Cn).—This soil is on ridgetops and sides of small drainageways in the uplands. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of Harney, Nibson, and Bogue soils. Some of the Harney soils have a surface layer of silty clay loam and are eroded. Also included were areas of soils similar to Corinth soils, except that the surface layer is eroded and light brownish-gray heavy silty clay loam is exposed. These eroded areas are shown on the soil map by a special symbol.

Runoff is medium to rapid. Water erosion is the main hazard, but soil blowing is a concern if the soil is left bare. Iron chlorosis is a concern if sorghum is planted, because of the high lime content in the soil.

About half of the acreage of this soil is cultivated, and half is in native grass, to which it is well suited. Wheat and sorghum are the main crops. Terraces, waterways, and contour farming help to reduce water erosion. Good management of crop residue through stubble mulching helps to control soil blowing, increase water intake, and maintain the content of organic matter and good tilth. Good management practices on range include proper stocking, rotation grazing, deferred grazing, proper placement of salt and water, and cross fencing to attain more uniform grazing. Capability unit IVe–3; Limy Upland range site; windbreak suitability group 3.

Corinth silty clay loam, 7 to 15 percent slopes (Co).—This soil is on sides of drainageways. It has a profile similar to the one described as representative for the series, but the surface layer is 2 to 4 inches thinner.

Included with this soil in mapping were small areas of Wakeen, Nibson, and Bogue soils; Roxbury silt loam, frequently flooded; and Alluvial land, clayey. Also included were areas of soils similar to Corinth soils except that the surface layer is light brownish-gray heavy silty clay loam and is eroded. These eroded areas are shown on the soil map by a special symbol.

Runoff is rapid. Water erosion is the main hazard, but soil blowing also is a hazard if range is overgrazed or if cultivated areas are left unprotected.

Most areas of this soil are in native grass and are used for range. Small formerly cultivated areas have been reseeded to native grass. Good range management includes proper stocking, deferred grazing, rotation grazing, and cross fencing. Proper placement of salt and water helps to attain uniform grazing. Capability unit VIe–1; Limy Upland range site; windbreak suitability group 3.

Crete Series

The Crete series consists of deep, moderately well drained soils that formed in loess on uplands. These soils are nearly level or slightly depressional.

In a representative profile the surface layer is very dark gray silty clay loam about 12 inches thick. The subsoil is about 29 inches thick. The upper 4 inches is dark-gray, firm silty clay loam. Then, in sequence, are 13 inches of dark grayish-brown, very firm silty clay; 5 inches of grayish-brown, very firm silty clay that contains some hard lime concretions that are minute to 1/8 inch in diameter; and 7 inches of grayish-brown, firm silty clay loam that contains many masses of lime 1/4 inch in diameter. The underlying material is pale-brown silty clay loam.

Permeability is slow, and available water capacity is high. Most areas of these soils are in wheat and sorghum. A few small areas are in native grass.

Representative profile of Crete silty clay loam, 0 to 1 percent slopes, in native grass, 1,815 feet east and 700 feet south of the northwest corner of sec. 34, T. 13 S., R. 16 W.:

A1—0 to 12 inches, very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) moist; moderate, fine, granular structure; hard, friable; porous; many fine and medium roots; few worm casts; slightly acid; clear, smooth boundary.

B1—12 to 16 inches, dark-gray (10YR 4/1) silty clay loam, very dark brown (10YR 2/2) moist; moderate, fine and very fine, subangular blocky structure; hard, firm; common fine and medium roots; few worm casts; slightly acid; clear, smooth boundary.

B21t—16 to 23 inches, dark grayish-brown (10YR 4/2) silty clay; very dark grayish brown (10YR 3/2) moist; moderate, medium and fine, subangular blocky structure; very hard, very firm; clay films occur on ped faces and as fillings in pores; common fine and medium roots; slightly acid; clear, smooth boundary.

B22t—23 to 29 inches, dark grayish-brown (10YR 4/2) silty clay; very dark grayish brown (10YR 3/2) moist; moderate, medium, subangular and angular blocky structure; very hard, very firm; few fine and medium roots; clay films occur as coatings on peds and as fillings in pores; neutral; clear, smooth boundary.

B31ca—29 to 34 inches, grayish-brown (10YR 5/2) silty clay, dark grayish brown (10YR 4/2) moist; moderate, medium, angular blocky structure; very hard, very firm; few fine and medium roots; some lime concretions minute to ⅛ inch in diameter; matrix calcareous; mildly alkaline; clear, smooth boundary.

B32ca—34 to 41 inches, grayish-brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) moist; weak, medium, angular blocky structure; hard, firm; few fine roots; many masses of lime, ¼ inch or less in diameter; slightly effervescent; mildly alkaline; gradual, smooth boundary.

C—41 to 68 inches, pale-brown (10YR 6/3) silty clay loam, brown (10YR 5/3) moist; weak, coarse, prismatic structure; hard, friable; segregated calcium carbonate in root channels and pores; neutral.

The A horizon ranges from silt loam to silty clay loam in texture and from very dark gray to grayish brown in color. The upper layers that are dark grayish brown or darker range from 20 to 30 inches in combined thickness. These colors are throughout the A horizon and extend into the upper part of the B horizon. The B2t horizon is silty clay that averages between 45 to 52 percent clay. The B2t horizon ranges from dark grayish brown to pale brown in color. The depth to lime concretions or a calcareous matrix ranges from 25 to 40 inches.

Crete soils are associated with Harney, Carlson, and Armo soils. They have a more clayey and firm B2t horizon than Harney and Carlson soils. They are dark colored to a greater depth, and contain less carbonates in the solum than Armo soils and they have a B2t horizon which those soils lack. They lack the concentration of carbonates below the B2t horizon that is present in Carlson soils.

Crete silty clay loam, 0 to 1 percent slopes (Cr).—This nearly level to slightly depressional soil is on uplands. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of Harney silt loam and Harney silty clay loam. Also included were areas of small depressions and eroded spots, which are shown on the soil map by a symbol.

Runoff is slow, and ponding occurs in depressions. The clayey subsoil makes this soil droughty during periods of low rainfall. Soil blowing is a hazard if the soil is left bare.

Most areas of this soil are cultivated. Wheat and sorghum are the main crops. Good management of crop residue through stubble mulching helps to control soil blowing and maintain good tilth in the surface layer. Terraces and contouring help to control water erosion on long slopes. Capability unit IIs-1; Clay Upland range site; windbreak suitability group 2.

Crete silty clay loam, thin surface variant, 0 to 1 percent slopes (Ct).—This soil is in somewhat depressional areas on uplands. It has a profile similar to the one described as representative for the series, but the surface layer is thinner and the soil is calcareous at a shallower depth.

Included with this soil in mapping were small areas of Harney silt loam and Harney silty clay loam. Also included were small depressional and eroded spots, which are shown on the soil map by a symbol.

Runoff is slow, and some ponding occurs in depressions. The clayey subsoil makes this soil droughty during periods of low rainfall. Water erosion is a hazard on long slopes, and soil blowing is a hazard if the soil is left bare.

Most areas of this soil are in wheat and sorghum. Good management of crop residue through stubble mulching helps to control soil blowing, increase the intake of water, increase the content of organic matter, and maintain good tilth. Terraces and contour farming help to control water erosion on long slopes. Capability unit IIs-2; Clay Upland range site; windbreak suitability group 2.

Detroit Series

The Detroit series consists of deep, well-drained soils that formed in silty calcareous alluvium. These nearly level and gently undulating soils are on terraces along the major streams of the county.

In a representative profile the surface layer is about 16 inches thick. The upper 12 inches is very dark grayish-brown silt loam, and the lower 4 inches is very dark grayish-brown light silty clay loam. The subsoil is about 32 inches thick. The upper 10 inches is dark grayish-brown, firm light silty clay; the next 8 inches is brown, firm, calcareous heavy silty clay loam; the lower 14 inches is pale-brown, calcareous, firm silty clay loam.

The underlying material is light-gray, calcareous silt loam.

Permeability is slow, and available water capacity is high. Most areas of these soils are cultivated, but a few small areas are in native grass. Wheat and sorghum are the main crops, but some alfalfa is also grown.

Representative profile of Detroit silt loam, in native grass, 700 feet south and 300 feet east of the northwest corner of sec. 11, T. 15 S., R. 17 W.:

A1—0 to 12 inches, very dark grayish-brown (10YR 3/2) silt loam, very dark brown (10YR 2/2) moist; moderate, fine, granular structure; slightly hard, friable; many fine and medium roots; porous; few nests of worm casts; neutral; clear, smooth boundary.

A3—12 to 16 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, very dark brown (10YR 2/2) moist; moderate, fine, subangular blocky structure; hard, friable; few fine and medium roots; porous; few nests of worm casts; silt coatings on ped faces; neutral; clear, smooth boundary.

B21t—16 to 26 inches, dark grayish-brown (10YR 4/2) light silty clay, very dark grayish brown (10YR 3/2) moist; moderate, fine and medium, subangular blocky structure; very hard, firm; few fine roots mostly following cracks or ped faces; few fine open pores; few worm casts; mildly alkaline; clear, smooth boundary.

B22tca—26 to 34 inches, brown (10YR 5/3) heavy silty clay loam, dark grayish brown (10YR 4/2) moist; weak, coarse, prismatic structure parting to moderate, medium, subangular blocky; hard, firm; few fine roots; common fine pores; many soft masses of segregated lime; weakly effervescent; mildly alkaline; gradual, smooth boundary.

B3tca—34 to 48 inches, pale-brown (10YR 6/3) silty clay loam, brown (10YR 5/3) moist; weak, coarse, prismatic structure parting to weak, medium and coarse, subangular blocky; hard, firm; few fine and medium roots; many open pores; many soft masses of segregated lime; strongly effervescent; mildly alkaline; diffuse, smooth boundary.

C—48 to 63 inches, light-gray (10YR 7/2) silt loam, pale brown (10YR 6/3) moist; weak, coarse, prismatic structure; slightly hard, friable; few fine roots; very porous, many large open pores; few worm casts; few threads of segregated lime; weakly effervescent; mildly alkaline.

The A horizon ranges from silt loam to silty clay loam in texture and from grayish brown to very dark grayish brown in color. The B21t horizon ranges from silty clay loam to silty clay. The color is dark grayish brown or darker to a depth of 20 to 50 inches. The depth to free carbonates ranges from 22 inches to about 50 inches.

The Detroit soils are associated with Hord, Roxbury, McCook, New Cambria, and Eltree soils. They have a clayey B2t horizon that is lacking in Hord, Roxbury, New Cambria, McCook, and Eltree soils. They are leached of carbonates to about the same depth as Hord soils but are more deeply leached of carbonates than Roxbury, McCook, and Eltree soils. They have a less clayey A horizon than New Cambria soils and are on terraces below those soils.

Detroit silt loam (0 to 2 percent slopes) (De).—This nearly level and gently undulating soil is on terraces along the major streams in the county.

Included with this soil in mapping were small areas of Hord, Roxbury, and McCook soils. Also included were a few small areas of soils similar to Detroit soils but calcareous throughout. Areas of small depressions are shown on the soil map by a symbol.

Runoff is slow, and a few areas are ponded. There are no hazards except occasional flooding in a few low-lying areas.

Most areas of this soil are cultivated. Wheat and sorghum are the main crops, but some alfalfa also is grown. Good crop residue management through stubble mulching increases the water intake rate and helps to maintain good tilth. The potential for irrigation is high if water is available. A few acres of this soil are irrigated. Capability unit I-2; Loamy Terrace range site; windbreak suitability group 1.

Eltree Series

The Eltree series consists of deep, well-drained soils that formed in calcareous, silty, colluvial-alluvial sediment. These nearly level to strongly sloping soils are on high terraces and sides of valleys.

In a representative profile the surface layer is grayish-brown silt loam about 26 inches thick. The subsoil is about 23 inches thick. The upper part is grayish-brown, friable heavy silt loam about 9 inches thick; and the lower part is light brownish-gray, firm light silty clay loam about 14 inches thick. The underlying material is pale-brown light silty clay loam.

Permeability is moderate, and available water capacity is high. Most areas of the nearly level to sloping soils are cultivated. Most areas of the strongly sloping soils are in native grass and are used for range. Wheat and sorghum are the main crops.

Representative profile of Eltree silt loam, 0 to 1 percent slopes, in a cultivated field, 1,700 feet south and 3,800 feet east of the northwest corner of sec. 35, T. 15 S., R. 18 W.:

A11—0 to 10 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak, fine, granular structure; slightly hard, friable; few fine and medium roots; many fine pores; many nests of worm casts; weakly effervescent; mildly alkaline; clear, smooth boundary.

A12—10 to 19 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; slightly hard, friable; common fine and medium roots; common fine and medium pores; common nests of worm casts; strongly effervescent; moderately alkaline; gradual, smooth boundary.

A13—19 to 26 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak, fine, granular structure; slightly hard, friable; few fine and medium roots; common fine and medium open pores; common nests of worm casts; strongly effervescent; several spots and threads of calcium carbonate; moderately alkaline; clear, smooth boundary.

B21ca—26 to 35 inches, grayish-brown (10YR 5/2) heavy silt loam, dark grayish brown (10YR 4/2) moist; weak, medium, subangular blocky structure; hard, friable; few fine roots; common fine and large pores; common nests of worm casts; several spots and threads of calcium carbonate; strongly effervescent; moderately alkaline; clear, smooth boundary.

B22ca—35 to 49 inches, light brownish-gray (10YR 6/2) light silty clay loam, dark grayish brown (10YR 4/2) moist; moderate, medium, subangular blocky structure; hard, firm; few fine roots; common fine and medium pores; many soft masses and threads and a few small concretions of lime; strongly effervescent; moderately alkaline; gradual, smooth boundary.

C—49 to 63 inches, pale-brown (10YR 6/3) light silty clay loam, brown (10YR 5/3) moist; structureless; hard, firm; few concretions and common soft masses and threads of lime; weakly effervescent; moderately alkaline.

The solum ranges from 35 to 60 inches in thickness but is typically 40 to 50 inches thick. The A horizon ranges from loam to silty clay loam. The color is dark grayish brown or darker to a depth of 20 to 40 inches. The B horizon ranges from loam to silty clay loam in texture and from grayish brown to very pale brown in color. The C horizon ranges from light brownish gray to very pale brown in color and is loam, silt loam, or silty clay loam. The soil is typically calcareous throughout, but it is noncalcareous to a depth of 15 inches in some places.

Eltree soils are near Armo, Holdrege, Anselmo, Wakeen, Detroit, Hord, and Roxbury soils. They are deeper to bedrock than Wakeen soils. Their dark A horizon is thicker and more silty than that of Armo soils, and they contain less gravel and sand below the solum than those soils. They are calcareous at a lesser depth than Hord or Detroit soils. They lack the B2t horizon present in Detroit soils and contain less clay than those soils. They have more evident zones of lime accumulation and less evident stratification than Roxbury soils. They lack the B2t horizon present in Holdrege soils. They are more silty than Anselmo soils.

Eltree silt loam, 0 to 1 percent slopes (Ee).—This soil is on smooth, old, high terraces on valley sides along the major streams of the county. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of Harney, Holdrege, and Armo soils. Also included were small areas of soils that are similar to Eltree soils but that have silty clay layers in the subsoil or below.

Runoff is slow. Lack of rainfall is the main limitation to the use of this soil.

Most areas of this soil are cultivated. The main crops are wheat and sorghum, but some alfalfa is also grown. Good management of crop residue through stubble mulching helps to control soil blowing, increase water infiltration, and improve tilth. This soil has a good potential for irrigation if water is available. Capability unit IIc–1; Limy Upland range site; windbreak suitability group 3.

Eltree silt loam, 1 to 3 percent slopes (Ef).—This soil is on old, high alluvial terraces and valley sides.

Included with this soil in mapping were small areas of Armo, Holdrege, Harney, Anselmo, and Wakeen soils and Hilly land. Also included were small areas of soils that are similar to Eltree soils, except that the surface layer is dark grayish brown or darker and is less than 10 inches thick. There are also small eroded areas, rock outcrops, and sand spots, which are shown on the soil map by symbols.

Runoff is medium. Water erosion is the main hazard, but soil blowing also is a hazard if the soil is left bare.

Most areas of this soil are cultivated. Wheat and sorghum are the main crops. Terraces, waterways, and contour farming help to control water erosion. Stubble mulching or good management of crop residue helps to control soil blowing, increase the intake of water, and maintain good tilth. The soil has a good potential for irrigation. It can be bench leveled or sprinkler irrigated if water is available. Capability unit IIe–1; Limy Upland range site; windbreak suitability group 3.

Eltree silt loam, 3 to 7 percent slopes (Eg).—This soil is on old alluvial terraces and valley sides along the major streams in the county. It has a profile similar to the one described as representative for the series, but the surface layer is slightly thinner.

Included with this soil in mapping were small areas of Armo, Brownell, Wakeen, Anselmo, Roxbury, and McCook soils and Hilly land. Also included are areas of soils that have a texture similar to that of Eltree soils but are noncalcareous to a depth of 15 to 25 inches and small areas of soils that have a surface layer 10 inches or less thick. There are also eroded areas, which are shown on the soil map by a symbol.

Runoff is medium to rapid. Water erosion is the main hazard, but soil blowing also is a hazard if the soil is left bare.

Most areas of this soil are cultivated. Wheat and grain sorghum are the main crops. A small acreage is in native grass and is used for range. Terraces, waterways, and contour farming help to control water erosion. Stubble mulching or good management of crop residue helps to control soil blowing, increase the intake of water, and maintain good tilth. Capability unit IIIe–1; Limy Upland range site; windbreak suitability group 3.

Eltree silt loam, 7 to 15 percent slopes (Eh).—This soil is on old, high alluvial terraces and valley sides along the major streams in the county. Slopes are convex. This soil has a profile similar to the one described as representative for the series, but the surface layer is thinner and the subsoil contains less clay.

Included with this soil in mapping were small areas of Armo, McCook, Roxbury, Wakeen, Penden, Brownell, and Campus soils and Hilly land. Also included are areas of soils that are similar to Eltree soils but that have a dark surface layer less than 20 inches thick.

Runoff is rapid. Water erosion is a severe hazard in cultivated areas or if range is overgrazed or is left bare.

Nearly all the acreage of this soil is in native grass, to which it is well suited. Proper rate of stocking, deferred grazing, and rotation grazing help to improve range condition. Suitable sites for water impoundments are generally available. Capability unit VIe–1; Limy Upland range site; windbreak suitability group 3.

Harney Series

The Harney series consists of deep, well-drained soils that formed in calcareous, medium-textured loess. These soils are nearly level to sloping and are on uplands.

In a representative profile the surface layer is 10 inches thick. The upper 6 inches is dark grayish-brown silt loam, and the lower 4 inches is dark grayish-brown light silty clay loam. The subsoil is about 30 inches thick. The upper 9 inches is grayish-brown, firm heavy silty clay loam; the next 11 inches is grayish-brown, firm light silty clay; and the lower 10 inches is light brownish-gray, calcareous, friable heavy silty clay loam. The underlying material is light brownish-gray light silty clay loam in the upper 19 inches and light-gray silt loam below (fig. 15).

Permeability is moderately slow, and available water capacity is high. Most areas of the nearly level and gently sloping soils are cultivated. About 60 percent of the sloping areas is cultivated, and 40 percent is in native grass and is used for range.

Representative profile of Harney silt loam, 0 to 1 percent slopes, in a cultivated field, 1,000 feet west and 150 feet south of the northeast corner of sec. 34, T. 12 S., R. 18 W.:

A1—0 to 6 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) moist; weak, fine, granular structure; slightly hard, friable; many fine roots; few worm casts; neutral; clear, smooth boundary.

A3—6 to 10 inches, dark grayish-brown (10YR 4/2) light silty clay loam, very dark brown (10YR 2/2) moist; moderate, medium and fine, subangular blocky structure; hard, friable; few fine roots; few worm casts; neutral; clear, smooth boundary.

B21t—10 to 19 inches, grayish-brown (10YR 5/2) heavy silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, medium and fine, subangular blocky structure; hard, firm; few fine roots; neutral; clear, smooth boundary.

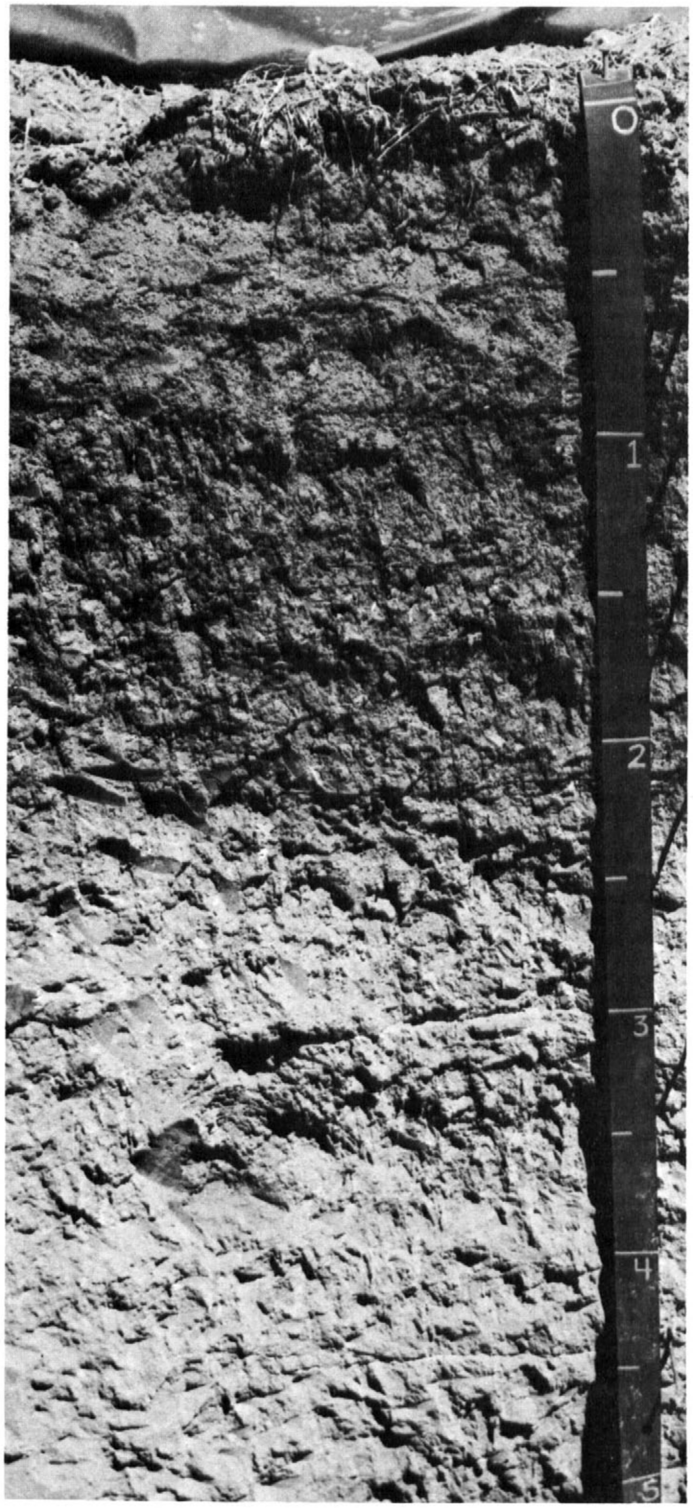

Figure 15.—**Profile of Harney silt loam, 0 to 1 percent slopes.**

B22t—19 to 30 inches, grayish-brown (10YR 5/2) light silty clay, dark grayish brown (10YR 4/2) moist; moderate, medium and fine, blocky structure; very hard, firm; shiny surfaces on peds; neutral; clear, smooth boundary.

B3ca—30 to 40 inches, light brownish-gray (10YR 6/2) heavy silty clay loam, grayish brown (10YR 5/2) moist; moderate, medium, prismatic structure breaking to moderate, medium, blocky; hard, friable; many carbonate concretions; strongly effervescent; moderately alkaline; gradual, smooth boundary.

C1ca—40 to 48 inches, light brownish-gray (10YR 6/2) light silty clay loam, grayish brown (10YR 5/2) moist; weak, coarse, prismatic structure breaking to weak, medium, blocky; slightly hard, friable; many carbonate concretions; strongly effervescent; moderately alkaline; diffuse, smooth boundary.

C2ca—48 to 59 inches, light brownish-gray (10YR 6/2) light silty clay loam, grayish brown (10YR 5/2) moist; weak, coarse, prismatic structure; slightly hard, friable; many carbonate concretions; strongly effervescent; moderately alkaline; diffuse, smooth boundary.

C3ca—59 to 74 inches, light-gray (10YR 7/2) silt loam, grayish brown (10YR 5/2) moist; massive; slightly hard, friable; thin films of lime and common carbonate concretions, weakly effervescent; moderately alkaline.

The solum ranges from 30 to 54 inches in thickness. The A1 and A3 horizons combined range from 7 to 16 inches in thickness. The A1 horizon ranges from silt loam to light silty clay loam in texture and from dark grayish brown to brown in color. The A horizon is slightly acid or neutral. The B2t horizon ranges from silty clay loam to silty clay, and the upper 20 inches is 35 to 42 percent clay. The Bt horizon ranges from neutral to moderately alkaline in reaction and from grayish brown to pale brown in color. The Cca horizon is calcareous loess in most places, but in some places, where the loess mantle is thin, contrasting material occurs below a depth of 40 inches. Depth to free carbonates ranges from 18 to 30 inches. The C horizon ranges from neutral to moderately alkaline.

Harney soils are near Carlson, Mento, Crete, Holdrege, Corinth, and Wakeen soils. They have a less clayey Bt horizon than Crete soils and are darkened to a lesser depth. They lack the highly calcareous layers below the B2t horizon of Carlson soils. They are more clayey than Armo and Wakeen soils and have a clayey B2t horizon. They have a darker A horizon than Corinth soils and are not restricted in depth by clay shale. They have a more clayey and firm B2t horizon than Holdrege soils. They are deeper and contain less sodium than Mento soils.

Harney silt loam, 0 to 1 percent slopes (Ha).—This soil is on tablelands. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of Crete, Carlson, and Wakeen soils. Also included were small depressions and eroded areas, which are shown on the soil map by a symbol.

This soil is limited mainly by droughtiness. Runoff is slow. There is a slight hazard of water erosion on long slopes and a hazard of soil blowing if the soil is left bare.

Most areas of this soil are cultivated, but a few small areas are in native grass. Wheat and sorghum are the main crops, but some alfalfa is also grown. Good management of crop residue through stubble mulching helps to control soil blowing, increase the intake of water, and improve tilth. This soil is well suited to leveling for flood irrigation. Capability unit IIc–2; Loamy Upland range site; windbreak suitability group 2.

Harney silt loam, 1 to 3 percent slopes (Hb).—This soil is on ridgetops and broad tablelands. It has a profile similar to the one described as representative for the series, but the surface layer is about 12 inches thick and the subsoil is about 27 inches thick.

Included with this soil in mapping were small areas of Carlson, Holdrege, Mento, Armo, Crete, and Wakeen soils. Also included were small areas of soils that are similar to Harney soils but are leached of carbonates to a depth of 30 to 36 inches. There are also small eroded areas, which are shown on the soil map by a symbol.

Runoff is medium. Water erosion is a hazard, and soil blowing also is a hazard if the soil is left bare.

Most areas of this soil are cultivated. Wheat and sorghum are the main crops, but a small amount of alfalfa is also grown. Terracing, constructing waterways, and contour farming help to control water erosion. Good management of crop residue through stubble mulching helps to control soil blowing, increase the intake of water, and maintain good tilth. This soil is suited to land leveling for flood irrigation. Capability unit IIe–2; Loamy Upland range site; windbreak suitability group 2.

Harney silt loam, 3 to 7 percent slopes (Hc).—This soil has convex slopes. It has a profile similar to the one described as representative for the series, but the surface layer is as much as 16 inches thick in areas of native grass where soil material washed from higher lying eroded soils has accumulated. In other areas, where this soil has been cultivated and not protected from erosion, the surface layer is as thin as 8 inches.

Included with this soil in mapping were small areas of Carlson, Armo, Campus, Eltree, and Wakeen soils. Also included were some small areas of eroded soils and rock outcrops, which are shown on the soil map by a symbol.

Runoff is medium to rapid. Water erosion is the main hazard, but soil blowing also is a hazard if the soil is left bare.

About 60 percent of the acreage of this soil is cultivated. Wheat and sorghum are the main crops. About 40 percent of the acreage of this soil is in native grass, to which it is well suited. Terracing, constructing waterways, and contour farming help to control water erosion. Good management of crop residue through the use of stubble mulching helps to control soil blowing, reduce evaporation, increase the intake of water, and maintain good tilth. Proper rate of stocking, rotation grazing, deferred grazing, and cross fencing help to maintain a good range condition. The proper placement of salt and water helps to maintain a better distribution of grazing. Capability unit IIIe–2; Loamy Upland range site; windbreak suitability group 2.

Harney silty clay loam, 2 to 5 percent slopes, eroded (Hd).—This soil is on rounded hills along drainageways and drainheads in the uplands. It has a profile similar to the one described as representative for the series, but the surface layer is 2 to 6 inches thick. Tillage has mixed the material in the surface layer with that in the subsoil. In some places all of the original surface layer has been removed by erosion, and the present surface layer consists entirely of subsoil material. Depth to calcareous material is about 4 inches less than in the representative profile. In some places the layers below the subsoil are brown or dark brown.

Included with this soil in mapping were small areas of Armo, Mento, Wakeen, and Corinth soils and small areas of Harney silt loam and Mento silty clay loam. Also included were areas of soils that are similar to this Harney soil but are calcareous between depths of 12 and 18 inches. There are also small severely eroded spots, which are shown on the soil map by a symbol.

Runoff is rapid. Water erosion is a severe hazard in cultivated areas, and soil blowing is a hazard if the soil is left bare.

About 70 percent of the acreage of this soil is cultivated. Wheat and sorghum are the main crops. About 30 percent has been reseeded to native grass or is in native grass. Terracing, constructing waterways, contour farming, and stubble mulching help to control water erosion. Good management of crop residue helps to control soil blowing, increase the intake of water, reduce evaporation, and prevent surface sealing. Planting close-grown crops rather than row crops also helps to control erosion. Crops respond well to nitrogen and phosphate. Capability unit IIIe–5; Loamy Upland range site; windbreak suitability group 2.

Harney-Armo complex, 3 to 7 percent slopes, eroded (He).—This complex is along sloping drainageways on tablelands where thin deposits of loess cover calcareous colluvium and outwash from limestone. About 45 percent of this complex is Harney soils, 45 percent is Armo soils, and 10 percent is included soils. About 40 percent of the acreage of Harney soils is moderately eroded. Some small areas of Harney soils are underlain by chalky limestone or chalky shale at a depth of 36 to 60 inches. About 55 percent of the acreage of Armo soils is moderately eroded.

Included with these soils in mapping were small areas of Wakeen, Corinth, Bogue, and Campus soils and Roxbury silt loam, frequently flooded. Also included are small severely eroded spots and rock outcrops, which are shown on the soil map by a symbol.

Runoff is rapid. Water erosion is the main hazard, but soil blowing also is a hazard if these soils are left bare.

Most areas of these soils are cultivated, but a small acreage is in native grass. Wheat and sorghum are the main crops. Terracing, constructing waterways, and contour farming help to control water erosion. Planting close-grown drilled crops rather than row crops where terraces cannot be used helps to control erosion. Good management of crop residue, such as stubble mulching, helps to control soil blowing, increase the intake of water, and maintain good tilth. Planting these areas to grass and keeping them in grass for a period of years also help to reduce water erosion and soil blowing. Both soils in capability unit IVe–4; Harney soils in Loamy Upland range site and windbreak suitability group 2; Armo soils in Limy Upland range site and windbreak suitability group 3.

Harney-Carlson silt loams, 0 to 1 percent slopes (Hf).—This complex is on uplands. Areas of this complex are 40 to 60 percent Harney soils, 25 to 40 percent

Carlson soils, and 5 to 15 percent Armo soils or Campus soils. The Harney soils have a profile similar to the one described as representative for the series, but in a few small areas they are underlain by sandy loam or are noncalcareous below a depth of 30 inches. The Carlson soils have a profile similar to the one described as representative for the series.

Included with these soils in mapping were small areas of Armo and Campus soils. Armo soils are mostly in the eastern part of the county, and Campus soils are mostly in the western part. Also included were small depressions, eroded areas, and rock outcrops, which are shown on the soil map by symbols.

Runoff is slow. These soils are limited mainly by droughtiness. Soil blowing is a hazard if these soils are left bare.

Most areas of this complex are cultivated. Wheat and sorghum are the main crops. Good management of crop residue, such as stubble mulching, helps to control soil blowing, increase water intake, and maintain good tilth. This complex is suitable for land leveling for flood irrigation if water is available. Capability unit IIc–2; Loamy Upland range site; windbreak suitability group 2.

Harney-Carlson silt loams, 1 to 3 percent slopes (Hg).—This complex is on ridgetops and tablelands. Areas of this complex are about 40 to 55 percent Harney soils, 35 to 45 percent Carlson soils, and 10 to 20 percent Armo soils or Campus soils. Harney soils have a profile similar to the one described as representative for the series, but in some small areas the surface layer is eroded and is 4 to 6 inches thinner than that of the representative profile, and in other small areas the soils have a sandy loam layer below the subsoil and are noncalcareous to a depth of more than 30 inches. A Carlson soil in this complex has the profile described as representative for the Carlson series.

Included with these soils in mapping were small depressions, eroded areas, and rock outcrops, which are shown on the soil map by symbols. Also included were small areas of Armo and Campus soils.

Runoff is medium. Water erosion is the main hazard, but soil blowing also is a hazard if these soils are left bare.

Most areas of this complex are cultivated. Wheat and sorghum are the main crops. Terracing, constructing waterways, and contour farming help to control water erosion. Good management of crop residue, such as stubble mulching, helps to control soil blowing, increase the intake of water, and maintain good tilth. This complex is suitable for land leveling and flood irrigation. Capability unit IIe–2; Loamy Upland range site; windbreak suitability group 2.

Harney-Wakeen silt loams, 0 to 1 percent slopes (Hh).—This complex is on tablelands and ridgetops. Areas of this complex are about 40 to 50 percent Harney soils, 20 to 25 percent Wakeen soils, 20 to 30 percent soils similar to Harney soils, and 10 percent other included soils. The soils that are similar to Harney soils have a higher lime content below the subsoil and have chalky limestone or calcareous shale at a depth of 3 to 5 feet.

Included with this complex in mapping were small areas of Nibson, Mento, Corinth, and Armo soils. Also included were small depressions and eroded spots, which are shown on the soil map by symbols.

Runoff is slow. Use of the major soils of this complex is limited mainly by droughtiness. Soil blowing is a hazard if these soils are left bare. The high content of lime in the Wakeen soils causes iron chlorosis and may affect the growth of sorghum.

Most areas of this complex are cultivated, but a small acreage is in native grass and is used for range. Wheat and sorghum are the main crops. Good management of crop residue, such as stubble mulching, helps to control soil blowing, increase the intake of water, and maintain good tilth. Both soils in capability unit IIc–2; Harney soils in Loamy Upland range site and windbreak suitability group 2; Wakeen soils in Limy Upland range site and windbreak suitability group 3.

Harney-Wakeen silt loams, 1 to 3 percent slopes (Hk).—The gently sloping or gently undulating soils in this complex are on ridgetops and tablelands. Areas of this complex are about 30 to 40 percent Harney soils, 25 to 35 percent Wakeen soils, 20 to 30 percent soils similar to Harney soils and 10 to 15 percent other included soils. The soils similar to Harney soils have a layer below the subsoil that is higher in content of lime, and they are underlain by bedded chalky limestone or calcareous shale at a depth of 3 to 5 feet. The Wakeen soils have a profile similar to the one described as representative for the Wakeen series, but in a few small areas the surface layer is 5 to 7 inches thick.

Included with these soils in mapping were small areas of Nibson, Mento, Corinth, and Armo soils. Also included were small depressions, eroded spots, and areas of rock outcrops, which are shown on the soil map by use of symbols.

Runoff is medium. Water erosion is the main hazard, but soil blowing also is a hazard if the soils are left bare. The high content of lime in Wakeen soils causes iron chlorosis and may affect the growth of sorghum.

Most areas of this complex are cultivated, but some areas are in native grass and are used for range. Wheat and sorghum are the main crops. Terracing, constructing waterways, and contour farming help to control water erosion. Good management of crop residue, such as stubble mulching, helps to control soil blowing, increase the intake of water, and maintain good tilth. Both soils in capability unit IIe–2; Harney soils in Loamy Upland range site and windbreak suitability group 2; Wakeen soils in Limy Upland range site and windbreak suitability group 3.

Heizer Series

The Heizer series consists of shallow, well-drained soils that formed in material weathered from chalky limestone. These soils are strongly sloping to moderately steep and are on uplands.

In a representative profile the surface layer is dark-gray gravelly loam about 6 inches thick. The next layer is gray, friable channery loam about 3 inches thick. The underlying material is 5 inches of light brownish-gray channery loam that overlies chalky limestone bedrock.

Permeability is moderate, and available water capacity is very low. The soils are well suited to the native grasses grown in the county. Nearly all of the acreage of these soils is in native grass and is used for range.

Representative profile of Heizer gravelly loam in an area of Heizer-Armo complex, in native grass, 900 feet east and 250 feet north of the southwest corner of sec. 32, T. 11 S., R. 17 W.:

A1—0 to 6 inches, dark-gray (10YR 4/1) gravelly loam; very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; slightly hard, friable; many fine and medium roots; porous; strongly effervescent; mildly alkaline; clear, smooth boundary.

AC—6 to 9 inches, gray (10YR 5/1) channery loam, dark grayish brown (10YR 4/2) moist; moderate, fine, granular structure; slightly hard, friable; common fine and medium roots; violently effervescent; moderately alkaline; clear, smooth boundary.

C—9 to 14 inches, light brownish-gray (10YR 6/2) channery loam, grayish brown (10YR 5/2) moist; weak, fine, granular structure; slightly hard, friable; few fine roots; common to many fragments of limestone 1 to 6 inches long; violently effervescent; moderately alkaline; abrupt, smooth boundary.

R—14 to 30 inches, white (10YR 8/2) chalky limestone that has a few vertical cracks.

The A1 horizon ranges from 6 to 10 inches in thickness and from dark gray to grayish brown in color. It ranges from loam to gravelly loam in texture. The AC horizon ranges from gray to light brownish gray in color and from gravelly loam to channery loam in texture. The C horizon ranges from light brownish gray to light gray in color and from gravelly loam to channery loam in texture.

Heizer soils are associated with Brownell, Armo, and Bogue soils. They have bedrock at a lesser depth than Brownell, Armo, and Bogue soils. They contain more gravel and channery fragments and less clay than Armo and Bogue soils.

Heizer-Armo complex (8 to 25 percent slopes) (Hl).—This complex is on uplands. Areas are incised by downcutting drains. About 35 to 45 percent is Heizer soils, 20 to 30 percent is Armo soils, 5 to 15 percent is barren geologic material, and 15 to 25 percent is included soils. The Armo soil has a profile similar to the one described as representative for the Armo series, but the surface layer is 8 to 10 inches thinner in a few small areas.

Included with these soils in mapping were small areas of Brownell and Bogue soils and Roxbury silt loam, frequently flooded.

Runoff is rapid. Water erosion and soil blowing are hazards if the range is overgrazed.

This complex is not suited to cultivation, but it is suited to native grass. Most of the complex is in native grass and is used for range. Good range management practices include proper rate of stocking, deferred grazing, rotation grazing, cross fencing, and proper placement of salt and water. Both soils in capability unit VIIs–2; Heizer soil in Shallow Limy range site and windbreak suitability group 4; Armo soil in Limy Upland range site and windbreak suitability group 3.

Hilly Land

Hilly land (Hn) consists of loamy, well-drained soils along the valley sides of the Saline and Smoky Hill Rivers and at the mouths of tributaries. The soils have a surface layer of dark grayish-brown sandy loam to silt loam; a subsoil of grayish-brown sand to clay loam; and underlying material of sandy loam, loamy sand, or sand (fig. 16). Slopes are 5 to 20 percent.

Figure 16.—**Roadside cut in Hilly land. Material below the sand is clay shale.**

The soils are calcareous throughout where slopes are convex and noncalcareous to a depth of 20 inches where slopes are concave around small drains and drainheads. Hilly land contains numerous pockets and bands of sand and gravel. Many of these are excavated for sand and gravel.

Included in mapping were small areas of rock outcrop, which are shown on the soil map by a symbol.

Runoff is medium. Soil blowing is a major hazard if the range is overgrazed, and water erosion also is a hazard.

Most of this land type is in range, to which it is well suited. Good range management includes proper rate of stocking, deferred grazing, rotation grazing, cross fencing, and proper placement of salt and water. Capability unit VIe–1; Limy Upland range site; windbreak suitability group 3.

Holdrege Series

The Holdrege series consists of deep, well-drained soils that formed in calcareous silty loess. These soils are nearly level to gently sloping and are on loess-covered valley sides.

In a representative profile the surface layer is dark grayish-brown silt loam about 10 inches thick. The subsoil is 20 inches thick. The upper 4 inches is dark grayish-brown, firm light silty clay loam; the next 11 inches is grayish-brown, firm silty clay loam; and the lower 5 inches is light brownish-gray, friable silt loam. The upper 9 inches of the underlying material is pale-brown silt loam, and the lower 24 inches is brown silty clay loam.

Permeability is moderate, and available water capacity is high. Most areas of these soils are cultivated, but a few small areas are in native grass.

Representative profile of Holdrege silt loam, 0 to 1 percent slopes, in a cultivated field, 2,540 feet north and 1,400 feet west of the southeast corner of sec. 17, T. 11 S., R. 19 W.:

A1—0 to 10 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; upper 3 inches has weak, fine, platy structure, below has moderate, fine, granular structure; slightly hard, friable; few fine roots; few open pores; neutral; clear, smooth boundary.

B1—10 to 14 inches, dark grayish-brown (10YR 4/2) light silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, subangular blocky structure; hard, firm; few fine roots; few open pores; common nests of worm casts; neutral; clear, smooth boundary.

B2t—14 to 25 inches, grayish-brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) moist; moderate, fine, subangular blocky structure; hard, firm; few fine roots; few open pores; few nests of worm casts; neutral; clear, smooth boundary.

B3ca—25 to 30 inches, light brownish-gray (10YR 6/2) silt loam, grayish brown (10YR 5/2) moist weak, medium, subangular blocky structure; hard, friable; many open pores; common semihard concretions and spots of segregated lime; weakly effervescent mildly alkaline; gradual, smooth boundary.

C1—30 to 39 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) moist; weak, medium, subangular blocky structure; slightly hard, friable; many open pores; many spots and threads of segregated lime; strongly effervescent; moderately alkaline; gradual, smooth boundary.

C2—39 to 63 inches, brown (10YR 5/3) silty clay loam, dark-brown (10YR 4/3) moist; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable; many open pores; strongly effervescent; moderately alkaline.

The A horizon ranges from dark grayish brown to very dark grayish brown in color and from fine sandy loam to silt loam in texture. The B horizon ranges from dark grayish brown to very pale brown in color. The B2t horizon ranges from light to medium silty clay loam. Depth to carbonates ranges from 25 to 40 inches.

Holdrege soils are near Eltree, Harney, and Anselmo soils. They have a less clayey B2t horizon than Harney soils. They are more clayey than Eltree and Anselmo soils and have a B2t horizon that those soils lack.

Holdrege silt loam, 0 to 1 percent slopes (Ho).—This soil is on old, high alluvial terraces that are covered by silty loess. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of Harney, Eltree, and Armo soils. Also included are areas of soils that are similar to this Holdrege soil but become calcareous at a depth of 12 to 20 inches. Small eroded spots are shown on the soil map by a symbol.

Runoff is slow. The soil has little if any limitation to use except for the lack of moisture, but it is subject to soil blowing if it is left bare.

Most areas of this soil are cultivated. Wheat and sorghum are the main crops, but some alfalfa also is grown. Good management of crop residue, such as stubble mulching, helps to control soil blowing, increase the intake of water, and maintain good tilth. This soil is suitable for irrigation by sprinkler or flooding if water is available. Capability unit IIc–1; Loamy Upland range site; windbreak suitability group 2.

Holdrege silt loam, 1 to 3 percent slopes (Hp).—This soil is on loess–covered valley sides.

Included with this soil in mapping were small areas of Eltree, Harney, Armo, Anselmo, and Wakeen soils. Also included are small areas of soils similar to Holdrege soils but become calcareous at a depth of 15 to 20 inches.

Runoff is medium. Water erosion is the main hazard, but soil blowing also is a hazard if the soil is left bare.

Most areas of these soils are cultivated, but a few small areas are in native grass. Wheat and sorghum are the main crops. Use of terraces, waterways, and contour farming helps to control water erosion. Good management of crop residue, such as stubble mulching, helps to control soil blowing, increase the intake of water, and maintain good tilth. This soil is suitable for irrigation by sprinkler or flooding if water is available. Capability unit IIe–1; Loamy Upland range site; windbreak suitability group 2.

Hord Series

The Hord series consists of deep, well-drained soils that formed in calcareous silty alluvium. These soils are nearly level to gently undulating and occur on terraces along the major streams in the county.

In a representative profile the surface layer is 18 inches thick. The upper part is very dark grayish-brown silt loam about 12 inches thick, and the lower part is very dark grayish-brown heavy silt loam about 6 inches thick. The subsoil is 25 inches thick. The upper part is dark grayish-brown, friable light silty clay loam about 10 inches thick; and the lower part is light brownish-gray, calcareous, friable light silty clay loam about 15 inches thick. The underlying material is pale-brown, calcareous heavy silt loam.

Permeability is moderate, and available water capacity is high. Most areas of these soils are cultivated, but a small area is in native grass.

Representative profile of Hord silt loam, in native grass, 1,340 feet west and 2,440 feet south of the northeast corner of sec. 14, T. 14 S., R. 18 W.:

A11—0 to 12 inches, very dark grayish-brown (10YR 3/2) silt loam, very dark brown (10YR 2/2) moist; moderate, fine, granular structure; slightly hard, friable; common fine and medium roots; few fine pores; few nests of worm casts; mildly alkaline; clear, smooth boundary.

A12—12 to 18 inches, very dark grayish-brown (10YR 3/2) heavy silt loam, very dark brown (10YR 2/2) moist; moderate, fine, subangular blocky structure; slightly hard, friable; common fine and medium roots; common fine and medium pores; mildly alkaline; gradual, smooth boundary.

B2—18 to 28 inches, dark grayish-brown (10YR 4/2) light silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, fine and medium, subangular blocky structure; slightly hard, friable; few fine and medium roots; common fine and medium pores; mildly alkaline; gradual, smooth boundary.

B3ca—28 to 43 inches, light brownish-gray (10YR 6/2) light silty clay loam, dark grayish brown (10YR 4/2) moist; weak, fine and medium, subangular blocky structure; slightly hard, friable; few fine roots; common fine and medium pores; common fine threads of segregated lime; strongly effervescent moderately alkaline; diffuse, smooth boundary.

C—43 to 65 inches, pale-brown (10YR 6/3) heavy silt loam, dark grayish brown (10YR 4/2) moist; weak, coarse, prismatic structure; slightly hard, friable; few fine roots; common fine and medium pores; coatings of lime on ped faces; strongly effervescent; moderately alkaline.

The solum ranges from 35 to 55 inches in thickness. It is dark grayish brown or darker to a depth of 20 to 30 inches. The A and B horizons range from loam to light silty clay loam. Carbonates occur in the lower part of the B horizon in a few places.

Hord soils are near Roxbury, McCook, Eltree, and Detroit soils. They are leached of carbonates to a greater depth than Roxbury, McCook, or Eltree soils. They contain less clay than Detroit soils and more clay than McCook soils.

Hord silt loam (0 to 2 percent slopes) (Hr).—This nearly level and gently undulating soil is on smooth alluvial terraces along the major streams in the county.

Included with this soil in mapping were small areas of McCook, Roxbury, Detroit, and Eltree soils. Also included were small depressions, which are shown on the soil map by a symbol.

Runoff is slow. This soil has no limitations to use.

Most areas of this soil are cultivated, but a few areas are in native grass. Wheat and sorghum are the main crops, but some alfalfa also is grown. This soil is among the best soils in the county for crops. Good management of crop residue, such as stubble mulching, helps to increase the intake of water and maintain good tilth. This soil is among the best soils in the county for irrigation. Land leveling and flood irrigation or sprinkler irrigation are suitable methods of irrigation if water is available. Capability unit I–1; Loamy Terrace range site; windbreak suitabililty group 1.

Inavale Series

The Inavale series consists of deep, well-drained soils that formed in coarse-textured alluvium. These nearly level to strongly sloping soils are on flood plains and on foot slopes of terraces.

In a representative profile the surface layer is grayish-brown loamy sand about 9 inches thick. The next layer is soft, grayish-brown loamy sand about 5 inches thick. The upper part of the underlying material is light brownish-gray sand about 17 inches thick; the next 8 inches is light brownish-gray loamy sand; and the lower part is light brownish-gray loamy sand stratified with thin layers of medium sand and coarse silt loam less than 3 inches thick.

Permeability is rapid, and available water capacity is low. Most areas of these soils are in native grass and are used for range. Some areas are still cultivated, but the hazard of soil blowing is severe in these areas.

Representative profile of Inavale loamy sand, in native grass, 550 feet east and 300 feet south of the northwest corner of sec. 15, T. 11 S., R. 18 W.:

A1—0 to 9 inches, grayish-brown (10YR 5/2) loamy sand, dark grayish brown (10YR 4/2) moist; single grained; soft, very friable; many fine and medium roots; mildly alkaline; clear, smooth boundary.

AC—9 to 14 inches, grayish-brown (10YR 5/2) loamy sand, dark grayish brown (10YR 4/2) moist; single grained; soft, loose; few fine roots; weakly effervescent; moderately alkaline; gradual, smooth boundary.

C1—14 to 31 inches, light brownish-gray (10YR 6/2) sand, brown (10YR 5/3) moist; single grained; loose; few fine roots; strongly effervescent; gradual, smooth boundary.

C2—31 to 39 inches, light brownish-gray (10YR 6/2) loamy sand, dark grayish brown (10YR 4/2) moist; single grained; soft, loose; few fine roots; strongly effervescent; moderately alkaline; gradual, smooth boundary.

C3—39 to 63 inches, light brownish-gray (10YR 6/2) loamy sand, brown (10YR 5/3) moist; single grained, stratified with medium sand and thin layers of coarse silt loam less than 3 inches thick; few fine roots; strongly effervescent; moderately alkaline.

The solum ranges from 10 to 30 inches in thickness. The A horizon ranges from slightly acid to moderately alkaline in reaction and from dark grayish brown to very pale brown in color. It is typically loamy sand but ranges from silt loam to sand. The AC and C horizons range from grayish brown to very pale brown in color.

Inavale soils are near Munjor and McCook soils. They are coarser textured than Munjor or McCook soils. Their A horizon is not so dark as that of McCook soils.

Inavale loamy sand (0 to 10 percent slopes) (In).—This soil is on flood plains and on foot slopes of terraces.

Included with this soil in mapping were small areas of Munjor, McCook, and Boel soils. Also included are small areas of soils that are coarser textured than this Inavale soil.

Runoff is slow. Soil blowing is the main hazard. Overgrazing causes soil blowing.

Most areas of this soil are in native grass and are used for range. A few small areas are cultivated. Good range management includes proper rate of stocking, deferred grazing, rotation grazing, cross fencing, and proper placement of salt and water. Capability unit VIe–4; Sands range site; windbreak suitability group 1.

McCook Series

The McCook series consists of deep, well-drained soils that formed in calcareous, medium-textured alluvium. These soils are nearly level to gently undulating and are on low terraces.

In a representative profile the surface layer is grayish-brown light silt loam about 10 inches thick. The next layer is grayish-brown, very friable light silt loam about 6 inches thick. The underlying material is light-gray coarse silt loam that is thinly stratified with fine sandy loam and very fine sandy loam.

Permeability and available water capacity are moderate. Most areas of these soils are cultivated.

Representative profile of McCook silt loam, in a cultivated field, 800 feet north and 500 feet east of the southwest corner of sec. 26, T. 11 S., R. 16 W.:

A1—0 to 10 inches, grayish-brown (10YR 5/2) light silt loam, very dark grayish brown (10YR 3/2) moist; upper 6 inches disturbed by cultivation, lower 4 inches weak, fine, granular structure; slightly hard, very friable; many fine and medium roots; very porous; many worm casts; slightly effervescent; mildly alkaline; gradual, smooth boundary.

AC—10 to 16 inches, grayish-brown (10YR 5/2) light silt loam, very dark grayish brown (10YR 3/2) moist; weak to moderate, fine, granular structure; slightly hard, very friable; few fine roots; very porous; many worm casts; strongly effervescent; moderately alkaline; gradual, smooth boundary.

C1—16 to 36 inches, light-gray (10YR 7/2) coarse silt loam, thinly stratified with very fine sandy loam, grayish brown (10YR 5/2) moist; weak, coarse, prismatic structure parting to weak, fine, granular; slightly hard, very friable; few fine roots; a few large pores and many medium and fine pores; strongly effervescent; moderately alkaline; gradual, smooth boundary.

C2—36 to 72 inches, light-gray (10YR 7/2) coarse silt loam thinly stratified with very fine sandy loam, grayish brown (10YR 5/2) moist; weak, coarse, prismatic structure parting to weak, fine, granular; slightly hard, very friable; few fine roots; very porous; strongly effervescent; moderately alkaline.

The A1 horizon ranges from fine sandy loam to silt loam in texture and from dark grayish brown to brown in color. The AC horizon is stratified with thin layers of loam, silt loam, very fine sandy loam, or fine sandy loam in a few places. Depth to free carbonates ranges from 0 to 10 inches.

McCook soils are near Roxbury, Hord, Detroit, Munjor, Wann, and Inavale soils. They are less clayey than Roxbury, Hord, and Detroit soils. Their dark A horizon is thinner than that of Hord soils. They lack the B2t horizon present in Detroit soils. They are more silty and are deeper to sand than Munjor and Inavale soils. They are less sandy than Wann soils and lack a water table.

McCook fine sandy loam (0 to 2 percent slopes) (Mc).—This nearly level and gently undulating soil is on low terraces and high bottom lands. This soil has a profile similar to the one described as representative for the series, but the surface layer is about 14 inches thick.

Included with this soil in mapping were small areas of McCook silt loam and Munjor and Inavale soils. Also included were areas of soils similar to McCook silt loam, except that the surface layer is loamy sand 10 to 20 inches thick or sandy loam 18 to 24 inches thick. Small sand spots are shown on the soil map by a symbol.

Runoff is slow. Soil blowing is the main hazard.

Most areas of these soils are in wheat and sorghum, but some alfalfa is also grown. A few small areas are in native grass. Stubble mulching and stripcropping help to control soil blowing. Stubble mulching also helps to increase the infiltration rate of water, control evaporation, and improve tilth. Some areas of this soil are irrigated. Capability unit IIe–3; Sandy Terrace range site; windbreak suitability group 1.

McCook silt loam (0 to 2 percent slopes) (Md).—This nearly level and gently undulating soil is on low terraces and high bottom lands along the major streams. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of Roxbury silt loam, McCook fine sandy loam, and Munjor soils. Also included were a few small depressions and sand spots, which are shown on the soil map by a symbol.

Runoff is slow. Nothing limits the use of this soil.

Most areas of these soils are in wheat, sorghum, and alfalfa. Much of the alfalfa is irrigated. Stubble mulching helps to improve soil structure and tilth and reduce evaporation. Capability unit I–1; Loamy Terrace range site; windbreak suitability group 1.

Mento Series

The Mento series consists of deep, well-drained soils that formed in thin loess deposited over chalky limestone. Some mixing of loess and material from the chalky limestone occurred at the time of the loess deposition. These nearly level to sloping soils are on ridgetops, along drainageways, and on narrow tablelands.

Figure 17.—**Profile of Mento silt loam, 0 to 1 percent slopes.**

In a representative profile the surface layer is dark grayish-brown silt loam about 9 inches thick. The subsoil is about 22 inches thick. The upper part is grayish-brown, very firm heavy silty clay loam about 6 inches thick; the middle part is grayish-brown, firm heavy silty clay loam about 6 inches thick; and the lower part is pale-brown, firm, calcareous silty clay loam about 10 inches thick. The underlying material is about 36 inches thick. The upper part is pale-brown, calcareous light silty clay loam about 10 inches thick; and the lower 26 inches is white, calcareous clay loam that has many fragments of chalk or limestone that are sand and gravel size. Bedrock is chalky limestone (fig. 17).

Permeability is slow, and available water capacity is high. Most areas of the nearly level to gently sloping soils are cultivated. About 65 percent of the acreage of the sloping soils is cultivated, and the rest is in native grass and is used for range.

Representative profile of Mento silt loam, 0 to 1 percent slopes, in a cultivated field, 200 feet east and 600 feet north of the southwest corner of sec. 16, T. 13 S., R. 20 W.:

Ap—0 to 9 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) moist; weak, medium, platy structure parting to weak, fine, granular; slightly hard, friable; few fine roots; neutral; abrupt, smooth boundary.

B21t—9 to 15 inches, grayish-brown (10YR 5/2) heavy silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, prismatic structure parting to moderate, medium, blocky; very hard, very firm; few fine roots; mildly alkaline; gradual, smooth boundary.

B22t—15 to 21 inches, grayish-brown (10YR 5/2) heavy silty clay loam, dark grayish brown (10YR 4/2) moist; moderate, medium, blocky structure; hard, firm; few fine roots; many, soft, medium-sized carbonate concretions; calcareous, strongly effervescent; moderately alkaline; gradual, smooth boundary.

B3ca—21 to 31 inches, pale-brown (10YR 6/3) silty clay loam, brown (10YR 4/3) moist; weak, medium, subangular blocky structure; hard, firm; few very fine roots; few coarse root channels filled with darker colored soil material; soft carbonate concretions common but fewer and smaller than in B22t horizon; calcareous, strongly effervescent; moderately alkaline; gradual, smooth boundary.

C1ca—31 to 41 inches, pale-brown (10YR 6/3) light silty clay loam, brown (10YR 5/3) moist; massive; hard, friable; calcareous, violently effervescent; moderately alkaline; gradual, wavy boundary.

IIC2—41 to 67 inches, white (10YR 8/2) clay loam, light gray (10YR 7/2) moist; massive; porous; hard, friable; gravelly clay loam in lower 8 inches; sand and gravel-size coarse fragments mostly chalk or limestone; calcareous; violently effervescent; moderately alkaline; abrupt, smooth boundary.

IIR—67 to 80 inches, level bedded, chalk; few joints.

The Ap horizon ranges from 5 to 10 inches in thickness. The A horizon ranges from dark grayish brown to brown. The ped faces in the lower 1 to 3 inches of the A horizon generally have gray silt coatings. The B2t horizon ranges from grayish brown to pale brown in color and from silty clay loam to light silty clay in texture. The B2t horizon ranges from 7 to 17 inches in thickness. The B3ca horizon ranges from grayish brown to very pale brown. The B horizon contains from 5 to 15 percent exchangeable sodium. The Cca horizon ranges from brown to pale brown, and the IIC horizon ranges from white to very pale brown. The C horizon contains 10 to 25 percent exchangeable sodium. The depth to chalky limestone bedrock is typically 50 to 60 inches but ranges from 40 to 70 inches. The depth to free carbonates in the form of threads, films, or soft masses ranges from 10 to 20 inches.

Mento soils are near Harney, Wakeen, Brownell, and Carlson soils. They have textures similar to those of Harney and Carlson soils but contain 5 to 15 percent exchangeable sodium in the B horizon and have bedrock at a depth of 40 to 70 inches. They are calcareous at a lesser depth than Harney soils. They are leached of carbonates to a greater depth, are more clayey, and are deeper to bedrock than Wakeen or Brownell soils.

Mento silt loam, 0 to 1 percent slopes (Me).—This soil is on narrow tablelands and smooth ridgetops. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of Harney, Wakeen, Brownell, and Carlson soils and areas of eroded Harney soils. Also included were areas of soils similar to this Mento soil, except that bedrock is at a depth of less than 40 inches. A few small depressions were mapped with this soil. Small areas of rock outcrops are shown on the soil map by a symbol.

Runoff is slow to medium. Slow permeability reduces the intake of water and causes the soil to be droughty. The soil blows if it is left bare.

Most of the acreage of this soil is cultivated. Wheat and sorghum are the main crops. A small acreage is in grass. Good management of crop residue, such as stubble mulching, helps to control soil blowing, increase the intake of water, and maintain good tilth. Capability unit IIs–2; Clay Upland range site; windbreak suitability group 2.

Mento silt loam, 1 to 3 percent slopes (Mf).—This soil is on ridgetops and tablelands. It has a profile similar to the one described as representative for the series, but chalk is at a depth of 50 to 60 inches.

Included with this soil in mapping were small areas of Harney, Wakeen, and Brownell soils and areas of soils similar to Harney soils except that the layers below the subsoil contain more carbonates than Harney soils and bedrock is at a depth of 36 to 60 inches. Also included are small areas of soils similar to Mento soils except that bedrock is at a depth of 20 to 40 inches. Small eroded areas and rock outcrops are shown on the soil map by symbols.

Water erosion is the main hazard, but soil blowing also is a hazard if the soil is left bare. Runoff is medium.

Most areas of this soil are cultivated, but a few small areas are in native grass and are used for range. Wheat and sorghum are the main crops. Terraces, waterways, and contour farming help to control water erosion. Good management of crop residue, such as stubble mulching, helps to control soil blowing, increase the intake of water, and maintain good tilth. Capability unit IIIe–4; Clay Upland range site; windbreak suitability group 2.

Mento silty clay loam, 1 to 3 percent slopes, eroded (Mg).—This soil is on ridgetops, on side slopes, and along narrow, shallow drainageways in the uplands. It is moderately eroded. The surface layer has been eroded to the extent that ordinary tillage mixes the remains of the surface layer with part of the subsoil. As a result, the surface layer is finer textured than that in the profile described as representative for the series. In some places rills and small gullies have formed.

Included with this soil in mapping were small areas of Harney, Wakeen, Brownell, and Carlson soils. Also included were small areas of soils similar to Mento soils except that bedrock is at a depth of 20 to 40 inches. Also included were small areas of rock outcrops, which are shown on the soil map by a symbol.

Water erosion is the main hazard, but soil blowing also is a hazard if the soil is left bare.

Most areas of this soil are cultivated, but some areas have been reseeded to native grass and are used for range. Wheat and sorghum are the main crops. Planting close-grown crops such as drilled sorghums and small grains helps to control erosion. Terraces, waterways, and contour farming help to control water erosion. Good management of crop residue, such as stubble mulching, helps to control soil blowing, increase the intake of water, and improve tilth. Plants respond well to nitrogen and phosphate fertilizers. Capability unit IIIe–7; Clay Upland range site; windbreak suitability group 2.

Mento soils, 3 to 7 percent slopes, eroded (Mo).—This moderately eroded soil is mostly on sides of drainageways, but it is also on sides of narrow ridgetops. About 40 percent of the acreage of this soil has a surface layer 5 to 9 inches thinner than that in the profile described as representative for the series. This surface layer has been eroded to such an extent that ordinary tillage mixes the remains of the surface layer with part of the subsoil, which gives the surface layer a silty clay loam texture.

Included with this soil in mapping were small areas of Wakeen, Brownell, and Heizer soils; Roxbury silt loam, frequently flooded; and Harney silty clay loam. Also included were areas of soils similar to Mento soils, except that bedrock is at a depth of 20 to 40 inches; and areas of Mento soils that have been so eroded that the original surface layer and most of the subsoil have been removed and the present surface layer and the underlying material are calcareous silty clay loam; and severely eroded spots and rock outcrops, which are shown on the soil map by symbols.

Runoff is rapid. Water erosion is the main hazard, but soil blowing also is a hazard if the soil is left bare.

About 65 percent of the acreage of this soil is cultivated. Wheat and sorghum are the main crops. The remaining 35 percent of the acreage has been reseeded to native grass and is used for range. Close-growing crops, such as wheat and drilled sorghum, provide more residue and better cover to help to control water erosion and soil blowing than do other crops. Terraces, waterways, and contour farming help to control water erosion. Good management of crop residue, such as stubble mulching, helps to control soil blowing and water erosion, increase the intake of water, and improve tilth. Proper rate of stocking, rotation grazing, deferred grazing, cross fencing, and proper placement of salt and water help to attain a good range condition. Capability unit IVe–1; Clay Upland range site; windbreak suitability group 2.

Munjor Series

The Munjor series consists of deep, well-drained soils that formed in moderately sandy, calcareous alluvium. These nearly level to gently undulating soils are on flood plains along the major streams in the county.

In a representative profile the surface layer is grayish-brown sandy loam about 7 inches thick. The upper part of the underlying material is light brownish-gray, very friable sandy loam, about 37 inches thick, that is stratified with thin layers of finer textured and coarser textured materials; and the lower part is pale-brown medium sand.

Permeability is moderately rapid, and available water capacity is moderate. Most of the acreage of these soils is cultivated, but some is in native grass and is used for range.

Representative profile of Munjor sandy loam, in native grass, 2,300 feet west and 1,200 feet north of southeast corner of sec. 29, T. 15 S., R. 16 W.:

A1—0 to 7 inches, grayish-brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) moist; weak, medium, granular structure; soft, very friable; few fine and medium roots; calcareous, strongly effervescent; mildly alkaline; gradual, smooth boundary.

C1—7 to 44 inches, light brownish-gray (10YR 6/2) sandy loam, grayish brown (10YR 5/2) moist; weak, medium, granular structure in the upper part, massive below; soft, very friable; thin, stratified layers of fine-textured and coarse-textured materials throughout the horizon; calcareous, strongly effervescent; moderately alkaline; gradual, smooth boundary.

IIC2—44 to 60 inches, pale-brown (10YR 6/3) medium sand; brown (10YR 5/3) moist; single grained; loose; calcareous, strongly effervescent; moderately alkaline.

The solum ranges from 3 to 15 inches in thickness. Depth to coarse-textured strata ranges from 28 to 50 inches. Depth to free carbonates is less than 10 inches. The A horizon ranges from grayish brown to very pale brown in color and is typically sandy loam and less commonly loamy sand or loam in texture. The C horizon ranges from grayish brown to pale brown. Texture ranges from loamy sand to heavy silt loam in thin strata and averages sandy loam. The IIC horizon is pale-brown, light-gray, or very pale brown loamy sand or medium sand. In some places faint mottles are below a depth of 20 inches and distinct mottles below a depth of 30 inches.

Munjor soils are near Inavale, McCook, and Roxbury soils. They are near Inavale soils on flood plains, but they are less sandy to a depth of 28 to 50 inches than Inavale soils. They are below McCook and Roxbury soils, but they have a sandier texture and a less dark colored surface layer than those soils.

Munjor sandy loam (0 to 2 percent slopes) (Mu).—This soil is on flood plains along major streams and on a few low terraces. It is nearly level to gently undulating.

Included with this soil in mapping were small areas of Inavale, McCook, and Roxbury soils. Also included were small areas of soils similar to this soil, except that the surface layer is dark grayish brown or darker and is 10 to 12 inches thick.

Frequent flooding and soil blowing are the main hazards. Flooding can damage or destroy wheat or sorghum either by inundation or by silting.

Most of the acreage of this soil is cultivated, but some is in native grass and is used for range. Wheat and sorghum are the main crops. Good management of crop residue, such as stubble mulching, helps to control soil blowing, reduce evaporation, and maintain good tilth. This soil is suitable for irrigation, mostly by sprinklers. The hazard of flooding must be eliminated before the soil is suitable for gravity systems. Capability unit IIIw–2; Sandy Lowland range site; windbreak suitability group 1.

New Cambria Series

The New Cambria series consists of deep, moderately well drained soils that formed in clayey, calcareous alluvium. These soils are nearly level to gently sloping and are on terraces along the major streams.

In a representative profile the surface layer is dark-gray heavy silty clay about 9 inches thick. The subsoil is grayish-brown, very firm silty clay about 29 inches thick. The underlying material is light brownish-gray heavy silty clay loam to a depth of about 46 inches. Below a depth of 46 inches is dark grayish-brown light silty clay loam.

Permeability is slow, and available water capacity is high. Most areas of these soils are cultivated, but a few small areas are in native grass and are used for range.

Representative profile of New Cambria silty clay, in a cultivated field, 1,640 feet north and 600 feet west of the southeast corner of sec. 14, T. 11 S., R. 17 W.:

A1—0 to 9 inches, dark-gray (10YR 4/1) heavy silty clay, very dark brown (10YR 2/2) moist; moderate, fine, subangular blocky structure; upper 3 inches disturbed by cultivation; very hard, very firm; few fine roots; few, fine, open pores; a few limestone fragments, minute to ¼ inch in size; mildly alkaline; clear, smooth boundary.

B21—9 to 25 inches, grayish-brown (2.5Y 5/2) silty clay, very dark grayish brown (2.5Y 3/2) moist; moderate, medium, subangular blocky structure; very hard, very firm; few fine roots; many open pores; a few limestone fragments, minute to ¼ inch in size; strongly effervescent; moderately alkaline; diffuse, smooth boundary.

B22—25 to 38 inches, grayish-brown (10YR 5/2) silty clay, very dark grayish brown (10YR 3/2) moist; weak to moderate; medium, subangular blocky structure; very hard, very firm; few fine roots; many, fine, open pores; few limestone fragments, minute to ¼ inch in size; strongly effervescent; moderately alkaline; diffuse, smooth boundary.

C—38 to 46 inches, light brownish-gray (10YR 6/2) heavy silty clay loam, dark grayish brown (10YR 4/2) moist; weak, medium, subangular blocky structure; hard, firm; few fine roots; few open pores; lower 3 inches of horizon contains enough limestone fragments to make the texture gravelly clay loam; strongly effervescent; moderately alkaline; clear, smooth boundary.

A1b—46 to 60 inches, dark grayish-brown (10YR 4/2) light silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, subangular blocky structure; hard, firm; few very fine roots; common threads of segregated lime and gypsum; several pores; strongly effervescent; moderately alkaline.

The solum is typically 28 to 36 inches thick but ranges from 25 to 45 inches in thickness. Depth to calcareous matrix is typically less than 10 inches but ranges from 0 to 15 inches. The A1 horizon ranges from very dark gray to grayish brown in color and from silty clay loam to clay in texture. The B horizon ranges from very dark gray to grayish brown. The C horizon ranges from dark gray to pale brown in color and is silty clay loam or silty clay.

New Cambria soils are near Bogue, Detroit, and Corinth soils and Alluvial land, clayey. They are on higher terraces and have a more clayey A horizon than Detroit soils, and they lack the B2t horizon of these soils. They do not flood so frequently as Alluvial land, clayey, and lack the stratification of Alluvial land, clayey. They are deeper than Bogue and Corinth soils and are not limited by clayey bedrock.

New Cambria silty clay (0 to 2 percent slopes) (Nc).—This soil is on smooth terraces of the stream valley. The terraces are interrupted in places by small, narrow drainageways that head in the uplands above or on these terraces.

Included with this soil in mapping were small areas of Bogue and Corinth soils and Alluvial land, clayey. Also included were areas of soils similar to New Cambria soils but noncalcareous to a depth of 15 to 25 inches. There are also small wet areas, which are shown on the soil map by a symbol.

This soil absorbs water slowly and gives it up slowly, causing it to be droughty. Runoff is slow to medium. Water erosion is the main hazard, but soil blowing also is a hazard if the soil is left bare.

Most areas of this soil are cultivated, but a few small areas are in native grass and are used for range. Terraces, waterways, and contour farming help to control water erosion. Good management of crop residue, such as stubble mulching, helps to control soil blowing, increase the intake of water, and maintain good tilth. Capability unit IIs–2; Clay Terrace range site; windbreak suitability group 1.

Nibson Series

The Nibson series consists of shallow, somewhat excessively drained soils that formed in material weathered from interbedded chalky shale and chalky limestone. These soils are sloping to strongly sloping and are on erosional uplands.

In a representative profile the surface layer is dark grayish-brown heavy silt loam about 7 inches thick. The subsoil is 7 inches thick. The upper 3 inches is grayish-brown, friable silty clay loam; and the lower 4 inches is light yellowish-brown, friable silty clay loam.

The underlying material is 5 inches of pale-yellow, weathered shale and limestone of silty clay loam texture. Bedrock is pale-yellow shale and limestone. Nibson soils are calcareous.

Permeability is moderate, and available water capacity is very low. Nearly all of the acreage of these soils is in native grass and is used for range, to which it is well suited.

Representative profile of Nibson silt loam, 5 to 12 percent slopes, in native grass, 200 feet west and 50 feet north of the southeast corner of sec. 11, T. 15 S., R. 17 W.:

A1—0 to 7 inches, dark grayish-brown (10YR 4/2) heavy silt loam, very dark grayish brown (10YR 3/2) moist; strong, fine, granular structure; slightly hard, friable; many fine to coarse roots; many worm casts; many scattered ¼- to ½-inch limestone fragments; calcareous, violently effervescent; mildly alkaline; clear, smooth boundary.

B21—7 to 10 inches, grayish-brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; moderate, fine, granular structure; slightly hard, friable; many fine and medium roots; many worm casts; many limestone fragments ¼ to ½ inch in size; calcareous, violently effervescent; moderately alkaline; gradual, smooth boundary.

B22—10 to 14 inches, light yellowish-brown (2.5Y 6/4) silty clay loam, grayish brown (2.5Y 5/3) moist; moderate, very fine, subangular blocky structure; slightly hard, friable; many fine and medium roots; many worm casts; many limestone fragments ½ to 1 inch in size; calcareous, violently effervescent; abrupt, smooth boundary.

C—14 to 19 inches, pale-yellow (2.5Y 7/4) silty clay loam, light yellowish brown (2.5Y 6/4) moist; shale that has moderate, fine and medium, platy structure; few medium roots; few worm casts mainly along root channels in the shale; somewhat broken layers of limestone produce channery fragments 3 to 4 inches in length in the lower 2 inches; clear, wavy boundary.

R—19 to 30 inches, pale-yellow (2.5Y 7/4) shale, light yellowish brown (2.5Y 6/4) moist; roots are flattened and tend to follow the limestone layers and extend into fractures; layers of shale and limestone alternate with depth.

The A horizon ranges from 5 to 8 inches in thickness and from loam to heavy silt loam in texture. It ranges from dark gray to grayish brown in color. The B horizon ranges from silt loam to silty clay loam and is 18 to 35 percent clay. Coarse fragments in the A and B horizons make up less than 15 percent of the horizons. The C horizon ranges from light brownish gray to very pale brown. Reaction of the soil mass ranges from mildly alkaline to strongly alkaline.

Nibson soils are near Wakeen, Mento, Corinth, and Armo soils. They are shallower than Wakeen, Mento, Corinth and Armo soils. They are less clayey than Mento and Corinth soils.

Nibson silt loam, 5 to 12 percent slopes (Nn).—This soil is on ridgetops and side slopes and along drainageways.

Included with this soil in mapping were small areas of Wakeen and Armo soils, Roxbury silt loam, frequently flooded, and limestone outcrops.

Runoff is medium to rapid. Water erosion and soil blowing are hazards if range is overgrazed.

Most areas of this soil are in native grass and are used for range, to which it is well suited. A few small areas adjoining arable soils are cultivated. Use of a proper rate of stocking, deferred grazing, and cross fencing helps to improve range condition. Capability unit VIe–3; Limy Upland range site; windbreak suitability group 4.

Penden Series

The Penden series consists of deep, well-drained soils that formed in calcareous unconsolidated outwash. These sloping to strongly sloping soils are on uplands.

In a representative profile the surface layer is about 14 inches thick. The upper 8 inches is very dark grayish-brown light clay loam, and the lower 6 inches is dark grayish-brown clay loam. The next layer is grayish-brown, friable clay loam about 13 inches thick. The underlying material is pale-brown light clay loam. The upper 15 inches of the underlying material has a carbonate content of 15 to 25 percent.

Permeability is moderate, and available water capacity is high. Most areas of these soils are in native grass and are used for range. A few small areas are cultivated.

Representative profile of Penden clay loam in an area of Campus-Penden complex, 5 to 15 percent slopes, in native grass, 600 feet south and 600 feet west of the northeast corner of sec. 22, T. 12 S., R. 20 W.:

A11—0 to 8 inches, very dark grayish-brown (10YR 3/2) light clay loam, very dark brown (10YR 2/2) moist; moderate, fine, granular structure; slightly hard, friable; many fine and medium roots; many nests of worm casts; calcareous, strongly effervescent; gradual, smooth boundary.

A12—8 to 14 inches, dark grayish-brown (10YR 4/2) clay loam, very dark grayish brown (10YR 3/2) moist; moderate, fine and medium, granular structure; hard, friable; many fine roots; many nests of worm casts; calcareous, strongly effervescent; gradual, smooth boundary.

AC—14 to 27 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) moist; weak, fine, subangular blocky structure; hard, friable; common fine and medium roots; common nests of worm casts; few ¼-inch fragments of caliche and soft masses of calcium carbonate; calcareous, strongly effervescent; diffuse, smooth boundary.

C1ca—27 to 42 inches, pale-brown (10YR 6/3) light clay loam, brown (10YR 5/3) moist; weak, medium, subangular blocky structure; hard, friable; few fine, medium, and large pores; common scattered nests of worm casts; calcareous, violently effervescent; many soft masses of calcium carbonate caliche fragments ¼ to ½ inch in diameter; diffuse boundary.

C2—42 to 64 inches, pale-brown (10YR 6/3) light clay loam, brown (10YR 5/3) moist; weak, coarse, prismatic structure; slightly hard, friable; few fine roots; common fine and medium pores; few caliche fragments ¼ to ½ inch in diameter; calcareous, strongly effervescent.

The A1 horizon ranges from 7 to 20 inches in thickness and from very dark grayish brown to brown in color. The A horizon is typically clay loam but is silty clay loam in places. Depth to carbonate ranges from 0 to 6 inches. The C horizon ranges from brown to light gray. The Cca horizon ranges from 15 to 25 percent carbonates.

Penden soils are near Canlon and Campus soils and Rough broken land. They are deeper to bedrock than Canlon and Campus soils and Rough broken land. They are below Canlon and Campus soils and above Rough broken land on the landscape.

In Ellis County, Penden soils are mapped only in a complex with Campus soils.

Rough Broken Land

Rough broken land (7 to 30 percent slopes) (Ro) consists of rough, broken, dissected areas of uplands. It is made up of strongly calcareous, loamy, shallow to deep soils and nearly barren chalk outcrops. Rough broken land is about 45 percent shallow soils over chalk, 12 percent moderately deep soils over chalk, 23 percent chalk outcrops, and 20 percent deep soils that formed in colluvial and alluvial sediment on the floor of drainageways. The moderately deep soils are on the narrow ridges that divide the steep, dissected areas. In most places the chalk outcrops are at the higher elevations in the area, and the shallow soils are on the slopes below.

Runoff is rapid. Water erosion is a serious hazard, mainly because of the chalk outcrops.

Most areas of Rough broken land are in native grass and are used for range. Vegetation is very sparse on the chalk outcrops. The grass cover is better on the moderately deep and deep soils than it is on the more shallow soils. Careful management of the grassland is needed. Proper rate of stocking, deferred grazing, rotation grazing, cross fencing, and proper location of salt and water help to maintain good range condition. Capability unit VIIs–3; Shallow Limy range site; windbreak suitability group 4.

Roxbury Series

The Roxbury series consists of deep, well-drained soils that formed in calcareous silty alluvium. These nearly level and gently undulating soils are on terraces along the major streams in the county.

In a representative profile the surface layer is grayish-brown silt loam about 24 inches thick. The next layer is grayish-brown, firm light silty clay loam about 26 inches thick. The underlying material is light brownish-gray light silty clay loam. Roxbury soils are calcareous.

Permeability is moderate, and available water capacity is high. Most areas of these soils are cultivated, but a few small areas are in native grass. These soils are among the most suitable for crops in the county.

Representative profile of Roxbury silt loam, in a cultivated field, 2,300 feet west and 1,400 feet south of the northeast corner of sec. 23, T. 13 S., R. 19 W.:

Ap—0 to 11 inches, grayish-brown (10YR 5/2) silt loam, very dark brown (10YR 2/2) moist; weak, very thick, platy structure parting to weak, medium, granular; slightly hard, friable; few fine roots; weakly effervescent; neutral; clear, smooth boundary.

A1—11 to 24 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; slightly hard, friable; few fine roots; many worm casts; a few thin films of segregated lime in lower 8 inches; strongly effervescent; mildly alkaline; gradual, wavy boundary.

AC—24 to 50 inches, grayish-brown (10YR 5/2) light silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, subangular blocky structure; hard, firm; few fine roots; common fine threads of segregated lime; strongly effervescent; mildly alkaline; gradual, smooth boundary.

C—50 to 68 inches, light brownish-gray (10YR 6/2) light silty clay loam, dark grayish brown (10YR 4/2) moist; weak, medium, subangular blocky structure; hard, firm; films and threads thicker and more common than in AC horizon; strongly effervescent; mildly alkaline.

The A1 horizon ranges from silt loam to light silty clay loam in texture and from grayish brown to dark gray in color. Depth to free carbonates ranges from 0 to 15 inches. Unconforming sandy or clayey strata or mottles, or both, are below a depth of 40 inches in places. The C horizon ranges from brown to light gray in color.

Roxbury soils are near Hord, Detroit, McCook, Eltree and Munjor soils. They have free carbonates at a lesser depth than Hord soils. They are less clayey than Detroit soils and lack the clayey B2t horizon of Detroit soils. They have a thicker and darker A horizon and are more clayey than McCook soils. They lack distinct zones of lime accumulation of Eltree soils and have more evidence of stratification than those soils. They are less sandy than Munjor soils.

Roxbury silt loam (0 to 2 percent slopes) (Rb).—This nearly level and gently undulating soil is on terraces along the major streams in the county. It is very rarely flooded. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of Hord, Detroit, McCook, and Eltree soils. Also included were small depressions and wet areas, which are shown on the soil map by symbols.

Runoff is slow. Soil blowing is a slight hazard if the soil is left bare.

Most areas of this soil are cultivated, but a few small areas are in native grass and are used for range. This soil has a high potential for wheat, sorghum, and alfalfa. It is one of the best soils in the county for irrigation. It is suited to flood irrigation or sprinklers. Capability unit I–1; Loamy Terrace range site; windbreak suitability group 1.

Roxbury silt loam, frequently flooded (0 to 2 percent slopes) (Rf).—This soil is on flood plains along the smaller creeks and drainageways. It has a profile similar to the one described as representative for the series, but it is more stratified with darker and lighter colors or with thin layers of loam, sandy loam, or silty clay loam.

Included with this soil in mapping were small areas of Hord, McCook, and Wann soils.

Runoff is slow. The main limitation is frequent flooding and silting.

About half the acreage of this soil is cultivated, and the rest is in native grass and is used for range. Sorghum and wheat are the main crops, but a limited amount of alfalfa also is grown. Losses of wheat and alfalfa are severe in some years because of flooding and silting. Sorghum is less affected.

Proper rate of stocking, deferred grazing, rotation grazing, cross fencing, and proper location of salt and water help to improve range condition. Capability unit IIIw–1; Loamy Lowland range site; woodland suitability group 1.

Wakeen Series

The Wakeen series consists of moderately deep, well-drained soils that formed in residuum derived from chalky limestone. These gently sloping to strongly sloping soils are on uplands.

In a representative profile the surface layer is 17 inches thick. The upper 5 inches is dark grayish-brown silt loam, the next 5 inches is dark grayish-brown light silty clay loam, and the lower 7 inches is grayish-brown silty clay loam. The subsoil is very pale brown, friable silty clay loam about 12 inches thick. The underlying material is very pale brown silty clay loam about 7 inches thick over brownish-yellow, bedded chalk bedrock (fig. 18).

Permeability is moderate, and available water capacity is moderate. Most areas of the gently sloping and sloping soils are cultivated. Most areas of the strongly sloping soils are in native grass.

Representative profile of Wakeen silt loam, 1 to 3 percent slopes, in a cultivated field, 150 feet west and 1,200 feet north of the southeast corner of sec. 29, T. 12 S., R. 20 W.:

Ap—0 to 5 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) moist; weak, medium, granular structure; hard, friable; common fine roots; calcareous, strongly effervescent; mildly alkaline; clear, smooth boundary.

A1—5 to 10 inches, dark grayish-brown (10YR 4/2) light silty clay loam, very dark grayish brown (10YR 3/2) moist; strong, fine and medium, granular structure; slightly hard, friable; common fine roots; many worm cast granules; few chalk fragments as much as 2 centimeters in diameter; calcareous, strongly effervescent; mildly alkaline; gradual, smooth boundary.

A3—10 to 17 inches, grayish-brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) moist;

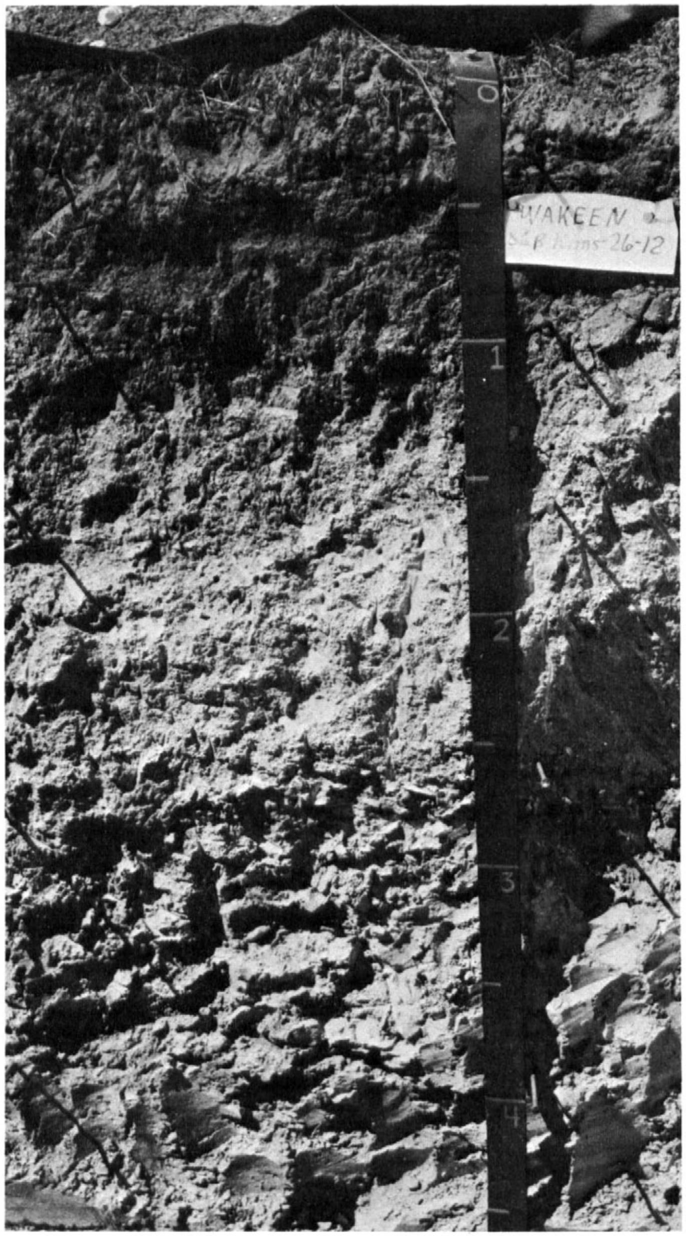

Figure 18.—**Profile of Wakeen silt loam, 1 to 3 percent slopes.**

strong, medium and coarse, granular structure; hard, friable; few fine roots; many worm cast granules of pale brown (10YR 6/3) brown (10YR 5/3) moist; few fragments of chalk as much as 5 centimeters in diameter; calcareous, violently effervescent; moderately alkaline; gradual, smooth boundary.

B2—17 to 29 inches, very pale brown (10YR 8/4) silty clay loam, light yellowish brown (10YR 6/5) moist; moderate, medium, subangular blocky structure; very hard, friable; few fine roots; few coarse root channels filled with darker colored material; calcareous, violently effervescent; moderately alkaline; gradual, smooth boundary.

C—29 to 36 inches, very pale brown (10YR 8/4), weathered, thinly bedded chalk that crushes to silty clay loam; light yellowish brown (10YR 6/5) moist; weak, coarse, subangular blocky structure parting to weak, fine, platy; very hard, brittle; few very fine roots; calcareous, violently effervescent; strongly alkaline; gradual, wavy boundary.

R—36 to 46 inches, brownish-yellow (10YR 6/6), thinly bedded chalk; no roots observed.

The A1 horizon ranges from very dark gray to dark grayish brown in color and from silt loam to silty clay loam in texture. It has moderate to strong, fine to medium, granular structure. The depth to carbonates ranges from 0 to 12 inches. The B horizon ranges from grayish brown to very pale brown or reddish yellow. Depth to underlying bedded chalky deposits ranges from 20 to 40 inches. The C horizon ranges from light brownish gray to yellow.

Wakeen soils are near Harney, Nibson, Brownell, Heizer, and Carlson soils. They are shallower to bedrock and contain less clay than Harney and Carlson soils. They contain fewer coarse fragments than Brownell and Heizer soils. They are deeper to bedrock than Nibson and Heizer soils.

Wakeen silt loam, 1 to 3 percent slopes (Wa).—This soil is on ridgetops and tablelands. It has a profile described as representative for the series.

Included with this soil in mapping were small areas of Harney, Mento, Brownell, Nibson, and Armo soils. Also included are small areas of soils that are similar to Wakeen soils but are 50 to 60 inches deep to underlying bedded chalky limestone; small areas of eroded Wakeen soils; and small areas of rock outcrops, which are shown on the soil map by symbols.

Runoff is medium. Water erosion is the main hazard, but soil blowing also is a hazard if the soil is left bare.

Most areas of this soil are cultivated, but a few areas are in native grass and are used for range. Wheat and sorghum are the main crops. Terracing, constructing waterways, and contour farming help to control water erosion. Good management of crop residue, such as stubble mulching, helps to control soil blowing, increase the intake of water, and maintain good tilth. Capability unit IIIe–8; Limy Upland range site; windbreak suitability group 3.

Wakeen silt loam, 1 to 3 percent slopes, eroded (We).—This soil is on uplands on knolls and ridgetops and along drainageways. It has a profile similar to the one described as representative for the series, but the surface layer is 5 to 9 inches thick.

Included with this soil in mapping were small areas of Nibson, Brownell, Mento, and Armo soils. About a third of the area mapped are uneroded Wakeen silt loam. Also included were small areas of rock outcrops, which are shown on the soil map by a symbol.

Runoff is medium to rapid. Water erosion is the main hazard, but soil blowing also is a hazard if the soil is left bare.

Most areas of this soil are cultivated, but a few areas have been reseeded to native grass and are used as waterways. Wheat and sorghum are the main crops. Terracing, constructing waterways, and contour farming help to control water erosion. Good management of crop residue, such as stubble mulching, helps to control soil blowing, increase the intake of water, and maintain good tilth. Close-growing crops, such as wheat and drilled sorghum, produce a large amount of residue, which helps to control erosion. Iron chlorosis is a management concern if sorghum is grown. Capability unit IVe–5; Limy Upland range site; windbreak suitability group 3.

Wakeen silt loam, 3 to 7 percent slopes (Wh).—This soil is on ridgetops and side slopes and along drainageways. It has a profile similar to the one described as representative for the series, but bedded chalky limestone is at a depth of 24 to 32 inches.

Included with this soil in mapping were small areas of Nibson, Brownell, Mento, and Armo soils; small areas of Roxbury silt loam, frequently flooded; and areas of soils in which the depth to bedrock ranges from 41 to 60 inches. Also included are areas of soils that have a profile similar to the one described as representative for the series, but the surface layer is 5 to 7 inches thick. There are also eroded areas and rock outcrops, which are shown on the soil map by symbols.

Runoff is medium to rapid. Water erosion is the main hazard. Soil blowing is a hazard if the soil is left bare.

Most areas of this soil are cultivated, but a few areas are in native grass and are used for range. Wheat and sorghum are the main crops. Terracing, constructing waterways, and contour farming help to control erosion. Good management of crop residue, such as stubble mulching, helps to control soil blowing, increase the intake of water, and maintain good tilth. Iron chlorosis can lower production of sorghum. Capability unit IVe–2; Limy Upland range site; windbreak suitability group 3.

Wakeen silt loam, 5 to 15 percent slopes, eroded (Wk).—This soil is on ridgetops and side slopes and along drainageways on uplands. It has a profile similar to the one described as representative for the series, but the surface layer is 5 to 7 inches thick.

Included with this soil in mapping were small areas of Brownell, Nibson, and Armo soils and Roxbury silt loam, frequently flooded. Also included were small areas of soils that have a profile similar to the one described as representative for the series but have bedrock at a depth of 40 to 50 inches. There are also small, severely eroded areas and rock outcrops, which are shown on the soil map by a symbol.

Runoff is rapid. Water erosion is the main hazard, but soil blowing also is a hazard if the soil is left bare.

About 40 percent of the acreage of this soil is cultivated, and 60 percent is in native grass. The soil is better suited to native grass than to crops, and it is used for range. Some of the underlying limestone is thick enough to be used as building material and is strip mined. Proper rate of stocking, deferred grazing, rotation grazing, cross fencing, and proper placement of salt and water help to maintain range condition. Sites are available for water impoundments in most places. Capability unit VIe–1; Limy Upland range site; windbreak suitability group 3.

Wann Series

The Wann series consists of deep, somewhat poorly drained soils that formed in calcareous, stratified, loamy alluvium along the major streams. These nearly level and gently undulating soils are on flood plains where the water table fluctuates between depths of 2 and 6 feet (fig. 19).

In a representative profile the surface layer is dark-gray loam about 12 inches thick. The next layer is grayish-brown, very friable fine sandy loam about 12 inches thick. The upper 10 inches of the underlying material is grayish-brown loam that has faint mottling; the next 10 inches is dark-gray loam that has faint mottling; and the lower part is light brownish-gray very fine sandy loam that has common distinct mottles.

Permeability is moderately rapid, and available water capacity is moderate. The water table fluctuates between depths of 2 and 6 feet and is at a depth of 2 feet during wet periods. Most of the acreage of this soil is cultivated, but about a third of it is in native grass, to which it is well suited.

Representative profile of Wann loam, in a cultivated field, 2,800 feet south and 135 feet west of the northeast corner of sec. 14, T. 11 S., R. 20 W.:

A1—0 to 12 inches, dark-gray (10YR 4/1) loam, very dark gray (10YR 3/1) moist; moderate, fine, granular structure; slightly hard, friable; few fine roots; many worm casts in root channels and nests;

Figure 19.—**Profile of Wann loam.**

strongly effervescent; mildly alkaline; clear, smooth boundary.

AC—12 to 24 inches, grayish-brown (10YR 5/2) fine sandy loam, dark grayish brown (10YR 4/2) moist; single grained; soft, very friable; strongly effervescent; moderately alkaline; clear, smooth boundary.

C1—24 to 34 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) moist; weak, fine, granular structure; slightly hard, friable; few faint mottles; porous; few worm casts; common ½ inch gravel; strongly effervescent; moderately alkaline; clear, smooth boundary.

A1b—34 to 44 inches, dark-gray (10YR 4/1) loam, very dark gray (10YR 3/1) moist; moderate, fine, granular structure; slightly hard, friable; very porous; few faint mottles; several worm casts; a few, small, soft spots of segregated calcium carbonate; strongly effervescent; moderately alkaline; gradual, smooth boundary.

C2b—44 to 64 inches, light brownish-gray (10YR 6/2) very fine sandy loam, grayish brown (10YR 5/2) moist; weak, fine, granular structure; slightly hard, friable; common distinct mottles; very porous; many nests of worm casts; strongly effervescent; moderately alkaline; water table at a depth of 44 inches.

The solum ranges from 11 to 20 inches in thickness. The A horizon ranges from silt loam to sandy loam. The A1 horizon ranges from dark gray to grayish brown. The AC horizon ranges from 1 to 12 inches in thickness and is intermediate in color between the A and C horizons. The C horizon ranges from gray to light gray. It is stratified with 1- to 3-inch layers of loam or loamy sand.

Wann soils are near Boel, Inavale, and McCook soils. They contain less sand than Boel and Inavale soils. They are similar to Boel soils in being somewhat poorly drained, but they are less well drained than Inavale and McCook soils. They are more sandy than McCook soils.

Wann loam (0 to 2 percent slopes) (Wn).—This nearly level and gently undulating soil is on flood plains.

Included with this soil in mapping were small areas of Boel, McCook, and Inavale soils. Also included were areas of soils that are similar to Wann soils, except that the water table is below a depth of 6 feet. Small saline spots are shown on the soil map by a symbol.

Flooding and a high water table limit the use of this soil.

Most of the acreage of this soil is cultivated, but about a third is in native grass.

Wheat and sorghum are the main crops. Crops may be damaged or lost through flooding or silting, or both. In wet years the high water table prevents harvesting. In years of below-average rainfall, however, the soil is very productive. The production of native grass is high, and this soil is well suited to range and meadow. Capability unit IIIw-2; Subirrigated range site; windbreak suitability group 1.

Use and Management of the Soils

This section first discusses the use of soils for crops, briefly explains the system of capability classification used by the Soil Conservation Service, and gives predictions of yields for dryland. Then it discusses the use of the soils for range, for windbreaks, for wildlife habitat, and for engineering purposes.

General Management of Dryland Soils [2]

The soils in Ellis County were covered with grass before the sod was broken for cultivation. Roots permeated the soil, and living and dead vegetation covered the surface. The action of rain and wind on these protected soils caused little damage. Rains were absorbed rapidly by the soils, and there was little runoff. Winds had little chance to move protected soils. Erosion was limited to a slow, relatively harmless rate known as geologic erosion. In most areas erosion and soil formation were in balance.

Cultivation has reduced the content of organic matter in the soils. In many places the soil structure and general physical condition have deteriorated. This poorer physical condition, combined with management that left the soil bare and unprotected, has resulted in both soil blowing and water erosion.

Conservation of cropland in Ellis County should be based on continuously keeping a cover on the surface of the soil. It generally will not be necessary to restore the native vegetation on present cropland.

Such practices as conservation cropping systems, stubble mulching, and minimum tillage are needed on all cropland in the county. Terracing, contour farming, and wind stripcropping are additional practices that can be used to control soil blowing and water erosion. Erosion control and water conservation are more successful if a proper combination of these practices is used. A single practice may reduce erosion or conserve moisture, but it is seldom enough to conserve soil and water resources (fig. 20).

Winter wheat and sorghum are the principal dryland crops in the county. Three common cropping systems are summer fallow, wheat, wheat; summer fallow, wheat, wheat, sorghum; and summer fallow, wheat, sorghum. Most farmers, however, prefer a flexible cropping system. Such a system permits them to take advantage of moisture to produce protective cover and to stabilize farming in the county.

Crop production is often uncertain, even if summer fallow is used. But summer fallowing has increased in recent years, mainly because of crop reduction programs.

During the last 10 years about one-half of the wheat produced in Ellis County was planted on land fallowed the preceding year. Although not an efficient way to increase total moisture stored, the practice did increase wheat yields by 33 percent as compared to the continuous wheat system.

Crop residue does the most good if it is left on the surface to protect the soil from erosion. Residue also protects soil structure from the deteriorating effect of splashing raindrops. If left bare and unprotected, most of the cropland soils in the county are very susceptible to sealing and crusting after rainstorms.

Minimum, or reduced, tillage helps to prevent breakdown of soil aggregates and maintains more residue on the surface. Tilling when the soils are too wet should be avoided, because it causes a tillage pan to form, particularly in loam and silt loam. Terraces may be used on sloping soils to shorten the length of slope and help to prevent water erosion. Generally, a terrace will reduce water erosion by about 50 percent. Contour farming and other good management practices should be used together with terraces. Each row planted on the contour between terraces acts as a miniature ter-

[2] By EARL J. BONDY, conservation agronomist, Soil Conservation Service.

Figure 20.—**Snow trapped in sorghum stubble on terraced and contour-farmed Harney silt loam, 1 to 3 percent slopes.**

race by holding back water and letting it soak into the soil. If both terracing and contour farming are used, crop production is increased and soil losses are decreased.

Wind stripcropping may be used on the few acres of sandy soils to control soil blowing by shortening the distance that the loose soil can move. Wind stripcropping is much more effective if used together with good residue management, minimum tillage, proper cropping system and a good fertility program.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are so used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or for engineering.

In the capability system, the kinds of soils are grouped at three levels: the capability class, subclass, and unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes 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*, used in Ellis County but not in all parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are 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 for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–4 or IIIe–6. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraphs; and the Arabic numeral specifically identifies the capability unit within each subclass.

The eight capability classes in the system and the subclasses and units in the county are defined in the following pages.

Class I. Soils that have few limitations that restrict their use (no subclasses).

Unit I–1. Deep, nearly level, well-drained soils that have a medium-textured surface layer and subsoil; on stream terraces.

Unit I–2. Deep, nearly level, well-drained soils that have a medium-textured surface layer and a moderately fine textured to fine textured subsoil; on stream terraces.

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

Subclass IIe. Soils subject to moderate erosion if they are not protected.

Unit IIe–1. Deep, gently sloping, well-drained soils that have a medium-textured surface layer and a medium-textured and moderately fine textured subsoil; on uplands.

Unit IIe–2. Deep, gently sloping, well-drained soils that have a medium-textured surface layer and a fine-textured subsoil; on uplands.

Unit IIe–3. Deep, nearly level, well-drained soils that have a moderately coarse textured surface layer and medium-textured layers below; on terraces.

Unit IIe–4. Deep, gently sloping, well-drained, calcareous soils that have a medium-textured surface layer and a moderately fine textured subsoil; on uplands.

Subclass IIs. Soils that have moderate limitations due to slow permeability or slight to moderate sodium content.

Unit IIs–1. Deep, nearly level, moderately well drained soils that have a moderately fine textured surface layer and a fine textured subsoil; on uplands.

Unit IIs–2. Deep, nearly level, well drained to moderately well drained soils that have a medium-textured to fine-textured surface layer and a moderately fine textured subsoil; on uplands and terraces.

Subclass IIc. Soils that have slight limitations due to lack of moisture.

Unit IIc–1. Deep, nearly level, well-drained soils that have a medium-textured surface layer and a medium textured to moderately fine textured subsoil; on uplands.

Unit IIc–2. Deep, nearly level, well-drained soils that have a medium-textured surface layer and a moderately fine textured to fine textured subsoil; on uplands.

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

Subclass IIIe. Soils subject to severe erosion if they are not protected.

Unit IIIe–1. Deep, sloping, well-drained soils that have a medium-textured surface layer and medium-textured to moderately fine textured subsoil; on uplands.

Unit IIIe–2. Deep, sloping, well-drained soils that have a medium-textured surface layer and a fine-textured subsoil; on uplands.

Unit IIIe–3. Deep, gently sloping to sloping, well-drained soils that have a moderately coarse textured surface layer and subsoil; on uplands.

Unit IIIe–4. Deep, gently sloping, well-drained soils that have a medium-textured surface layer and a moderately fine textured subsoil that is high in sodium; on uplands.

Unit IIIe–5. Deep, gently sloping to sloping, well-drained, moderately eroded soils that have a moderately fine textured surface layer and a moderately fine textured to fine textured subsoil; on uplands.

Unit IIIe–6. Deep, sloping, well-drained, calcareous soils that have a medium-textured surface layer and a moderately fine textured subsoil; on uplands.

Unit IIIe–7. Deep, gently sloping, well-drained, moderately eroded soils that have a moderately fine textured surface layer and a moderately fine textured subsoil that is high in sodium; on uplands.

Unit IIIe–8. Moderately deep, gently sloping, well-drained, calcareous soils that have a medium-textured surface layer and a moderately fine textured subsoil; on uplands.

Uuit IIIe–9. Moderately deep, gently sloping, well-drained, calcareous soils that have a moderately fine textured surface layer and subsoil; on uplands.

Subclass IIIw. Soils that have severe limitations because of excess water either from flooding or a water table, or both.

Unit IIIw–1. Deep, nearly level, well-drained soils that have a medium-textured surface layer and subsoil; on bottom lands that are frequently flooded.

Unit IIIw–2. Deep, nearly level, well-drained to somewhat poorly drained soils that have a moderately coarse textured surface layer and a moderately coarse textured to coarse textured subsoil; on bottom lands that are frequently flooded.

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

Subclass IVe. Soils that have very severe limitations that require special conservation treatment to control erosion if they are cultivated and not protected.

Unit IVe–1. Deep, sloping, well-drained, moderately eroded soils that have a moderately fine textured surface layer and a moderately fine textured subsoil that is high in sodium; on uplands.

Unit IVe–2. Moderately deep and deep, sloping, well-drained, calcareous and noncalcareous soils that have a medium-textured surface layer and a medium-textured to fine-textured subsoil; on uplands.

Unit IVe–3. Moderately deep, sloping, well-drained, calcareous soils that have a moderately fine textured surface layer and subsoil; on uplands.

Unit IVe–4. Deep, sloping, well-drained, moderately eroded, calcareous soils that have a medium-textured to moderately fine textured surface layer and a moderately fine textured to fine textured subsoil; on uplands.

Unit IVe–5. Moderately deep, gently sloping, well-drained, calcareous, moderately eroded soils that have a moderately fine textured surface layer and subsoil; on uplands.

Class V. Soils subject to little erosion, if any, but have other limitations, impractical to remove, that limit their use largely to pasture, range, or wildlife food and cover.

Subclass Vw. Soils that are too wet for cultivation because of a high water table.

Unit Vw–1. Deep, nearly level, somewhat poorly drained and poorly drained soils that have a medium-textured surface layer and subsoil; on bottom lands.

Class VI. Soils that have severe limitations that make them generally unsuited to cultivation without major reclamation and limit their use largely to pasture, range, woodland, or wildlife food and cover.

Subclass VIe. Soils severely limited, mainly by risk of erosion, if protective cover is not maintained.

Unit VIe–1. Deep and moderately deep, sloping to strongly sloping, well-drained, calcareous soils that have a moderately coarse textured to moderately fine texture surface layer and subsoil; on uplands.

Unit VIe–2. Moderately deep, sloping to strongly sloping, moderately well drained soils that have a fine-textured surface layer and subsoil; on uplands.

Unit VIe–3. Shallow and moderately deep, gently sloping to strongly sloping, well-drained and somewhat excessively drained, calcareous soils that have a medium-textured surface layer and subsoil; on uplands.

Unit VIe–4. Deep, nearly level to strongly sloping, well-drained soils that have a coarse-textured surface layer and subsoil; on flood plains and terrace foot slopes.

Subclass VIw. Soils that have severe limitations because of flooding or a high water table, or both.

Unit VIw–1. Deep, nearly level to gently undulating, well-drained soils that have a fine-textured surface layer and subsoil; on flood plains along small drainageways.

Unit VIw–2. Deep, nearly level to gently undulating, somewhat poorly drained soils that have a moderately coarse textured surface layer and a coarse-textured subsoil; on bottom lands that are frequently flooded.

Class VII. Soils that have very severe limitations that make them unsuited to cultivation without major reclamation and restrict their use mainly to range, woodland, or wildlife food and cover.

Subclass VIIw. Alluvial soils that are subject to a severe hazard of flooding.

Unit VIIw–1. Steep, broken, medium-textured alluvial material along banks and beds of creeks and streams that frequently overflow.

Subclass VIIs. Soils that have very severe soil limitations because of depth, texture, available water capacity, or permeability.

Unit VIIs–1. Moderately deep to deep, moderately well drained and well drained soils that have a medium-textured to fine-textured surface layer and subsoil; on rough broken uplands.

Unit VIIs–2. Shallow, moderately deep, and deep, well-drained, calcareous, sloping to moderately steep soils that have a medium-textured surface layer and a medium-textured to moderately fine textured subsoil; on uplands.

Unit VIIs–3. Shallow to deep, well-drained, calcareous, medium-textured soils and chalk outcrops; on rough broken uplands.

Class VIII. Soils and land forms that have limitations that preclude their use for commercial plant production without major reclamation and restrict their use to recreation, wildlife, water supply, or aesthetic purposes. (None in Ellis County)

The capability classification of the soils in Ellis County is given at the end of each mapping unit description and in the "Guide to Mapping Units" at the end of this survey.

Yield predictions

The average yields per acre that can be expected from seeded wheat, grain sorghum, and alfalfa over a long period of time on arable soils under a high level of management in Ellis County are given in table 2. These predictions are based on data obtained from farmers, personnel of the Fort Hays Experiment Station, the County Extension Agent, and members of the soil survey party. Predicted yields may not apply directly to any specific tract of soil in any particular year, because management practices vary slightly from farm to farm and climate fluctuates from year to year.

Under high-level management for wheat or sorghum, tillage is done on the contour and all sloping fields are

TABLE 2.—*Predicted average yields per acre of seeded wheat, sorghum, and alfalfa on arable soils under high-level management*

[A dash indicates that alfalfa is not commonly grown on the soil]

Soil name	Wheat	Grain sorghum	Alfalfa
	Bu	*Bu*	*Tons*
Anselmo fine sandy loam, 2 to 6 percent slopes	25	45	----------
Armo loam, 1 to 3 percent slopes	24	33	2.2
Armo loam, 3 to 7 percent slopes	21	30	2.0
Armo loam, 3 to 7 percent slopes, eroded	18	26	----------
Campus-Carlson complex, 3 to 7 percent slopes	18	30	----------
Corinth silty clay loam, 1 to 3 percent slopes	20	30	----------
Corinth silty clay loam, 3 to 7 percent slopes	17	27	----------
Crete silty clay loam, 0 to 1 percent slopes	32	48	2.2
Crete silty clay loam, thin surface variant, 0 to 1 percent slopes	27	43	2.1
Detroit silt loam	30	50	2.6
Eltree silt loam, 0 to 1 percent slopes	34	52	3.5
Eltree silt loam, 1 to 3 percent slopes	32	50	3.0
Eltree silt loam, 3 to 7 percent slopes	30	48	----------
Harney silt loam, 0 to 1 percent slopes	32	50	2.7
Harney silt loam, 1 to 3 percent slopes	30	46	2.0
Harney silt loam, 3 to 7 percent slopes	26	42	----------
Harney silty clay loam, 2 to 5 percent slopes, eroded	24	40	----------
Harney-Armo complex, 3 to 7 percent slopes, eroded	22	38	----------
Harney-Carlson silt loams, 0 to 1 percent slopes	27	46	----------
Harney-Carlson silt loams, 1 to 3 percent slopes	26	44	----------
Harney-Wakeen silt loams, 0 to 1 percent slopes	26	44	----------
Harney-Wakeen silt loams, 1 to 3 percent slopes	25	42	----------
Holdrege silt loam, 0 to 1 percent slopes	34	52	2.7
Holdrege silt loam, 1 to 3 percent slopes	32	50	2.2
Hord silt loam	34	52	3.1
McCook silt loam	25	46	3.5
McCook fine sandy loam	30	46	3.0
Mento silt loam, 0 to 1 percent slopes	23	42	----------
Mento silt loam, 1 to 3 percent slopes	20	40	----------
Mento silty clay loam, 1 to 3 percent slopes, eroded	18	36	----------
Mento soils, 3 to 7 percent slopes, eroded	16	32	----------
Munjor sandy loam	24	35	----------
New Cambria silty clay	26	45	----------
Roxbury silt loam	34	52	2.8
Roxbury silt loam, frequently flooded	25	46	----------
Wakeen silt loam, 1 to 3 percent slopes	22	36	----------
Wakeen silt loam, 1 to 3 percent slopes, eroded	15	28	----------
Wakeen silt loam, 3 to 7 percent slopes	17	29	----------
Wann loam	25	33	----------

terraced to control erosion. Stubble mulching is used to keep the surface covered by residue. Generally, one operation with a sweep-type blade in the fall on wheat stubble is all that is used, and occasionally no operations are used in the fall, especially on sorghum stubble. Hybrid or improved seed is used, and nitrogen and phosphate are applied when the moisture condition is good.

Irrigation [3]

Irrigation was little used on farms in the county until the organization of the Cedar Bluff Irrigation District. Before this, irrigation was confined to areas located near Big Creek, Smoky Hill, and Saline Rivers and to a few isolated areas suitable for irrigation wells.

During the first year of operation, in 1946, the Ellis County Soil Conservation District had four irrigation systems on a total of 116 acres. By 1960 a total of 601 acres had been leveled for irrigation, and most of the acreage was near streams. Only six to eight wells had been developed at that time.

The Cedar Bluff Irrigation District was officially organized in 1958 to irrigate 6,600 acres. The potential is estimated to be 6,900 acres. About 400 acres is in Trego County, and the rest is in Ellis County. By 1969 a total of 3,713 acres had been leveled for irrigation in the district.

Water was first available for crops in 1962, and in 1969 more than 5,500 acres received water. Some acreage was wild flooded.

The 1969 annual report of the Ellis County Soil Conservation District shows that 5,444 acres has been leveled or developed for flood irrigation in the county. Another 1,200 acres is irrigated with sprinkler systems.

Factors to be considered in planning an irrigation system, whether sprinkler or flooding, are the kind of soil, the quality and amount of irrigation water available, and the type of system to be used.

The kind of soil has been determined by study and evaluation of the properties and characteristics of the

[3] BERTEL E. SODERBLOOM, district conservationist, Soil Conservation Service, helped prepare this section.

soil by the soil scientist. Some of the properties important to the irrigation planner and irrigator are the depth of the soil and the texture and structure of the surface layer, subsoil, and underlying material. From these soil properties such characteristics as permeability, available water capacity, and drainage can be discerned and the suitability of the soil for irrigation determined.

Permeability, which is determined by texture and structure, is the rate of water movement through the soil. The least permeable layer in the root zone governs the infiltration of the water into the soil. The infiltration rate determines the length of run and the period of time required to irrigate the soil.

Available water capacity depends on the depth and texture. A loamy sand does not hold so much water available to plants as a silty clay loam. Inavale loamy sand, for instance, has low available water capacity, but Harney silt loam has high available water capacity. Available water capacity determines the frequency and amount of water applications needed.

Good subsurface drainage below the root zone is necessary to keep soluble salts from being deposited in the zone. Leaching of the soil with additional water may be necessary in some places to move salts from the root zone and into the substratum drainage flow.

All natural waters used for irrigation contain some soluble salts, generally chlorides and sulfates of calcium, magnesium, potassium, and sodium. The higher the concentration of these salts in the water, the poorer the quality of the water. Tests should be made of all water to be used for irrigation to determine the kind and amount of soluble salts in the water.

Range[4]

Native grassland covers about 238,540 acres, or about 41 percent, of the farmland in Ellis County. There are three grassland areas in the county. The largest is along the northern edge of the county, adjacent to both sides of the Saline River Valley. Another is in the central part of the county, adjacent to both sides of Big Creek Valley. In the southern part of the county, the grassland area is adjacent to both sides of the Smoky Hill River Valley. Small tracts of range occur throughout the county, intermingled with larger acreages of cropland, and are generally suitable for cultivation. About a third of the range is suitable for cultivation.

Beef production is the largest farm industry in the county. The principal livestock enterprise is a cow-calf operation. There are several feeder cattle operations in the county. Most of the ranches include some cropland that is used for supplemental grazing. The chief crops used for temporary grazing are wheat pasture and sorghum stubble.

Because the forage produced on rangeland is marketed through the sale of livestock and livestock products, the success of the livestock enterprise depends upon the way the ranchers manage their rangelands.

The native grass in most areas of Ellis County is a mixture of short, tall, and mid grasses. The major range sites are Limy Upland and Loamy Upland. The Limy Upland range site produces a cover of mostly tall and mid grasses if it is in excellent condition. The Loamy Upland range site produces a cover of short, mid, and tall grasses if it is in excellent condition. Slope and topography enhance or limit the grazing of a particular area by affecting the accessibility to livestock.

Range sites and condition classes

Different kinds of soil vary in their capacity to produce grasses and other plants for grazing. Soils are grouped into range sites on the basis of similarity in the characteristics that affect their capacity for producing native forage plants. Each site has a distinctive potential plant community, the composition of which depends on a combination of environmental conditions, mainly the combined effects of climate on soil. The potential plant community reproduces itself so long as the environmental conditions remain the same. The potential plant community is referred to as climax vegetation and is considered the most productive combination of plants adapted to the soil and climatic conditions for each site. Range sites are areas of rangeland that differ from each other in their ability to produce different kinds and amounts of climax vegetation.

The plants on any given range site are identified, according to their response to grazing, as decreasers, increasers, and invaders. Decreasers are species in the potential plant community that tend to decrease in relative amount under continuous overgrazing. They generally are the tallest and most productive perennial grasses and forbs and are the most palatable to livestock. Increasers are species in the potential plant community that increase in relative amount as the decreaser plants decline. Invaders are plants not common in the climax plant community but that invade the site during extremes in weather or when the site is overgrazed. Most invaders are annual weeds. Some are forbs that have some grazing value, but others have little or no value for grazing.

Range condition is rated by comparing the composition of the existing plant community with that of the potential plant community. The purpose of classifying range condition is to provide an approximate measure of the deterioration that has taken place from the potential plant community, and thereby provide a basis for predicting the degree of improvement feasible. Potential forage production depends on the range site. Current forage production depends upon the range condition and the moisture that the plant receives during the growing season. Four range condition classes are recognized. A range is in *excellent* condition if 76 to 100 percent of the existing vegetation is of the same composition as that of the potential stand. It is in *good* condition if the percentage is 51 to 76, in *fair* condition if 26 to 50, and in *poor* condition if less than 26.

One of the main objectives of good range management is to keep range in excellent to good condition. If this is done, water is conserved, production is improved, and the soil is protected. The problem is in the recognition of the important changes in the kind of cover on a range site. These take place gradually and can be mis-

[4] By H. Ray Brown and Harland E. Dietz, range conservationists, Soil Conservation Service.

calculated or overlooked. Growth encouraged by heavy rainfall may lead to the conclusion that the range is in good condition, but actually the cover is weedy and the long-time trend is toward lower production. In contrast, some range that has been closely grazed for relatively short periods under the supervision of a careful manager may have a degraded appearance that temporarily conceals its quality and ability to recover.

Stocking the right kind and number of livestock on a range site results in the highest production and in the best use of the range resources. A feed and forage program that includes available range forage, concentrates, tame and native hay, silage, and tame pastures, and which will keep livestock in a productive or desirable condition throughout the year, is necessary. Roughage may be reserved and fed during an emergency to conserve plant cover, soil, and water. These reserves are in addition to normal winter requirements. Feed shortages can be avoided by carrying in reserve the surplus produced in years of high production.

In addition to providing adequate forage and reserve feed supplies, it is often desirable to keep part of the livestock as readily saleable livestock such as stocker steers. This allows ranchers to balance the number of livestock on hand with the available forage without marketing breeding stock.

Descriptions of the range sites

The soils of Ellis County have been grouped into fifteen range sites. Because of differences in the soils, the range sites vary considerably in the amount of forage produced. The total annual production of forage varies from year to year because of differences in the amount of precipitation, in the amount of grazing in past years, and in relief. Trampling or the activity of rodents and insects may damage forage plants or cause them to disappear.

The approximate total annual yield of forage on range in excellent condition, based on plot clippings, is given in air-dry weight per acre in average, favorable, and less favorable years. To find out the soils in each site, refer to the "Guide to Mapping Units."

BLUE SHALE RANGE SITE

This range site is on moderately deep, moderately well drained soils that formed in material weathered from clay shale. These soils have a clay surface layer and subsoil. They are sloping to moderately steep and are on uplands. The soils have slow permeability and have low available water capacity. They are easily eroded by water, and soil blowing is a hazard if the soils are overgrazed or otherwise mismanaged.

The climax plant community consists mostly of short and mid grasses and some tall grasses. About 70 percent of the total annual production is such decreasers as side-oats grama, western wheatgrass, tall dropseed, big bluestem, Illinois bundleflower, leadplant, and catclaw sensitivebriar. The principal increasers are blue grama, buffalograss, red three-awn, western ragweed, and common pricklypear. Common invaders are silver bluestem, annual brome, and prairie three-awn.

The first plant to decrease under continuous overuse is big bluestem, then side-oats grama and western wheatgrass. Because of long years of overuse, a large part of this range site is only in fair condition, and buffalograss and blue grama are the main plants grazed.

Forage production varies greatly because of the fine texture of the soil and because of slope aspect. Western wheatgrass production increases after high precipitation in winter and spring. During an extremely dry winter and spring, western wheatgrass remains semidormant and production is low. The total annual production of air-dry herbage on this site averages approximately 1,800 pounds per acre, but it ranges from about 3,000 pounds in favorable years to 800 pounds in unfavorable years.

CLAY LOWLAND RANGE SITE

The only soil in this range site is Alluvial land, clayey. This is a deep, well-drained soil that formed in clayey alluvium. This soil has a fine-textured surface layer and subsoil. It is nearly level and gently undulating and is on flood plains, where it receives additional water. This soil has slow permeability and high available water capacity. The hazard of erosion is not severe.

The climax plant community consists mostly of tall and mid grasses. About 80 percent of the total annual production is such decreasers as big bluestem, switchgrass, little bluestem and indiangrass. Other perennial forbs and grasses make up the rest. The principal increasers are side-oats grama, western wheatgrass, blue grama, and western ragweed. Common invaders are annual bromes, cocklebur, and barnyardgrass.

The first plants to decrease under continuous overuse are big bluestem, little bluestem, and indiangrass, then switchgrass. In many places, because of overuse, this site is in only fair condition, and side-oats grama, switchgrass, and western wheatgrass are the main plants grazed.

The total annual production of air-dry herbage on this site averages approximately 4,500 pounds per acre, but it ranges from 5,500 pounds in favorable years to 3,500 pounds in less favorable years.

CLAY TERRACE RANGE SITE

The only soil in this range site is New Cambria silty clay. This is a deep, well-drained soil that formed in clayey alluvium. It has a fine-textured surface layer and subsoil. It is nearly level to gently sloping and is on terraces. This soil has slow permeability but high available water capacity. Water erosion is a hazard in the more sloping areas if they are overgrazed or otherwise mismanaged.

The climax plant community consists mostly of tall and mid grasses. About 70 percent of the total annual production is such decreasers as big bluestem, little bluestem, switchgrass, and indiangrass. Other perennial forbs and grasses make up the rest. The principal increasers are side-oats grama, blue grama, western wheatgrass, and western ragweed. Common invaders are annual bromes, windmillgrass, tumblegrass, and little barley.

The first plants to decrease under continuous overuse are big bluestem, little bluestem, and indiangrass, then switchgrass. Because of many years of overuse, part of this range site is in only fair condition, and side-oats grama, western wheatgrass, and blue grama are the main plants grazed.

The total annual production of air-dry herbage on this site averages approximately 3,500 pounds per acre, but it ranges from 4,500 pounds in favorable years to 2,000 pounds in unfavorable years.

CLAY UPLAND RANGE SITE

This range site is on deep, well drained to moderately well drained soils that formed in loess. These soils have a medium-textured to moderately fine textured surface layer and a moderately fine textured to fine textured subsoil. They are nearly level to sloping and are on uplands. The soils have slow permeability and high available water capacity. Water erosion is a hazard on the gently sloping soils if they are overgrazed or otherwise mismanaged. Soil blowing is a hazard in areas where overgrazing has bared the soils.

The climax plant community consists mostly of short and mid grasses. About 60 percent of the total annual production is such decreasers as western wheatgrass, side-oats grama, tall dropseed, slimflower scurfpea, and dotted gayfeather. Other perennial forbs and grasses make up the rest. The dominant increasers are buffalograss, blue grama, red three-awn, western ragweed, and common pricklypear. Western ragweed is the principal increaser forb. The principal invaders are prairie three-awn, annual bromes, little barley, and windmillgrass.

Side-oats grama generally is the first species to decrease under continuous overuse, then western wheatgrass. Because of many years of overuse, part of this range site is only in fair condition and blue grama and buffalograss are the most abundant plants.

Forage production varies greatly. If precipitation is high in winter and spring, the production of western wheatgrass is high; and if precipitation is low, the production is low. The total annual production of air-dry herbage on this site averages approximately 2,000 pounds per acre, but it ranges from 4,000 pounds in favorable years to 800 pounds in unfavorable years.

LIMY UPLAND RANGE SITE

This range site is on shallow, moderately deep, and deep, well-drained and somewhat excessively drained soils. These soils formed in material weathered from chalky limestone, chalky shale caliche, and calcareous clay shale, and in loess, colluvium, and outwash. These soils have a medium-textured surface layer and a medium-textured to moderately fine textured subsoil. They are nearly level to moderately steep and are on uplands. They have moderately slow to moderate permeability and very low to high available water capacity. Water erosion is a hazard on the sloping soils.

The climax plant community consists of tall and mid grasses. About 70 percent of the total annual production is such decreasers as big bluestem, little bluestem, switchgrass, indiangrass, leadplant, prairie-clover, and blacksamson. Other perennial forbs and grasses make up the rest. The principal increaser is side-oats grama, but blue grama, buffalograss, purple three-awn also are increasers. Common invaders are broom snakeweed, windmillgrass, tumblegrass, and annual bromes.

Big bluestem and little bluestem are the first plants to decrease under continuous overgrazing. Because of many years of overuse, part of this range site is in only fair condition, and side-oats grama and blue grama are the main plants grazed. The vegetation will improve greatly if grazing is deferred at times.

The total annual production of air-dry herbage on this site averages approximately 2,450 pounds per acre, but it ranges from 4,000 pounds in favorable years to 1,000 pounds in unfavorable years.

LOAMY LOWLAND RANGE SITE

This is a deep, well-drained soil that formed in calcareous alluvium. This soil has a medium-textured surface layer and a moderately fine textured subsoil. It is nearly level and gently undulating and is on flood plains. It has moderate permeability and high available water capacity. Erosion is not a hazard on this soil, except for that caused by flooding.

The climax plant community consists of tall and mid grasses. About 80 percent of the total annual production is such decreasers as big bluestem, switchgrass, little bluestem, and indiangrass. Other perennial forbs and grasses make up the rest. The principal increasers are side-oats grama, tall dropseed, western wheatgrass, blue grama, and western ragweed. Common invaders are annual bromes, Kentucky bluegrass, and cocklebur.

Such trees as elm, ash, cottonwood, and hackberry commonly grow along streambanks and increase in abundance under excessive overgrazing. Under the canopy of these trees grow such shade-tolerant, cool-season grasses as Canada wildrye, Virginia wildrye, green muhly, and western wheatgrass. Under continuous overuse, the first plants to decrease are big bluestem, little bluestem, and indiangrass, then switchgrass. Because of many years of overuse, a large part of this range site is in only fair to good condition and side-oats grama, western wheatgrass, and switchgrass are the main plants grazed.

The total annual production of air-dry herbage on this site averages approximately 4,500 pounds per acre, but it ranges from 6,000 pounds in favorable years to 3,500 pounds in unfavorable years.

LOAMY TERRACE RANGE SITE

This range site is on deep, well-drained soils that formed in calcareous alluvium. These soils have a medium-textured surface layer and a medium-textured to fine-textured subsoil. They are nearly level to gently undulating and are on alluvial terraces. They have slow to moderate permeability and high available water capacity. Erosion is not a hazard.

The climax plant community consists mostly of tall and mid grasses. About 70 percent of the total annual production is such decreasers as big bluestem, little bluestem, switchgrass, indiangrass, and Canada wildrye. The rest is other perennial forbs and grasses. The principal increasers are western wheatgrass, blue grama, side-oats grama, and buffalograss. Common invaders are annual bromes, windmillgrass, tumblegrass, little barley, and western ragweed (fig. 21).

The first plants to decrease under continuous overuse are big bluestem, little bluestem, and indiangrass, and then switchgrass. Because of many years of overuse, a large part of this range site is in only fair condition,

Figure 21.—**Root distribution from a solid stand of switchgrass on Roxbury silt loam.**

and side-oats grama, blue grama, western wheatgrass, and buffalograss are the main plants grazed.

The total annual production of air-dry herbage on this site averages approximately 3,500 pounds per acre, but it ranges from around 4,500 pounds in favorable years to 2,500 pounds in unfavorable years.

LOAMY UPLAND RANGE SITE

This range site is on deep, well-drained soils that formed in loess. These soils have a medium-textured surface layer and a moderately fine textured subsoil. They are nearly level to gently sloping and are on uplands. They have moderate to moderately slow permeability and high available water capacity. Water erosion is a slight hazard.

The climax plant community consists mostly of tall and mid grasses and a lesser amount of short grasses. About 65 percent of the total annual production is such decreasers as little bluestem, big bluestem, and switchgrass. Other perennial forbs and grasses make up the rest. The principal increasers are side-oats gramma, blue gramma, buffalograss, western wheatgrass, red three-awn, western ragweed, and prairie coneflower. Common invaders are windmillgrass, tumblegrass, annual bromes, and little barley.

The first plants to decrease under continuous overuse are big bluestem and little bluestem, and side-oats grama then increases. Because of many years of overuse, a large part of this range site is in only fair condition, and blue grama, buffalograss, and western wheatgrass are the main plants grazed.

The total annual production of air-dry herbage on this site averages approximately 3,000 pounds per acre, but it ranges from 3,500 pounds in favorable years to 2,500 pounds in unfavorable years.

SANDS RANGE SITE

The only soil in this site is Inavale loamy sand. This is a deep, well-drained soil that formed in coarse-textured alluvium. It has a coarse-textured surface layer and subsoil. It is nearly level to strongly sloping and is on high terraces. This soil has rapid permeability and low available water capacity. The hazard of water erosion is slight, but soil blowing is a severe hazard in areas that are overgrazed or otherwise mismanaged.

The climax plant community consists mostly of tall and mid grasses. About 80 percent of the total annual production is such decreasers as sand bluestem, big bluestem, little bluestem, switchgrass, indiangrass, sand lovegrass, prairie sandreed, and scribner panicum. Principal increasers are sand dropseed, blue grama, hairy grama, buffalograss, sand paspalum, wildplum, red three-awn, purple lovegrass, and hairy goldaster. Common invaders are silver bluestem, annual three-awn, six-weeks fescue, and annual bromes.

The first plants to decrease under continuous use are sand bluestem, big bluestem, and indiangrass, and then little bluestem and switchgrass.

The total annual production of air-dry herbage on this site averages approximately 3,000 pounds per acre, but it ranges from 3,500 pounds in favorable years to 2,500 pounds in unfavorable years.

SANDY RANGE SITE

The only soil in this site is Anselmo fine sandy loam, 2 to 6 percent slopes. This is a deep, well-drained soil that formed in moderately coarse textured outwash. It has a moderately coarse textured surface layer and subsoil. It is gently sloping to sloping and is on uplands. This soil has moderately rapid permeability and moderate available water capacity. The hazard of water erosion is slight, but soil blowing is a hazard if the range is overgrazed.

The climax plant community consists mostly of tall and mid grasses. About 70 percent of the total annual production is such decreasers as sand bluestem, big bluestem, little bluestem, switchgrass, indiangrass, and sand lovegrass. The principal increasers are sand dropseed, blue grama, hairy grama, buffalograss, sand paspalum, small soapweed, common pricklypear, wildplum, and red three-awn. Common invaders are silver bluestem, annual three-awn, windmillgrass, tumblegrass, and annual bromes.

The first plants to decrease under continuous use are big bluestem, sand bluestem, and indiangrass, and then switchgrass.

The total annual production of air-dry herbage on this site averages approximately 2,200 pounds per acre, but it ranges from 3,000 pounds in favorable years to 1,800 pounds in unfavorable years.

SANDY LOWLAND RANGE SITE

The only soil in this site is Munjor sandy loam. This is a deep, well-drained soil that formed in moderately coarse textured alluvium. It has a moderately coarse textured surface layer and subsoil. It is nearly level to gently undulating and is on flood plains. This soil has moderately rapid permeability and moderate available water capacity. The hazard of water erosion is slight, but soil blowing is a hazard if the range is overgrazed.

The climax plant community on this site consists mostly of tall and mid grasses. About 80 percent of the total annual production is such decreasers as sand bluestem, big bluestem, little bluestem, switchgrass, and indiangrass. Other perennial forbs and grasses make up the rest. The principal increasers are sand dropseed, blue grama, and western wheatgrass. Common invaders are sandbur, annual three-awn, annual bromes, and windmillgrass.

This site is readily accessible to grazing animals, and because of continuous overuse, it is generally in only fair condition. The first plants to decrease are big bluestem, little bluestem, and indiangrass, then switchgrass. Blue grama, sand dropseed, and western wheatgrass generally are the main plants grazed.

The total annual production of air-dry herbage on this site averages approximately 4,000 pounds per acre, but it ranges from 4,500 pounds per acre in favorable years to 3,500 pounds in unfavorable years.

SANDY TERRACE RANGE SITE

The only soil in this range site is McCook fine sandy loam. This is a deep, well-drained soil that formed in moderately coarse textured and medium-textured alluvium. It has a moderately coarse textured surface layer and a medium-textured subsoil. It is nearly level and gently undulating and is on terraces along the major streams. Permeability is moderate, and available water capacity is high. Water erosion is a slight hazard, but soil blowing is a severe hazard if the range is overgrazed.

The climax plant community consists mostly of tall and mid grasses. About 80 percent of the total annual production is such decreasers as big bluestem, little bluestem, switchgrass, and indiangrass. Other perennial forbs and grasses make up the rest. The principal increasers are blue grama, sand dropseed, side-oats grama, and western wheatgrass. Common invaders are sandbur, annual bromes, windmillgrass, and tumblegrass.

The first plants to decrease under continuous overuse are big bluestem, little bluestem, and indiangrass, and then switchgrass and side-oats grama. Because of many years of overuse, a large part of this range site is in

***Figure 22.*—Heizer-Armo complex in Shallow Limy and Limy Upland range sites.**

only fair condition, and side-oats grama, sand dropseed, and blue grama are the main plants grazed.

The total annual production of air-dry herbage on this site averages approximately 3,200 pounds per acre, but it ranges from 4,000 pounds in favorable years to 2,800 pounds in unfavorable years.

SHALLOW LIMY RANGE SITE

This range site is on shallow, well-drained, medium-textured soils that formed in material weathered from caliche or chalky limestone. They are sloping to moderately steep and are on uplands. In places there are outcrops of caliche or chalky limestone. The soils have moderate permeability but very low available water capacity. Water erosion is a severe hazard, and soil blowing is a hazard if the soils are severely overgrazed or otherwise mismanaged. The rough broken topography, characterized by some nearly vertical ledges, makes this site difficult for livestock to graze (fig. 22).

The climax plant community consists mostly of tall and mid grasses. About 80 percent of the total annual production is such decreasers as little bluestem, big bluestem, switchgrass, plains muhly, leadplant, resinous skullcap, and prairieclover. The principal increasers are side-oats grama, blue grama, hairy grama, purple three-awn, broom snakeweed, and aromatic and smooth sumac. A common invader is annual three-awn.

Because of rough topography, some areas of this site are not readily accessible to grazing livestock and are in good to excellent condition. Continuous overuse results mostly in the decrease of big bluestem and little bluestem. The vegetation on this site will improve greatly if grazing is deferred at times.

The total annual production of air-dry herbage on this site averages approximately 1,600 pounds per acre, but it ranges from 2,500 in favorable years to 900 pounds in unfavorable years.

SUBIRRIGATED RANGE SITE

This range site is on deep, somewhat poorly drained soils that formed in moderately coarse textured alluvium. These soils have a medium-textured to moderately coarse textured surface layer and a moderately coarse textured subsoil. They are nearly level to gently undulating and are on flood plains. The soils have moderately rapid permeability and low to high available water capacity. Water erosion is a slight hazard, and soil blowing is a hazard if the range is overgrazed or otherwise mismanaged.

The climax plant community consists mostly of tall and mid grasses. About 90 percent of the total annual production is such decreasers as big bluestem, indiangrass, switchgrass, Canada wildrye, prairie cordgrass, little bluestem, and Illinois bundleflower. Other perennial forbs and grasses make up the rest. The principal increasers are western wheatgrass, side-oats grama, blue grama, sedges, and western ragweed. Common invaders are Kentucky bluegrass, saltgrass, barnyardgrass, little barley, and annual bromes.

The first plants to decrease under continuous overuse are big bluestem and indiangrass, then little bluestem, switchgrass, and prairie cordgrass.

The total annual production of air-dry herbage on this site averages approximately 7,000 pounds per acre. The subirrigated conditions nullify the effects of moisture received in favorable and less favorable years.

WETLAND RANGE SITE

The only soil in this range site is Alluvial land, wet. This is a deep, somewhat poorly drained to poorly

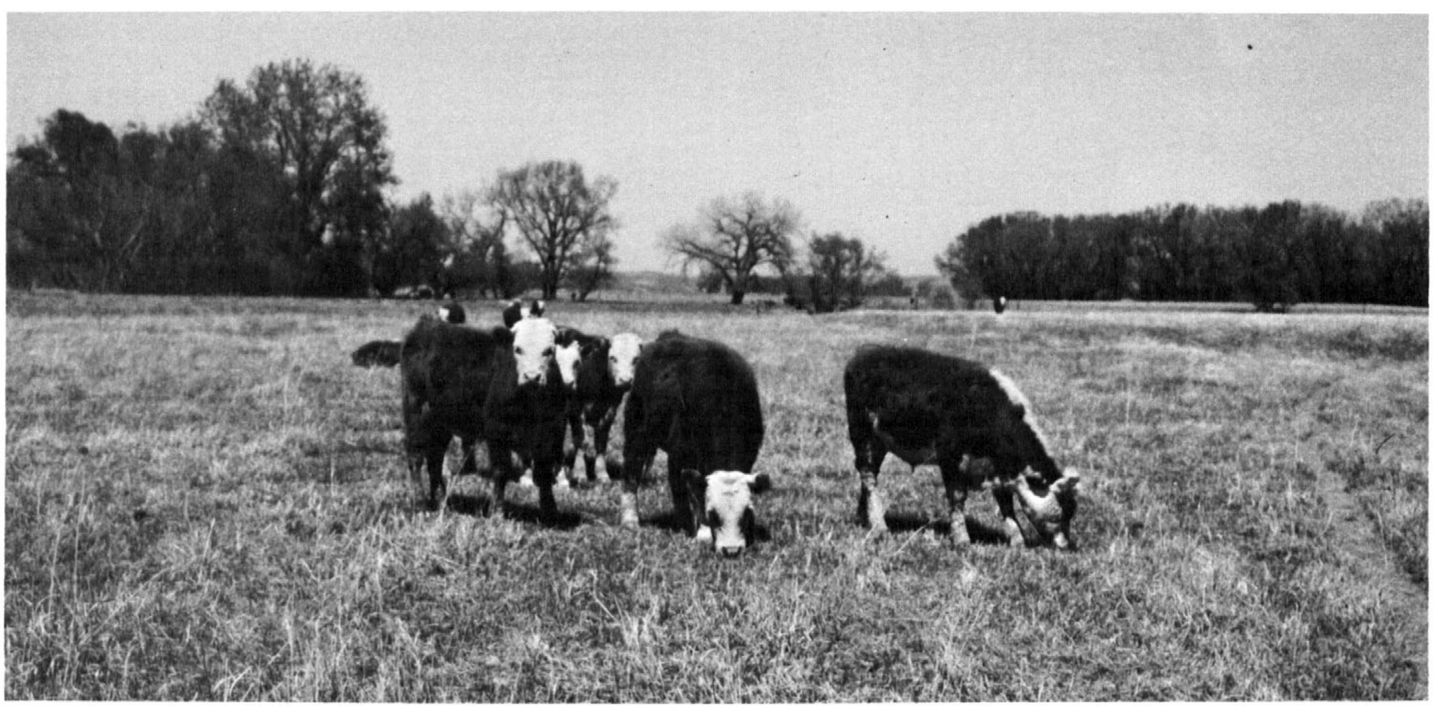

***Figure 23.*—Area of Wetland range site. Mixture of warm and cool-season grasses provides green forage for a long grazing season.**

drained, medium-textured soil that formed in alluvium. It is nearly level to gently undulating and is on flood plains adjacent to streams. The water table is above a depth of 2 feet most of the year. Permeability is moderate, and available water capacity is high. Water erosion, except for that produced by flooding, is slight. Soil blowing is not a hazard. This is one of the best sites for the production of forage (fig. 23).

The climax plant community consists mostly of tall grasses. About 90 percent of the total annual production is such decreasers as prairie cordgrass, alkali cordgrass, Canada wildrye, rice cutgrass, switchgrass, American bulrush, slough sedge, and Illinois bundleflower. Other perennial forbs and grasses make up the rest. The principal increasers are swamp smartweed, American licorice, knotroot bristlegrass, indigobush, slim sedge, foxtail barley, and cattail. Common invaders are barnyardgrass, yellow bristlegrass, annual sedge, and rushes.

The first plant to decrease under continuous overuse is switchgrass, and then rice cutgrass, prairie cordgrass, and alkali cordgrass.

The estimated total annual production of air-dry herbage averages approximately 7,500 pounds per acre. Wetness nullifies the effects of moisture received in favorable and less favorable years.

Windbreaks [5]

Native woodlands in Ellis County are narrow strips and belts of trees along major streams and in river valleys. The principal native tree species in the deep, fertile river valleys are cottonwood, sandbar and peachleaf willows, red elm, American elm, hackberry, boxelder, and green ash. These species rarely grow in stands large enough in acreage or in productivity to be rated as commercial woodland. The native woodlands did, however, provide the early settlers with wood for fuel, fenceposts, and rough lumber. At the present time trees are used mainly for farmstead windbreaks and field shelterbelts.

[5] By F. DEWITT ABBOTT, State resource conservationist.

Farmstead windbreaks are planted around the farmsteads and ranch houses, corrals, feed yards, and orchards to protect these areas from cold wintery winds. If properly designed, farmstead windbreaks also control snowdrifts and keep them out of the farmyards and corrals. The wind-chill index is greatly influenced by a good farmstead windbreak. Fuel bills in the farm home can be reduced and the area surrounding the farmyard made more attractive, all of which increase the value of the property (fig. 24).

Field windbreaks are most effective in protecting soils susceptible to blowing if they are planted in belts, two or more rows wide, across the fields. The belts should be planted 10 to 40 rods apart, depending on the degree of the hazard of soil blowing. In some years production may be increased, because blast damage from hot winds is prevented and damage to crops is reduced.

Windbreaks should be carefully designed and laid out before the trees are planted. The species of trees and shrubs selected should be those best adapted to the soils of the area.

Poor establishment and survival of trees in windbreak plantings is generally caused by lack of application of moisture conservation practices and inadequate seedbed preparation. It is essential that a firm, weedfree seedbed be prepared before the trees are planted. On most soils in Ellis County, areas to be planted to windbreaks should be prepared in the same way as for field crops.

The trees and shrubs should be planted early in

Figure 24.—**Windbreak of Siberian elm and redcedar on Harney silt loam, 0 to 1 percent slopes.**

spring. The seedlings must be protected from drying out before they are planted. As tree and shrub seedlings are planted, the soil should be firmly tamped around the roots.

Young trees need a considerable amount of care to grow well. Rainfall is likely to be limited and irregular. The windbreak should be cultivated as often as necessary to control weeds and to reduce competition for soil moisture.

The windbreak must be protected from livestock. Protection from fire is important and can be done by continuous cultivation for weed control on the isolation strip surrounding the windbreak. Sometimes rabbits and mice chew the bark and girdle young trees in a windbreak.

Windbreak suitability groups

Successful survival and growth of trees in the Central Great Plains is influenced to a great extent by the kinds of soil and by soil-air-moisture relationships. Trees normally grow best on a sandy loam. They have only fair to poor growth on clay, because soil moisture is absorbed and released slowly by the clay. This is especially true for clay soils on uplands, because they are more subject to drought. Very sandy soils are not well suited to trees, because they do not store enough water and plant nutrients.

The soils in each group are similar in characteristics that affect the growth of trees. The windbreak suitability group assigned to each soil is shown in the "Guide to Mapping Units" and in the section "Descriptions of the Soils."

A vigor rating for the best adapted species by windbreak suitability group is given in table 3. A vigor of *excellent* indicates that the trees grow well, leaves have good color, there are no dead branches in the upper part of the crown, and there is no indication of damage by fungi or disease. A rating of *good* indicates that the trees grow moderately well, there are few dead branches and some die-back in upper part of crown, and fungi or insects cause slight damage. A rating of *fair* indicates that at least half of the trees have a significant number of dead branches in the upper part of the crown, about one-fourth of the trees are dead, tree growth is slow, and fungi or insects cause moderate damage. A rating of *poor* indicates that the surviving trees will have severe die-back, less than three-fourths of the trees planted will survive, and fungi and insects cause severe damage.

Estimated height of trees at 20 years of age for the four windbreak suitability groups is also given in table 3. The height is based on measurements by resource conservationists and soil scientists working in this area.

Fish and Wildlife Management [6]

All soils in Ellis County can be managed to produce some kinds of wildlife. The soil associations provide information of value in planning wildlife habitat developments for the maximum use and production of the various species. Table 4 rates the potential of each of the seven soil associations for producing food and cover for various kinds of wildlife. In the following paragraphs, representative wildlife species are discussed according to the association in which they most generally occur.

Ring-necked pheasant are present on all soil associations. The Armo-Bogue-Heizer association probably has fewer birds, because it is dominantly range.

Fair to good populations of bobwhite are on all soil associations. The most are on the Roxbury-Eltree-Hord and Mento-Brownell-Wakeen associations.

White-tailed and mule deer are on all soil associations. White-tailed deer mainly inhabit the Roxbury-Eltree-Hord association. Mule deer are on all soil associations where there is woody cover.

Wetland wildlife, such as waterfowl, mink, and muskrat, is most numerous on the Roxbury-Eltree-Hord association. The soils of this association are in stream valleys, where trees and crops grow in close proximity.

Fishing varies from poor to good in the farm ponds, lakes, and streams in Ellis County. The Saline River, in the northern part of the county, provides limited fishing. The game fish in the county are largemouth bass, bluegill, channel catfish, yellow catfish, bullhead, and crappie.

Assistance in planning and developing wildlife habitat can be obtained at the local office of the Soil Conservation Service; the Kansas Forestry, Fish, and Game Commission; U.S. Fish and Wildlife Service; and the Extension Service.

Engineering Uses of the Soils [7]

This subsection provides information of special interest to engineers, contractors, farmers, and others who use soil as structural material or as foundation material upon which structures are built. It describes those properties of the soil that affect construction and maintenance of roads and airports, pipelines, building foundations, irrigation systems, water storage facilities, erosion control structures, drainage systems, landfills for solid waste disposal, and sewage disposal systems. Among the soil properties most important in engineering are permeability, shear strength, density, shrink-swell potential, available water capacity, grain size distribution, plasticity, and reaction. Information concerning these and related soil properties is furnished in tables 5, 6, and 7. The estimates and interpretations of soil properties in these tables can be used in—

1. Planning and designing agricultural drainage systems, farm ponds, irrigation systems, diversion terraces, waterways, and other structures for controlling water and conserving soil.
2. Selecting potential locations for highways, airports, pipelines, sewage disposal structures, underground cables, and solid waste disposal facilities.
3. Locating probable sources of sand, gravel, and rock suitable for use as construction material.

[6] By JACK W. WALSTROM, biologist, Soil Conservation Service.

[7] By LAWRENCE E. ROBINS, civil engineer, and ROBERT K. GLOVER, soil scientist, Soil Conservation Service.

TABLE 3.— *Suitability of adapted trees for windbreaks*

[Estimated height on soils given a poor suitability rating is not

Windbreak suitability group and description	Eastern redcedar		Ponderosa pine		Honeylocust		Siberian elm	
	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height
		Ft		*Ft*		*Ft*		*Ft*
Group 1: Deep, clayey and loamy lowland soils	Excellent	24	Excellent	25	Good	36	Excellent	47
Group 2: Deep, clayey and loamy upland soils	Excellent	19	Fair to good	19	Fair to poor	30	Fair	45
Group 3: Moderately deep to deep, limy, clayey and loamy upland soils.	Good	18	Fair	18	Fair to poor	22	Good	32
Group 4: Shallow, steep soils	Poor		Poor		([1])		Poor	

[1] Species not suited to soils of this group.

and estimated heights at 20 years of age

shown, because trees are either dead or resprouted but have little growth]

Cottonwood		Green ash		Hackberry		Mulberry		Osage-orange		Russian-olive	
Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height
	Ft		*Ft*		*Ft*		*Ft*		*Ft*		*Ft*
Excellent	48	Fair	29	Excellent	30	Excellent	17	Excellent	20	Good	20
Poor		Poor		Fair	21	Good	15	Excellent	19	Fair	15
Poor		Poor		Fair	19	Good	15	Good	18	Fair	15
[1]		[1]		Poor		Poor		Fair	15	Poor	

TABLE 4.—*Potential of the soil associations for providing habitat required for various kinds of wildlife*

[Absence of a rating indicates that that type of habitat is not applicable to fish]

Soil association	Kinds of wildlife	Potential for producing, for kinds of wildlife given—			
		Woody cover	Herbaceous cover	Aquatic habitat	Food
1. Roxbury-Eltree-Hord association.	Upland	Good	Good	Good	Good.
	Woodland	Good	Good	Good	Good.
	Wetland	Good	Good	Good	Good.
	Fish			Good	Good.
2. Mento-Brownell-Wakeen association.	Upland	Fair	Good	Good	Good.
	Woodland	Poor	Good	Fair	Fair.
	Wetland	Poor	Good	Fair	Fair.
	Fish			Fair	Good.
3. Armo-Bogue-Heizer association.	Upland	Fair	Good	Fair	Good.
	Woodland	Poor	Good	Fair	Fair.
	Wetland	Very poor	Fair	Fair	Fair.
	Fish			Fair	Fair.
4. Corinth-Harney association.	Upland	Fair	Good	Fair	Good.
	Woodland	Fair	Good	Fair	Fair.
	Wetland	Poor	Fair	Fair	Fair.
	Fish			Fair	Fair.
5. Campus-Harney-Carlson association.	Upland	Fair	Good	Fair	Good.
	Woodland	Fair	Good	Fair	Fair.
	Wetland	Poor	Fair	Fair	Fair.
	Fish			Fair	Fair.
6. Harney-Carlson-Armo association.	Upland	Fair	Good	Fair	Good.
	Woodland	Fair	Good	Fair	Fair.
	Wetland	Fair	Fair	Fair	Fair.
	Fish			Fair	Fair.
7. Harney-Wakeen-Nibson association.	Upland	Fair	Good	Fair	Good.
	Woodland	Poor	Good	Fair	Fair.
	Wetland	Poor	Fair	Fair	Fair.
	Fish			Fair	Fair.

4. Selecting potential industrial, commercial, residential, and recreational areas.

The engineering interpretations reported here do not eliminate the need for sampling and testing specific engineering works involving heavy loads at the site and where the excavations are deeper than the depths or layers here reported. Even in these situations, however, the soil map is useful in planning more detailed field investigations and for indicating the kind of problems that may be expected.

Some terms used by soil scientists may be unfamiliar to engineers, and some of the words have different meanings in soil science than they have in engineering. Among the terms that have special meaning in soil science are sand, clay, silt, surface layer, subsoil, and horizon. These and other terms are defined in the Glossary at the back of this publication.

Engineering classification systems

The two systems most commonly used in classifying samples of soil for engineering *(7)* are the AASHO system, adopted by the American Association of State Highway Officials, and the Unified system, used by SCS engineers, the Department of Defense, and others.

The AASHO system is used to classify soils according to those properties that affect use in highway construction *(1)*. In this system, a soil is placed in one of seven basic groups ranging from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A-1 are gravelly soils of high bearing strength, and at the other extreme, A-7, are clay soils that have low strength when wet. The best soils for subgrade are therefore classified as A-1, the next best as A-2, and so on to class A-7, the poorest soil for subgrade. Where laboratory data are available to justify a further breakdown, the A-1, A-2, and A-7 groups are divided as follows: A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, and A-7-6. If soil material is near a classification boundary, it is given a symbol showing both classes; for examples, A-2 or A-4. Within each group, the relative engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHO classification for tested soils, with index numbers in parentheses, is shown in table 7; the estimated classification for all soils mapped in the survey is given in table 5.

In the Unified system soils are classified according to particle-size distribution, plasticity, liquid limit, and organic-matter content *(12)*. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designed by symbols for both classes; for example CL or CH.

Estimated soil properties significant to engineering

Table 5 provides estimates of soil properties important to engineering. The estimates are based on field classification and description, physical and chemical tests of selected representative samples, test data from comparable soils in adjacent areas, and detailed experience in working with the individual kinds of soil in the survey area. The information is generalized for each soil and is the best available estimate of the specific soil properties. The properties of a soil designated by a given name may vary somewhat within the county. In addition, some mapping units contain small included areas of contrasting soils.

Seasonal high water table, not given in table 5, relates to the periodic presence of free water within the profile each year. Only two series in this county, Boel and Wann, have a seasonal high water table. In these soils the depth from the soil surface to the surface of existing free water may vary from 2 to 6 feet, and it generally rises and falls with changes in streamflow in the adjacent watercourse.

Depth to bedrock is the distance from the surface of the soil to the upper surface of the rock layer.

USDA texture is determined by relative proportions of sand, silt, and clay in soil material that is less than 2.0 millimeters in diameter *(9)*. "Sand," "silt," "clay," and some of the other terms used in the USDA textural classification are defined in the Glossary.

Permeability, as used in table 5, relates only to movement of water downward through undisturbed and uncompacted soil. It does not include lateral seepage. The estimates are based on structure and porosity of the soil. Plowpans, surface crusts, and other properties resulting from use of the soil are not considered.

Available water capacity is that amount of water in the soil available for plant growth after all free water has drained away.

Reaction is the degree of acidity of alkalinity of a soil, expressed as pH. The pH value and relative terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is an indication of the volume change to be expected of the soil material with changes in moisture content. Shrinking and swelling of soils cause much damage to building foundations, roads, and other structures. A high shrink-swell potential indicates hazards to construction and maintenance of structures constructed in, on, or of such material.

Interpretations of engineering properties of the soils

Table 6 contains selected information useful to engineers and others who plan to use soil material in construction of highways, farm facilities, buildings, sewage disposal systems, and solid waste disposal systems. Detrimental or undesirable features are emphasized, but important desirable features also are listed. The ratings and other interpretations in this table are based on estimated engineering properties of the soils given in table 5 and on field experience. Though the information applies to soils only at depths indicated in table 5, it is reasonably reliable to a depth of about 6 feet for most soils, and several feet more for some.

Sanitary land fill cover material is influenced chiefly by slope, workability, drainage, and thickness of material. The degree of limitation and principal reasons for assigning fair and poor values are given in the table.

Topsoil is fertile soil or soil material, ordinarily rich in organic matter, used as a topdressing for lawns, gardens, roadbanks, and the like. The ratings in table 6 indicate suitability for such use and the limitations that are present.

Sand and gravel ratings are based on the probability that mapped areas of soil contain deposits of sand and gravel. The ratings do not indicate the size of the deposit, but general restrictive features are given to indicate the quality of the material that can be expected.

Road subgrade is material used to support the subbase, base, and surface course of roads and highways. The ratings indicate the performance of soil material moved from borrow areas for this purpose.

Road fill is material used to build embankments. The ratings indicate performance of soil material moved from borrow areas for this purpose.

Highway location is influenced by features of the undisturbed soil that affect construction and maintenance of highways. The soil features, favorable as well as unfavorable, are the principal ones that affect geographic location of highways.

Pond reservoir areas are influenced by the features and qualities of undisturbed soils that affect their suitability for water impoundments. The controlling features for this use are permeability, slope, depth to restrictive layers, water table, sand, or bedrock.

Embankments, dikes, and levees are influenced by the features and qualities of disturbed soils that affect their suitability for constructing earthfills to impound or divert water. Soil features listed, favorable as well as unfavorable, are the principal ones that affect this use.

Terraces, diversions, and waterways are influenced by features of the soil, favorable as well as unfavorable, that affect stability or hinder layout, construction, and maintenance.

Irrigation is influenced by features, favorable as well as unfavorable, that affect the suitability of the soils for irrigation.

Septic tank absorption fields are affected mainly by permeability, depth to the water table, susceptibility to flooding, depth of the soil, and slope. The degree of limitation and principal reasons for assigning moderate or severe limitations are given.

Sewage lagoons are influenced chiefly by such soil features as permeability, depth to the water table, slope, and depth of the soil. The degree of limitation and principal reasons for assigning moderate or severe limitations are given.

Shallow excavations are those that require trenching to a depth of 6 feet or less. They include excavations for underground utility lines, cemeteries, sanitary land fills, basements, and open ditches. The factors influencing this land use are workability, soil drainage, water

TABLE 5.—*Estimates of soil*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. fully the instructions for referring to other series that appear in the first column

Soil series and map symbols	Depth to bedrock	Depth from surface	Classification: USDA texture
	Feet	*Inches*	
Alluvial land: Ab, Ac, Ad. Properties too variable to estimate.			
Anselmo: Ae	>5	0–10	Fine sandy loam
		10–35	Sandy loam
		35–60	Loamy sand
Armo: Am, An, Ao, Ar	>5	0–10	Heavy loam
		10–15	Silt loam
		15–41	Light clay loam
		41–51	Silt loam and gravelly loamy sand
		51–60	Fine and medium gravel
Boel:[1] Bf	>5	0–10	Fine sandy loam
		10–43	Loamy sand
		43–60	Silt loam
*Bogue: Bg, Bo. For Armo part of Bo, see Armo series.	2–3	0–17	Clay
		17–23	Clay
		23–32	Weathered clay shale
		32	Clay shale.
Brownell: Br	2–3	0–7	Gravelly loam
		7–15	Very gravelly loam
		15–30	Channery loam
		30	Chalky limestone.
*Campus: Cc, Cd. For Carlson part of Cc, see Carlson series; for Penden part of Cd, see Penden series.	2–3	0–9	Loam
		9–19	Light clay loam
		19–33	Loam
		33	Caliche.
Canlon: Ce	1–2	0–8	Loam
		8–13	Loam
		13	Caliche.
Carlson. Mapped only in a complex with Campus and Harney soils.	>5	0–8	Silt loam
		8–12	Silty clay loam
		12–18	Heavy silty clay loam
		18–23	Light silty clay loam
		23–60	Clay loam
Corinth: Cm, Cn, Co	2–3	0–9	Silty clay loam
		9–22	Heavy silty clay loam
		22–30	Heavy silty clay loam
		30–47	Weathered shale
Crete: Cr. Ct	>5	0–16	Silty clay loam
		16–34	Silty clay
		34–41	Silty clay loam
		41–68	Silty clay loam
Detroit:[1] De	>5	0–12	Silt loam
		12–16	Light silty clay loam
		16–26	Light silty clay
		26–48	Heavy silty clay loam
		48–63	Silt loam
Eltree: Ee, Ef, Eg, Eh	>5	0–35	Silt loam
		35–63	Light silty clay loam

See footnotes at end of table.

properties significant in engineering

The soils in such mapping units may have different properties and limitations, and for this reason it is necessary to follow care-
of this table. The symbol < means less than; the symbol > means more than]

Classification—Con.		Percentage less than 3 inches passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)				
						Inches per hour	*Inches per inch of soil*	*pH*	
SM	A-4	100	100	75-85	40-50	2.0-6.3	0.10-0.14	6.1-6.5	Low.
SM	A-4 or A-2	100	100	60-70	30-40	2.0-6.3	0.09-0.13	6.6-7.8	Low.
SM	A-2	100	100	65-75	15-25	2.0-6.3	0.06-0.09	7.4-7.8	Low.
CL	A-6	100	95-100	85-95	60-75	0.63-2.0	0.14-0.18	6.6-7.3	Low.
CL	A-6	100	95-100	90-100	80-90	0.63-2.0	0.14-0.18	7.4-7.8	Low.
CL	A-6	100	95-100	90-100	70-80	0.63-2.0	0.14-0.18	7.9-8.4	Low.
CL	A-6	85-95	70-80	65-75	51-60	0.63-2.0	0.14-0.16	7.9-8.4	Low.
SM or GM	A-1	50-70	25-35	20-30	15-25	2.0-6.3	0.03-0.05	7.9-8.4	Low.
SM	A-4	100	100	75-85	40-50	2.0-6.3	0.10-0.14	6.6-8.4	Low.
SM	A-2	100	100	65-75	15-30	2.0-6.3	0.06-0.09	6.6-8.4	Low.
ML	A-4	100	100	90-100	80-90	0.63-2.0	0.16-0.18	6.6-8.4	Low.
CH	A-7	100	100	95-100	90-100	<0.06	0.11-0.14	6.6-8.4	High.
CH	A-7	100	100	95-100	90-100	<0.06	0.11-0.14	4.5-6.0	High.
CH	A-7	100	100	90-100	90-100	<0.06	0.11-0.14	3.5-5.8	High.
SM or SC	A-2	[2]50-80	40-50	30-45	20-35	0.63-2.0	0.10-0.14	7.4-8.4	Low.
GM or GC	A-2	[2]40-50	30-45	20-40	13-30	0.63-2.0	0.06-0.10	7.9-8.4	Low.
GM, GC, GW-GM or GW-GC	A-1	[2]20-40	15-35	10-30	8-25	0.63-2.0	0.06-0.10	7.9-8.4	Low.
ML or ML-CL	A-7 or A-6	100	100	80-95	51-80	0.63-2.0	0.12-0.16	7.4-8.4	Low.
ML-CL or SM-SC	A-7	100	100	55-95	40-80	0.63-2.0	0.15-0.19	7.4-8.4	Low.
SM	A-4 or A-6	100	100	55-80	36-50	0.63-2.0	0.12-0.16	7.4-8.4	Low.
ML or ML-CL	A-7 or A-6	100	100	85-100	60-85	0.63-2.0	0.12-0.16	7.4-8.4	Low.
SM	A-6	100	100	55-80	36-50	0.63-2.0	0.12-0.16	7.4-8.4	Low.
ML or CL	A-4 or A-6	100	100	90-100	85-100	0.63-2.0	0.14-0.18	6.1-7.8	Low.
CL	A-7	100	100	95-100	90-100	0.63-2.0	0.14-0.18	6.6-7.8	Moderate.
CH or CL	A-7	100	100	95-100	90-100	0.2-0.63	0.14-0.18	7.4-8.4	High.
CH or CL	A-7	100	100	90-100	90-100	0.2-0.63	0.14-0.18	7.9-8.4	High.
CL	A-6 or A-7	100	100	90-100	70-80	0.63-2.0	0.14-0.18	7.9-8.4	Moderate.
CH or CL	A-7	100	100	95-100	70-90	0.2-0.63	0.14-0.18	7.4-7.8	Moderate.
CH or CL	A-7	100	100	95-100	75-95	0.2-0.63	0.14-0.18	7.9-8.4	Moderate.
CL or CH	A-7	100	100	95-100	75-95	0.2-0.63	0.14-0.18	7.9-8.4	Moderate.
CL or CH	A-7	100	100	95-100	75-95	0.2-0.63	0.14-0.18	7.9-8.4	Moderate.
CL	A-7	100	100	100	90-100	0.63-2.0	0.14-0.18	5.6-6.5	Moderate.
CH	A-7	100	100	100	90-100	0.06-0.2	0.14-0.18	5.6-7.8	High.
CH or CL	A-7	100	100	95-100	90-100	0.2-0.63	0.14-0.18	6.6-7.8	High.
CL or CH	A-7	100	100	100	90-100	0.63-2.0	0.14-0.18	6.6-7.8	Moderate.
ML or CL	A-4 or A-6	100	100	90-100	70-90	0.63-2.0	0.14-0.18	6.1-7.3	Moderate.
CH or CL	A-7	100	100	95-100	85-95	0.2-0.63	0.14-0.18	6.1-7.3	High.
CH	A-7	100	100	95-100	90-95	0.06-0.2	0.14-0.18	6.6-7.8	High.
CH or CL	A-7	100	100	95-100	85-95	0.2-0.63	0.14-0.18	7.4-8.4	High.
ML or CL	A-4 or A-6	100	100	90-100	70-90	0.63-2.0	0.14-0.18	7.4-8.4	Moderate.
ML-CL or CL	A-4 or A-6	100	100	90-100	70-90	0.63-2.0	0.14-0.18	6.6-7.3	Moderate.
CL	A-6	100	100	95-100	85-95	0.63-2.0	0.14-0.18	7.4-7.8	Moderate.

TABLE 5.—*Estimates of soil properties*

Soil series and map symbols	Depth to bedrock	Depth from surface	Classification: USDA texture
	Feet	*Inches*	
*Harney: Ha, Hb, Hc, Hd, He, Hf, Hg, Hh, Hk. For Armo part of He, see Armo series; for Carlson part of Hf and Hg, see Carlson series; for Wakeen part of Hh and Hk, see Wakeen series.	6-10	>5	Silt loam
		0-6	Light silty clay loam
		10-30	Heavy silty clay loam or light silty clay
		30-40	Heavy silty clay loam
		40-60	Light silty clay loam
*Heizer: Hl. For Armo part of Hl, see the Armo series.	1-2	0-6	Gravelly loam
		6-14	Channery loam
		14	Chalky limestone.
Hilly land: Hn. Properties too variable to estimate.			
Holdrege: Ho, Hp	>5	0-10	Silt loam
		10-25	Silty clay loam
		25-39	Silt loam
		39-63	Silty clay loam
Hord:[1] Hr	>5	0-18	Silt loam
		18-43	Light silty clay loam
		43-65	Heavy silt loam
Inavale:[1] In	>5	0-14	Loamy sand
		14-31	Sand
		31-63	Loamy sand
McCook:[1] Mc, Md	>5	0-16	Light silt loam
		16-76	Coarse silt loam
Mento: Me, Mf, Mg, Mo	3-6	0-9	Silt loam
		9-41	Silty clay loam
		41-67	Clay loam and gravelly clay loam
		67	Chalk.
Munjor:[1] Mu	>5	0-44	Sandy loam
		44-60	Medium sand
New Cambria: Nc	>5	0-38	Silty clay
		38-46	Heavy silty clay loam
		46-60	Light silty clay loam
Nibson: Nn	1-2	0-7	Heavy silt loam
		7-19	Silty clay loam
		19	Shale.
Penden. Mapped only in a complex with Campus soils.	>5	0-8	Light clay loam
		8-27	Clay loam
		27-64	Light clay loam
Rough broken land: Ro. Properties too variable to rate.			
Roxbury: Rb, Rf	>5	0-24	Silt loam
		24-60	Light silty clay loam
Wakeen: Wa, We, Wh, Wk	2-3	0-5	Silt loam
		5-10	Light silty clay loam
		10-36	Silty clay loam
		36	Chalk.
Wann:[1] Wn	>5	0-12	Loam
		12-24	Fine sandy loam
		24-44	Loam
		44-64	Very fine sandy loam

[1] Subject to flooding.

significant in engineering—Continued

Classification—Con.		Percentage less than 3 inches passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)				
						Inches per hour	*Inches per inch of soil*	*pH*	
ML-CL or CL	A–6 or A–7	100	100	95–100	80–95	0.63–2.0	0.14–0.18	6.1–7.3	Moderate.
CL	A–7	100	100	95–100	80–100	0.63–2.0	0.14–0.18	6.1–7.3	Moderate.
CL or CH	A–7	100	100	95–100	80–100	0.2–0.63	0.14–0.18	6.6–8.4	High.
CL or CH	A–7	100	100	95–100	80–100	0.2–0.63	0.14–0.18	7.4–8.4	High.
CL	A–6	100	100	95–100	80–100	0.63–2.0	0.14–0.18	7.4–8.4	Moderate.
SM or SC	A–2	50–80	40–50	30–45	25–35	0.63–2.0	0.10–0.14	7.9–8.4	Low.
GM, GC, GW-GM, or GW-GC	A–1	20–40	15–35	10–30	8–25	0.63–2.0	0.06–0.10	7.9–8.4	Low.
ML-CL or CL	A–4 or A–6	100	100	90–100	70–90	0.63–2.0	0.14–0.18	6.6–7.3	Low.
CL	A–7	100	100	95–100	85–95	0.63–2.0	0.14–0.18	6.6–7.3	Moderate.
ML-CL or CL	A–4 or A–6	100	100	90–100	70–90	0.63–2.0	0.14–0.18	7.4–8.2	Low.
ML-CL or CL	A–6 or A–7	100	100	90–100	70–90	0.63–2.0	0.14–0.18	7.4–8.2	Low.
ML-CL or CL	A–4 or A–6	100	100	90–100	70–90	0.63–2.0	0.14–0.18	6.6–7.8	Low.
CL	A–7	100	100	90–100	85–95	0.63–2.0	0.14–0.18	7.4–8.4	Low.
ML-CL or CL	A–4 or A–6	100	100	90–100	85–95	0.63–2.0	0.14–0.18	7.9–8.4	Low.
SM	A–2	100	100	50–75	15–30	6.3–20.0	0.06–0.09	7.4–7.8	Low.
SP-SM	A–3	100	100	50–70	5–10	6.3–20.0	0.03–0.05	7.4–7.8	Low.
SM	A–2	100	100	55–70	25–25	2.0–6.3	0.06–0.09	7.9–8.4	Low.
ML or ML-CL	A–4	100	100	90–100	70–100	0.63–2.0	0.12–0.16	7.4–8.4	Low.
ML or ML-CL	A–4	100	100	90–100	60–100	0.63–2.0	0.12–0.16	7.9–8.4	Low.
ML or CL	A–4 or A–6	100	100	90–100	85–100	0.63–2.0	0.14–0.18	6.6–7.8	Low.
CH or CL	A–7	100	95–100	90–100	85–100	0.06–0.2	0.14–0.18	7.4–8.4	High.
CL, SC, or SM	A–6 or A–7	100	85–95	55–85	45–75	0.2–0.63	0.14–0.18	7.9–8.4	Moderate.
SM or SM-SC	A–2	100	95–100	60–70	20–35	2.0–6.3	0.09–0.13	7.4–8.4	Low.
SP or SP-SM	A–3	95–100	90–95	55–70	0–10	6.3–20.0	0.06–0.09	7.4–8.4	Low.
CH	A–7	100	100	95–100	90–100	0.06–0.2	0.14–0.18	7.4–8.4	High.
CH	A–7	100	100	95–100	85–100	0.2–0.63	0.14–0.18	7.4–8.4	High.
CL	A–7	100	100	95–100	85–100	0.63–2.0	0.14–0.18	7.4–8.4	Moderate.
ML or CL	A–4 or A–6	70–100	70–95	65–95	60–90	0.63–2.0	0.12–0.16	7.4–8.3	Low.
ML or CL	A–6 or A–7	70–95	65–95	60–90	55–90	0.63–2.0	0.14–0.18	7.9–8.4	Low.
ML-CL or CL	A–6	100	100	90–100	70–80	0.63–2.0	0.14–0.18	7.4–8.4	Low.
CL	A–6	100	100	90–100	70–80	0.63–2.0	0.14–0.18	7.4–8.4	Low.
CL	A–6	100	100	90–100	70–80	0.63–2.0	0.14–0.18	7.9–8.4	Low.
ML or CL	A–6 or A–7	100	100	90–100	90–100	0.63–2.0	0.14–0.18	7.4–8.4	Low to moderate.
CL	A–6	100	100	95–100	85–100	0.63–2.0	0.14–0.18	7.4–8.4	Low to moderate.
ML-CL or CL	A–6 or A–7	100	100	90–100	70–90	0.63–2.0	0.14–0.18	7.4–8.4	Low.
ML-CL or CL	A–6 or A–7	100	100	95–100	70–90	0.63–2.0	0.14–0.18	7.4–8.4	Low to moderate.
ML-CL or CL	A–6 or A–7	100	100	95–100	80–95	0.63–2.0	0.14–0.18	7.9–8.4	Low to moderate.
ML	A–4	100	100	85–95	60–75	2.0–6.3	0.12–0.16	7.4–8.4	Low.
SM or ML	A–4	100	100	70–85	40–55	2.0–6.3	0.09–0.13	7.4–8.4	Low.
ML	A–4	100	100	85–95	60–75	2.0–6.3	0.12–0.16	7.4–8.4	Low.
ML	A–4	100	100	85–95	50–65	2.0–6.3	0.12–0.16	7.4–8.4	Low.

[2] Estimate of fragments larger than 3 inches in diameter in the Brownell soil is 0 to 10 percent in the 0- to 7-inch layer; 5 to 35 percent in the 7- to 15-inch layer; and 10 to 40 percent in the 15- to 30-inch layer.

TABLE 6.—*Interpretations of*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. the instructions for referring to other series

Soil series and map symbols	Suitability as source of—					Soil features affecting—	
	Sanitary land-fill cover material	Topsoil	Sand and gravel	Road subgrade [1]	Road fill [1]	Highway location [1]	Pond reservoir areas
Alluvial land: Ab, Ac, Ad. No interpretations, material too variable							
Anselmo: Ae	Good	Good	Poor: excessive fines.	Fair: fair shear strength.	Fair: fair shear strength.	Moderate erodibility.	Moderately rapid permeability; slopes of 2 to 6 percent.
Armo: Am, An, Ao, Ar.	Fair: slopes of 1 to 15 percent; clay loam subsoil.	Fair: slopes of 1 to 15 percent; calcareous.	Unsuited	Poor: low soil support.	Fair: fair shear strength.	Slopes of 1 to 15 percent.	Moderate permeability; slopes of 1 to 15 percent.
Boel: Bf	Fair: loamy sand texture.	Fair: fine sandy loam surface layer; loamy sand at a depth of 10 inches.	Fair: excessive fines.	Good	Good	Seasonal high water table at a depth of 2 to 6 feet; frequent flooding; moderate erodibility.	Moderately rapid permeability; slopes of 0 to 2 percent; seasonal high water table at a depth of 2 to 6 feet; good wet pit sites.
*Bogue: Bg, Bo For Armo part of of Bo, see Armo series.	Poor: slopes of 3 to 25 percent; clay texture; shale at a depth of 20 to 40 inches.	Poor: very firm if moist; slopes of 3 to 25 percent; clay texture.	Unsuited	Poor: high shrink-well potential.	Poor: poor shear strength.	Slopes of 3 to 25 percent; shale at a depth of 20 to 40 inches.	Very slow permeability; slopes of 3 to 25 percent; shale at a depth of 20 to 40 inches.

See footnotes at end of table.

engineering properties of the soils

The soils in such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully that appear in the first column of this table]

Soil features affecting—Con.			Degree and kind of limitation for—				
Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Foundations for low buildings	Sanitary landfill [2] (trench and area types)
Fair stability; good compaction if closely controlled; fair shear strength; high piping hazard.	Slopes of 2 to 6 percent; moderate erodibility; moderately rapid permeability.	Slopes of 2 to 6 percent; moderately rapid permeability; well drained; moderate available water capacity.	Slight	Severe: moderately rapid permeability.	Slight	Slight	Severe: moderately rapid permeability.
Fair stability; good compaction; fair shear strength.	Slopes of 1 to 15 percent; clay loam subsoil; moderate permeability.	Slopes of 1 to 15 percent; highly calcareous; well drained; high available water capacity.	Slight where slopes are 1 to 8 percent. Moderate where slopes are 8 to 15 percent: moderate permeability.	Moderate where slopes are 1 to 7 percent; moderate permeability. Severe where slopes are 7 to 15 percent.	Moderate: slopes of 1 to 15 percent; clay loam subsoil.	Slight where slopes are 1 to 8 percent. Moderate where slopes are 8 to 15 percent.	Slight for trench type. Slight for area type where slopes are 1 to 8 percent. Moderate for area type where slopes are 8 to 15 percent.
Fair stability; good compaction if closely controlled; high piping hazard; fair workability.	Frequently flooded; seasonal high water table at a depth of 2 to 6 feet; somewhat poorly drained.	Frequently flooded; somewhat poorly drained; low available water capacity.	Severe: seasonal high water table at a depth of 2 to 6 feet; frequently flooded.	Severe: seasonal high water table at a depth of 2 to 6 feet; frequently flooded.	Severe: seasonal high water table at a depth of 2 to 6 feet; somewhat poorly drained.	Severe: seasonal high water table at a depth of 2 to 6 feet; frequently flooded.	Severe: seasonal high water table at a depth of 2 to 6 feet; frequently flooded.
Poor stability; poor shear strength; poor workability; high shrink-swell potential.	Slopes of 3 to 25 percent; shale at a depth of 20 to 40 inches; clay texture; very firm if moist.	Slopes of 3 to 25 percent; shale at a depth of 20 to 40 inches; clay texture; very slow permeability.	Severe: very slow permeability; slopes of 3 to 25 percent; shale at a depth of 20 to 40 inches.	Moderate where slopes are less than 7 percent. Severe where slopes are 7 to 25 percent: shale at a depth of 20 to 40 inches.	Severe: shale at a depth of 20 to 40 inches; clay texture; slopes of 3 to 25 percent.	Severe: shale at a depth of 20 to 40 inches; slopes of 3 to 25 percent; high shrink-swell potential.	Severe: shale at a depth of 20 to 40 inches; clay texture; slopes of 3 to 25 percent.

TABLE 6.—*Interpretations of engineering*

Soil series and map symbols	Suitability as source of—					Soil features affecting—	
	Sanitary landfill cover material	Topsoil	Sand and gravel	Road subgrade [1]	Road fill [1]	Highway location [1]	Pond reservoir areas
Brownell: Br	Poor: chalky limestone at a depth of 20 to 40 inches; coarse fragments.	Poor: coarse fragments.	Fair: source of crushed rock.	Good in upper 15 inches. Poor below depth of 15 inches: coarse fragments.	Fair: fair compaction.	Chalky limestone at a depth of 20 to 40 inches; slopes of 2 to 10 percent.	Moderate permeability; slopes of 2 to 10 percent; chalky limestone at a depth of 20 to 40 inches.
*Campus: Cc, Cd. For Carlson part of Cc, see Carlson series; for Penden part of Cd, see Penden series.	Fair: caliche and outwash at a depth of 20 to 40 inches.	Fair: slopes of 3 to 15 percent; clay loam subsoil.	Unsuited	Poor: low soil support.	Fair: fair shear strength.	Slopes of 3 to 15 percent; moderate erodibility; caliche and outwash at a depth of 20 to 40 inches.	Moderate permeability; slopes of 3 to 15 percent; caliche and outwash at a depth of 20 to 40 inches.
Canlon: Ce	Poor: caliche at a depth of 10 to 20 inches; slopes of 5 to 25 percent.	Poor: caliche at a depth of 10 to 20 inches; slopes of 5 to 25 percent; highly calcareous.	Unsuited	Poor: low soil support.	Fair: fair shear strength.	Moderate erodibility; caliche at a depth of 10 to 20 inches; slopes of 5 to 25 percent.	Moderate permeability; slopes of 5 to 25 percent; caliche at a depth of 10 to 20 inches.
Carlson. Mapped only in a complex with Campus and Harney soils.	Fair: silty clay loam texture; firm.	Fair: 8 inches of silt loam over silty clay loam subsoil.	Unsuited: pockets of good sand in places; 4 to 6 feet of overburden.	Poor: high plasticity.	Fair: fair to poor shear strength.	Slopes of 0 to 7 percent.	Moderately slow permeability; slopes of 0 to 7 percent.
Corinth: Cm, Cn, Co.	Fair: firm; shale at a depth of 20 to 40 inches; silty clay loam texture; slopes of 1 to 15 percent.	Fair: silty clay loam texture; slopes of 1 to 15 percent.	Unsuited	Fair: fair shear strength.	Fair: fair shear strength.	Shale at a depth of 20 to 40 percent; slopes of 1 to 15 percent.	Moderately slow permeability; shale at a depth of 20 to 40 inches; slopes of 1 to 15 percent.

See footnotes at end of table.

properties of the soils—Continued

Soil features affecting—Con.			Degree and kind of limitation for—				
Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Foundations for low buildings	Sanitary landfill [2] (trench and area types)
Fair compaction; fair workability.	Slopes of 2 to 10 percent; coarse fragments; chalky limestone at a depth of 20 to 40 inches.	Slopes of 2 to 10 percent; chalky limestone at a depth of 20 to 40 inches; low available water capacity.	Severe: chalky limestone at a depth of 20 to 40 inches; slopes of 2 to 10 percent.	Severe: chalky limestone at a depth of 20 to 40 inches; slopes of 2 to 10 percent; coarse fragments.	Severe: chalky limestone at a depth of 20 to 40 inches; coarse fragments; slopes of 2 to 10 percent.	Moderate: slopes of 2 to 10 percent; chalky limestone at a depth of 20 to 40 inches.	Severe for trench type: chalky limestone at a depth of 20 to 40 inches. Slight to moderate for area type: slopes of 2 to 10 percent.
Poor stability; fair compaction; fair shear strength; high piping hazard.	Slopes of 3 to 15 percent; clay loam subsoil; caliche and outwash at a depth of 20 to 40 inches.	Caliche and outwash at a depth of 20 to 40 inches; slopes of 3 to 15 percent; low available water capacity.	Severe: caliche and outwash at a depth of 20 to 40 inches.	Severe: caliche and outwash at a depth of 20 to 40 inches.	Severe: slopes of 3 to 15 percent; caliche and outwash at a depth of 20 to 40 inches.	Moderate: slopes of 3 to 15 percent; caliche and outwash at a depth of 20 to 40 inches.	Severe for trench type: caliche and outwash at a depth of 20 to 40 inches. Moderate for area type: slopes of 3 to 15 percent.
Poor stability; fair compaction; high piping hazard; fair shear strength.	Caliche at a depth of 10 to 20 inches; slopes of 5 to 25 percent; low fertility.	Caliche at a depth of 10 to 20 inches; slopes of 5 to 25 percent; very low available water capacity.	Severe: caliche at a depth of 10 to 20 inches; slopes of 5 to 25 percent.	Severe: caliche at a depth of 10 to 20 inches; slopes of 5 to 25 percent.	Severe: caliche at a depth of 10 to 20 inches; slopes of 5 to 25 percent.	Severe: caliche at a depth of 10 to 20 inches; slopes of 5 to 25 percent.	Severe: caliche at a depth of 10 to 20 inches; slopes of 5 to 25 percent.
Poor stability; fair compaction; fair to poor shear strength.	Slopes of 0 to 7 percent; silty clay loam subsoil; moderately slow permeability; moderate erodibility.	Slopes of 0 to 7 percent; well drained; high available water capacity; moderately slow permeability.	Severe: moderately slow permeability.	Slight to moderate: slopes of 0 to 7 percent.	Slight	Moderate: silty clay loam texture; moderate to high shrink-swell potential.	Moderate for trench type: silty clay loam texture. Slight for area type.
Fair stability; fair compaction; moderate shrink-swell potential; high compressibility.	Shale at a depth of 20 to 40 inches; slopes of 1 to 15 percent; silty clay loam texture; moderately slow permeability.	Shale at a depth of 20 to 40 inches; slopes of 1 to 15 percent; well drained; moderate available water capacity; high erodibility.	Severe: shale at a depth of 20 to 40 inches; slopes of 1 to 15 percent.	Moderate where slopes are 1 to 7 percent. Severe where slopes are 7 to 15 percent: shale at a depth of 20 to 40 inches.	Severe: shale at a depth of 20 to 40 inches; slopes of 1 to 15 percent:	Moderate: slopes of 1 to 15 percent; shale at a depth of 20 to 40 inches; moderate shrink-swell potential.	Severe for trench type: shale at a depth of 20 to 40 inches. Slight to moderate for area type: slopes of 1 to 15 percent.

TABLE 6.—*Interpretations of engineering*

Soil series and map symbols	Suitability as source of—					Soil features affecting—	
	Sanitary landfill cover material	Topsoil	Sand and gravel	Road subgrade [1]	Road fill [1]	Highway location [1]	Pond reservoir areas
Crete: Cr, Ct	Poor: very firm; silty clay subsoil.	Fair: 16 inches of silty clay loam over silty clay subsoil.	Unsuited	Poor: high plasticity.	Fair: fair shear strength.	Slow permeability.	Slow permeability; slopes of 0 to 1 percent.
Detroit: De	Poor: silty clay subsoil.	Fair: 12 inches of silt loam over silty clay loam subsoil.	Unsuited	Poor: high plasticity.	Fair: fair shear strength.	All features favorable.	Slow permeability; slopes of 0 to 2 percent.
Eltree: Ee, Ef, Eg, Eh.	Fair: slopes of 0 to 15 percent.	Fair: slopes of 0 to 15 percent.	Unsuited	Fair: medium soil support.	Fair: fair shear strength.	Slopes of 0 to 15 percent.	Moderate permeability; slopes of 0 to 15 percent.
*Harney: Ha, Hb, Hc, Hd, He, Hf, Hg, Hh, Hk. For Armo part of He, see Armo series; for Carlson part of Hf and Hg, see Carlson series; for Wakeen part of Hh and Hk, see Wakeen series.	Fair: firm; silty clay loam subsoil.	Fair: 6 inches of loam over silty clay loam subsoil.	Unsuited	Fair: medium plasticity.	Fair: fair shear strength.	Slopes of 0 to 7 percent.	Moderately slow permeability; slopes of 0 to 7 percent.

See footnotes at end of table.

properties of the soils—Continued

Soil features affecting—Con.			Degree and kind of limitation for—				
Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Foundations for low buildings	Sanitary landfill [2] (trench and area types)
Fair stability; fair compaction; poor workability; high compressibilty.	Slopes of 0 to 1 percent; silty clay subsoil; slow permeability; moderate erodibility.	Slopes of 0 to 1 percent; moderately well drained; slow permeability; high available water capacity.	Severe: slow permeability.	Slight	Severe: silty clay subsoil.	Moderate: moderately well drained; high shrink-swell potential.	Severe for trench type: silty clay subsoil. Slight for area type.
Fair stability; fair compaction; high compressibility.	Slopes of 0 to 2 percent; occasional flooding; silty clay subsoil; slow permeability.	Slopes of 0 to 2 percent; occasional flooding; well drained; slow permeability; high available water capacity.	Severe: slow permeability; occasional flooding.	Severe: occasional flooding.	Severe: silty clay subsoil; occasional flooding.	Severe: occasional flooding; high shrink-swell potential.	Severe: occasional flooding.
Fair stability; good compaction; moderate shrink-swell potential; medium compressibility.	Slopes of 0 to 15 percent; silty clay loam subsoil; moderate erodibility.	Slopes of 0 to 15 percent; well drained; high available water capacity; moderate permeability.	Slight where slopes are 0 to 8 percent. Moderate where slopes are 8 to 15 percent: moderate permeability.	Severe: moderate permeability; slopes of 0 to 15 percent.	Moderate: slopes of 0 to 15 percent.	Moderate: slopes of 0 to 15 percent; moderate shrink-swell potential.	Moderate for trench type: silty clay loam subsoil. Slight to moderate for area type: slopes of 0 to 15 percent.
Fair stability; good compaction; high shrink-swell potential; medium compressibility.	Slopes of 0 to 7 percent; silty clay loam subsoil; moderately slow permeability; moderate erodibility.	Slopes of 0 to 7 percent; well drained; high available water capacity; moderately slow permeability.	Severe: moderately slow permeability.	Slight to moderate: slopes of 0 to 7 percent.	Slight	Severe: high shrink-swell potential; silty clay loam subsoil.	Moderate for trench type: silty clay loam subsoil. Slight for area type.

TABLE 6.—*Interpretations of engineering*

Soil series and map symbols	Suitability as source of—					Soil features affecting—	
	Sanitary land-fill cover material	Topsoil	Sand and gravel	Road subgrade [1]	Road fill [1]	Highway location [1]	Pond reservoir areas
*Heizer: Hl. For Armo part of Hl, see Armo series.	Poor: chalky limestone at at depth of 10 to 20 inches; slopes of 8 to 25 percent.	Poor: more than 35 percent coarse fragments; chalky limestone at a depth of 10 to 20 inches.	Good: road limestone gravel.	Poor: platy fragments 3 to 6 inches in diameter.	Fair: fair compaction.	Chalky limestone at a depth of 10 to 20 inches; slopes of 8 to 25 percent.	Moderate permeability; chalky limestone at a depth of 10 to 20 inches; slopes of 8 to 25 percent.
Hilly land: Hn. No interpretations, material too variable.							
Holdrege: Ho, Hp.	Fair: firm; silty clay loam subsoil.	Fair: 10 inches of silt loam over silty clay loam subsoil.	Unsuited	Fair: medium soil support.	Fair: fair shear strength.	All features favorable.	Moderate permeability; slopes of 0 to 3 percent.
Hord: Hr	Fair: silty clay loam subsoil.	Good	Unsuited	Fair: medium soil support.	Fair: fair shear strength.	All features favorable.	Moderate permeability; slopes of 0 to 2 percent.
Inavale: In	Fair: loamy sand texture; slopes of 0 to 10 percent.	Poor: loamy sand texture.	Fair for sand: excessive fines. Poor for gravel: 3 to 5 feet overburden.	Good	Good	High erodibility; slopes of 0 to 10 percent.	Rapid permeability; slopes of 0 to 10 percent.
McCook: Mc, Md.	Good	Good	Unsuited	Fair: medium soil support.	Good	Moderate erodibility.	Moderate permeability; slopes of 0 to 2 percent.

See footnotes at end of table.

properties of the soils—Continued

Soil features affecting—Con.			Degree and kind of limitation for—					
Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Foundations for low buildings	Sanitary landfill [2] (trench and area types)
Good stability; good compaction; high piping hazard.	Chalky limestone at a depth of 10 to 20 inches; gravelly loam surface; moderate erodibility.	Chalky limestone at a depth of 10 to 20 inches; well drained; very low available water capacity; highly calcareous.	Severe: chalky limestone at a depth of 10 to 20 inches; slopes of 8 to 25 percent.	Severe: chalky limestone at a depth of 10 to 20 inches; slopes of 8 to 25 percent.	Severe: chalky limestone at a depth of 10 to 20 inches; slopes of 8 to 25 percent.	Severe: chalky limestone at a depth of 10 to 20 inches; slopes of 8 to 25 percent.	Severe: chalky limestone at a depth of 10 to 20 inches; slopes of 8 to 25 percent.
Fair stability; good compaction characteristics; moderate piping hazard; moderate erodibility.	Slopes of 0 to 3 percent; silty clay loam subsoil; moderate erodibility.	Slopes of 0 to 3 percent; well drained; high available water capacity; moderate permeability.	Slight to moderate: moderate permeability.	Moderate: slopes of 0 to 3 percent; moderate permeability.	Slight	Moderate: moderate shrink-swell potential.	Slight: cover material good.
Fair stability; good compaction charisteristics; moderate piping hazard.	Slopes of 0 to 2 percent; silty clay loam subsoil; occasional flooding.	Slopes of 0 to 2 percent; occasional flooding; well drained; high available water capacity.	Slight to moderate in most areas: moderate permeability. Severe in low areas: occasional flooding.	Moderate in most areas: moderate permeability. Severe in low areas: occasional flooding.	Slight in most areas. Severe in low areas: occasional flooding.	Moderate: in most areas: fair shear strength. Severe in low areas: occasional flooding.	Slight where not flooded, severe where flooded; cover material good.
Fair stability; good compaction; high piping hazard.	Slopes of 0 to 10 percent; loamy sand texture; low available water capacity; high soil blowing hazard.	Slopes of 0 to 10 percent; occasional flooding; well drained; low available water capacity.	Severe: slopes of 0 to 10 percent; occasional flooding.	Severe: rapid permeability; slopes of 0 to 10 percent; occasional flooding.	Severe: loamy sand texture; occasional flooding.	Severe: occasional flooding.	Severe: occasional flooding.
Poor stability; good compaction if closely controlled; high piping hazard.	Slopes of 0 to 2 percent; well drained; moderate permeability; calcareous.	Slopes of 0 to 2 percent; moderate available water capacity; well drained; moderate permeability.	Moderate where not subject to flooding: moderate permeability. Severe where subject to flooding.	Moderate where not subject to flooding: moderate permeability. Severe where subject to flooding.	Slight	Slight	Slight.

TABLE 6.—*Interpretations of engineering*

Soil series and map symbols	Suitability as source of—					Soil features affecting—	
	Sanitary land-fill cover material	Topsoil	Sand and gravel	Road subgrade [1]	Road fill [1]	Highway location [1]	Pond reservoir areas
Mento: Me, Mf, Mg, Mo.	Fair: firm; silty clay loam subsoil.	Fair: silty clay loam subsoil.	Unsuited	Poor: high shrink-swell potential.	Poor: poor stability.	High sodium content; chalky limestone at a depth of 40 to 70 inches; slopes of 0 to 7 percent.	Slopes of 0 to 7 percent; chalky lime stone at a depth of 40 to 70 inches; slow permeability.
Munjor: Mu	Good	Fair: sandy loam texture.	Fair below a depth of 4 feet: excessive fines.	Good	Good	Frequently flooded; moderate erodibility.	Moderately rapid permeability; seasonal water table; slopes of 0 to 2 percent.
New Cambria: Nc.	Poor: very firm; silty clay texture.	Poor: very firm; silty clay texture.	Unsuited	Poor: high shrink-swell potential.	Poor: poor shear strength.	Slow permeability.	Slow permeability; slopes of 0 to 3 percent.
Nibson: Nn	Poor: limestone at a depth of 10 to 20 inches.	Fair: limestone at a depth of 10 to 20 inches; silty clay loam texture.	Unsuited	Poor: low soil support.	Fair: fair shear strength.	Limestone at a depth of 10 to 20 inches; slopes of 5 to 12 percent; moderate erodibility.	Moderate permeability; slopes of 5 to 12 percent; limestone at a depth of 10 to 20 inches.
Penden Mapped only in a complex with Campus soils.	Fair: clay loam texture.	Fair: clay loam texture; slopes of 5 to 15 percent.	Poor for sand: excessive fines; 5 to 7 feet of overburden.	Poor: low soil support.	Fair: fair shear strength.	Slopes of 5 to 15 percent.	Moderate permeability; slopes of 5 to 15 percent.

See footnotes at end of table.

properties of the soils—Continued

Soil features affecting—Con.			Degree and kind of limitation for—				
Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Foundations for low buildings	Sanitary landfill [2] (trench and area types)
Fair stability; fair compaction; moderate piping hazard.	Slopes of 0 to 7 percent; chalky limestone at a depth of 40 to 70 inches; silty clay loam subsoil; high erodibility.	Slopes of 0 to 7 percent; chalky limestone at a depth of 40 to 70 inches; high sodium content; high available water capacity.	Severe: chalky limestone at a depth of 40 to 70 inches; slow permeability.	Moderate where slopes are 2 to 7 percent; chalky limestone at a depth of 40 to 70 inches. Slight where slopes are 0 to 2 percent.	Moderate: chalky limestone at a depth of 40 to 70 inches.	Moderate: moderate to high shrink-swell potential; chalky limestone at a depth of 40 to 70 inches.	Severe for trench type: chalky limestone at a depth of 40 to 70 inches. Slight for area type.
Fair stability; good compaction; high piping hazard.	Slopes of 0 to 2 percent; seasonal water table; sandy loam texture; frequently flooded.	Slopes of 0 to 2 percent; frequently flooded; seasonal water table; moderate available water capacity.	Severe: seasonal water table; frequently flooded.	Severe: seasonal water table; frequently flooded.	Severe: frequently flooded; seasonal water table.	Severe: frequently flooded; seasonal water table.	Severe: seasonal water table; frequently flooded; moderately rapid permeability.
Fair stability; poor compaction; poor workability; poor shear strength; high compressibility.	Slopes of 0 to 3 percent; silty clay texture; slow permeability; miderately well drained; high shrink-swell potential.	Slopes of 0 to 3 percent; moderately well drained; high available water capacity; slow permeability; silty clay texture.	Severe: slow permeability.	Slight	Severe: silty clay texture; moderately well drained.	Severe: high shrink-swell potential.	Severe for trench type: silty clay texture. Slight for area type.
Limestone at a depth of 10 to 20 inches; fair stability; fair compaction; high piping hazard; fair shear strength.	Slopes of 5 to 12 percent; limestone at a depth of 10 to 20 inches; very low available water capacity; silty clay loam subsoil; highly calcareous.	Slopes of 5 to 12 percent; limestone at a depth of 10 to 20 inches; very low available water capacity; somewhat excessively drained.	Severe: limestone at a depth of 10 to 20 inches; slopes of 5 to 12 percent.	Severe: limestone at a depth of 10 to 20 inches; slopes of 5 to 12 percent.	Severe: limestone at a depth of 10 to 20 inches; slopes of 5 to 12 percent.	Severe: limestone at a depth of 10 to 20 inches; slopes of 5 to 12 percent.	Severe for trench type: limestone at a depth of 10 to 20 inches. Moderate for area type: slopes of 5 to 12 percent.
Fair stability; good compaction; high erodibility.	Slopes of 5 to 15 percent; clay loam texture; high erodibility; calcareous.	Slopes of 5 to 15 percent; well drained; high available water capacity.	Moderate: slopes of 5 to 15 percent; moderate permeability.	Severe: slopes of 5 to 15 percent; moderate permeability.	Severe: slopes of 5 to 15 percent; clay loam texture.	Moderate: well drained; slopes of 5 to 15 percent.	Moderate: clay loam texture; slopes of 5 to 15 percent.

TABLE 6.—*Interpretations of engineering*

Soil series and map symbols	Suitability as source of—					Soil features affecting—	
	Sanitary landfill cover material	Topsoil	Sand and gravel	Road subgrade [1]	Road fill [1]	Highway location [1]	Pond reservoir areas
Roxbury: Rb, Rf	Good	Good	Unsuited	Fair: medium soil support.	Fair: fair shear strength.	Occasional to frequent flooding.	Moderate permeability; slopes of 0 to 2 percent.
Rough broken land: Ro. No interpretations, material too variable.							
Wakeen: Wa, We, Wh, Wk.	Fair: silty clay loam texture; chalky limestone at a depth of 20 to 40 inches.	Fair: slopes of 1 to 15 percent; silty clay loam subsoil; highly calcareous.	Unsuited	Poor: low soil support.	Fair: fair shear strength.	Chalky limestone at a depth of 20 to 40 inches; slopes of 1 to 15 percent; moderate erodibility.	Moderate permeability; slopes of 1 to 15 percent.
Wann: Wn	Good	Good	Poor: high silt content.	Fair: medium soil support.	Fair: fair shear strength.	Fluctuating water table; frequently flooded; moderate erodibility.	Moderate permeability; slopes of 0 to 2 percent; seasonal water table at a depth of 2 to 6 feet.

[1] Interpretations for road subgrade, road fill, and highway location were made with the assistance of Norman Clark, engineer of soils, and Herbert E. Worley, soils research engineer, Kansas State Highway Commission, in cooperation with the U.S. Department of Commerce, Bureau of Public Roads.

properties of the soils—Continued

Soil features affecting—Con.			Degree and kind of limitation for—				
Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Foundations for low buildings	Sanitary landfill [2] (trench and area types)
Fair stability; good compaction; fair shear strength.	Slopes of 0 to 2 percent; silty clay loam subsoil; occasional to frequent flooding.	Slopes of 0 to 2 percent; well drained; moderate permeability; high available water capacity; occasional to frequent flooding.	Severe: occasional to frequent flooding.	Severe: moderate permeability; occasional to frequent flooding.	Severe: occasional to frequent flooding.	Severe: occasional to frequent flooding.	Severe: occasional to frequent flooding.
Fair stability; good compaction; fair shear strength; moderate erodibility.	Slopes of 1 to 15 percent; chalky limestone at a depth of 20 to 40 inches; silty clay loam subsoil; highly calcareous.	Slopes of 1 to 15 percent; chalky limestone at a depth of 20 to 40 inches; well drained; moderate permeability; moderate erodibility; highly calcareous.	Severe: chalky limestone at a depth of 20 to 40 inches; slopes of 1 to 15 percent.	Severe: chalky limestone at a depth of 20 to 40 inches; slopes of 1 to 15 percent.	Severe: chalky limestone at a depth of 20 to 40 inches; slopes of 1 to 15 percent.	Severe: chalky limestone at a depth of 20 to 40 inches; slopes of 1 to 15 percent.	Severe for trench type: chalky limestone at a depth of 20 to 40 inches. Slight to moderate for area type: slopes of 1 to 15 percent.
Poor stability; good compaction if closely controlled; high piping hazard.	Slopes of 0 to 2 percent; seasonal water table at a depth of 2 to 6 feet; moderate soil blowing hazard; frequently flooded.	Slopes of 0 to 2 percent; seasonal water table at a depth of 2 to 6 feet; somewhat poorly drained; frequent flooding; moderate available water capacity.	Severe: seasonal water table at a depth of 2 to 6 feet; frequently flooded.	Severe: seasonal water table at a depth of 2 to 6 feet; frequently flooded.	Severe: seasonal water table at a depth of 2 to 6 feet; frequently flooded.	Severe: seasonal water table at a depth of 2 to 6 feet; frequently flooded; somewhat poorly drained.	Severe: seasonal water table at a depth of 2 to 6 feet; frequently flooded.

[2] Onsite deep studies of the underlying strata and water table to determine the hazards of aquifer pollution and drainage into ground water should be made for landfills deeper than 5 to 6 feet.

TABLE 7.—*Engineering*

[Tests performed by the State Highway Commission of Kansas under a cooperative agreement with the Bureau of Public

Soil name and location	Parent material	SCS sample No.	Depth	Moisture-
				Maximum dry density
			In	*Lb per cu ft*
Armo loam: 1,400 feet E. and 3,500 feet N. of SW. corner of sec. 28, T. 11 S., R. 17 W. (modal).	Local colluvium from chalky limestone.	S-68-Kans-		
		26-7-2	2-10	103
		26-7-4	15-28	108
		26-7-6	28-41	114
Bogue clay: 1,550 feet E. and 450 feet S. of NW. corner of sec. 17, T. 12 S., R. 16 W. (modal).	Clay shale.	S-68-Kans-		
		26-1-2	0-6	93
		26-1-4	10-17	95
		26-1-6	23-32	94
Campus loam: 2,100 feet W. and 20 feet N. of SW. corner of sec. 5, T. 12 S., R. 20 W. (modal).	Caliche and unconsolidated outwash.	S-64-Kans-		
		26-15-1	0-8	107
		26-15-2	8-22	113
		26-15-3	22-42	108
Corinth silty clay loam: 2,140 feet S. and 1,600 feet W. of the NW. corner of sec. 10, T. 12 S., R. 16 W. (modal).	Calcareous shale.	S-64-Kans-		
		26-3-1	0-9	96
		26-3-2	9-20	100
		26-3-3	20-30	102
		26-3-4	30-48	102
Crete silty clay loam: 1,815 feet E. and 700 feet S. of NW. corner of sec. 34, T. 13 S., R. 16 W. (modal).	Loess.	S-64-Kans-		
		26-7-1	0-12	92
		26-7-2	16-23	95
		26-7-3	34-41	97
		26-7-4	41-68	99
Harney silt loam: 1,250 feet W. and 150 feet N. of SE. corner of sec. 17, T. 14 S., R. 20 W. (modal).	Calcareous loess.	S-64-Kans-		
		26-8-1	0-8	93
		26-8-2	14-23	97
		26-8-3	29-37	98
		26-8-4	45-56	101
Mento silt loam: 2,240 feet S. and 50 feet W. of NE. corner of sec. 8, T. 14 S., R. 20 W. (modal).	Thin loess over chalky limestone.	S-64-Kans-		
		26-11-1	0-8	94
		26-11-2	8-14	87
		26-11-3	21-32	99
		26-11-4	40-49	104
Roxbury silt loam: 2,300 feet W. and 1,400 feet S. of NE. corner of sec. 23, T. 13 S., R. 19 W. (modal).	Calcareous silty alluvium.	S-68-Kans-		
		26-11-3	11-16	101
		26-11-5	24-36	105
		26-11-6	36-50	103
Wakeen silt loam: 1,190 feet E. and 20 feet S. of NW. corner of sec. 29, T. 12 S., R. 20 W. (modal).	Residuum from chalky limestone.	S-64-Kans-		
		26-14-1	0-12	100
		26-14-2	12-20	97
		26-14-3	20-35	92
		26-14-4	35-55	90

[1] Based on AASHO Designation T99-57, Method A (*1*), with the following variations: (1) all material is ovendried at 230° F. and crushed in a laboratory crusher, and (2) no time is allowed for dispersion of moisture after mixing with the soil material.

[2] Mechanical analysis according to AASHO Designation T88-57 (*1*), with the following variations: (1) all material is ovendried at 230° F. and crushed in a laboratory crusher, (2) the sample is not soaked prior to dispersion, (3) sodium silicate is used as the dispersing agent, and (4) dispersing time, in minutes, is established by dividing the plasticity index value by 2; the maximum time is 15 minutes, and the minimum time is 1 minute. Results by this procedure may differ somewhat from results obtained

test data

Roads (BPR) in accordance with standard procedures of the American Association of State Highway Officials (AASHO)]

density [1]	Mechanical analysis [2]									Classification	
	Percentage less than 3 inches passing sieve—			Percentage smaller than—							
Optimum moisture	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	0.05 mm	0.02 mm	0.005 mm	0.002 mm	Liquid limit	Plasticity index	AASHO	Unified [3]
Pct								*Pct*			
17	98	94	71	62	42	20	17	36	14	A-6(9)	CL
17	99	97	75	66	45	27	22	31	12	A-6(9)	CL
13	99	92	77	64	39	24	20	28	11	A-6(8)	CL
23	100	100	97	96	90	78	66	65	41	A-7-6(20)	CH
22	100	100	98	97	91	78	63	64	38	A-7-6(20)	CH
25	100	100	98	97	91	78	63	64	38	A-7-6(20)	CH
14	100	82	51	42	23	7	4	37	13	A-6(4)	ML-CL
14	100	64	41	36	26	15	9	43	18	A-7-6(3)	SM-SC
15	100	67	40	36	28	17	9	38	18	A-6(3)	SM
22	100	98	81	73	57	41	32	52	29	A-7-6(18)	CH
20	100	99	87	82	73	59	48	51	28	A-7-6(17)	CH
21	100	97	88	85	77	62	47	49	29	A-7-6(17)	CL
22	100	98	89	83	73	58	45	50	29	A-7-6(18)	CL
23	100	100	93	81	52	27	20	43	19	A-7-6(12)	CL
20	100	100	97	89	68	48	44	62	41	A-7-6(20)	CH
23	100	99	95	88	66	43	36	53	33	A-7-6(19)	CH
23	100	100	96	89	63	34	26	46	24	A-7-6(15)	CL
20	100	100	88	77	45	21	15	45	19	A-7-6(13)	ML-CL
22	100	100	97	90	62	36	32	48	28	A-7-6(17)	CL
19	100	100	95	88	60	34	24	43	24	A-7-6(14)	CL
21	100	98	89	80	54	31	21	39	21	A-6(12)	CL
21	100	100	93	81	45	15	7	37	9	A-4(8)	ML
26	100	100	95	88	68	50	42	69	45	A-7-6(20)	CH
21	100	100	96	89	61	35	30	47	27	A-7-6(16)	CL
16	100	64	46	42	31	21	17	41	17	A-7-6(4)	SM
19	100	100	98	90	62	30	21	39	18	A-6(11)	CL
17	100	98	85	73	45	23	14	33	13	A-6(9)	CL
19	100	100	93	81	53	30	25	38	19	A-6(12)	CL
19	100	98	75	63	40	19	12	37	14	A-6(9)	ML-CL
22	100	96	74	67	53	36	27	44	19	A-7-6(12)	ML-CL
27	100	99	91	88	82	69	50	49	20	A-7-6(14)	ML-CL
29	100	100	92	89	84	69	47	48	19	A-7-6(13)	ML-CL

by 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 method and the material coarser than 2 millimeters in diameter is excluded from the calculations of grain-size fraction. The mechanical analysis data used in this table are not suitable for naming textural classes for soils.

[3] SCS and BPR have agreed to consider that all soils having plasticity indexes within two points of the A-line are to be given a borderline classification. Examples of borderline classifications obtained by this use are ML-CL and SM-SC.

table, flooding hazards, depth to bedrock, slopes, and soil texture. The principal reasons for assigning moderate or severe limitations are given in the table.

Foundations for low buildings are affected chiefly by features of the undisturbed soil that influence its capacity to support low buildings that have normal foundation loads. Specific values of bearing strength are not assigned.

Sanitary landfills are areas where layers of refuse are placed and compacted in existing gullies and depressions or in excavated trenches. The refuse is covered daily with 6-inch layers of soil until the gulley or trench is full, and then a final layer of soil 2 feet thick is placed on the landfill. The factors influencing this land use are hazard of flooding, water table, drainage, depth to bedrock, permeability, slope, and texture. The degree of limitation and reasons for assigning moderate or severe limitations are given in the table. Because soils in this survey were tested to depths of 6 feet or less, onsite investigation is essential for trench-type landfills.

Engineering test data

Table 7 contains the results of engineering tests performed by the Kansas State Highway Commission on several important soils in Ellis County. The table shows the specific location where samples were taken, the depth to which sampling was done, and the results of tests to determine particle-size distribution and other properties significant in soils engineering.

Maximum dry density is the maximum unit dry weight of the soil when it has been compacted at optimum moisture content by a prescribed method of compaction. The moisture content which gives the highest dry unit weight is called the optimum moisture content for the specific method of compaction.

Mechanical analyses show the percentages, by weight, of soil particles that pass sieves of specific sizes. Sand and coarser material does not pass through the No. 200 sieve. Silt and clay pass through the No. 200 sieve. Of the material that passes through the No. 200 sieve, silt is the material larger than 0.002 millimeters in diameter and clay is the material smaller than 0.002 millimeters in diameter. The clay fraction was determined by the hydrometer method, rather than the pipette method most soil scientists use in determining the clay in a sample.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a solid to a plastic state. If 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 changes from a solid to a plastic state; and the liquid limit, 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 plastic.

Recreation [8]

Several factors affect the increasing demand for various recreational facilities: the population is increasing and is becoming more mobile; highways are improving; personal incomes are rising, making more money available for leisure-time spending; and the amount of leisure time is increasing.

Ellis County is easily accessible by an excellent highway system. Interstate Highway 70 runs through the county from east to west, and U.S. Highway 183 runs north and south. Both highways are heavily used by vacationers.

Ft. Hays Kansas State University is located at Hays, and the students are potential recreation seekers. Three large reservoirs—Cedar Bluff, Webster, and Wilson—are located within 50 miles of Hays and provide much of the water-based recreation in the area.

Table 8 provides ratings of the limitation of the soils for recreational uses.

Camp areas are areas used for tents, small camp trailers, and related activities. They should be suitable for heavy foot or vehicular traffic. These areas are used frequently during the camping season. Suitability of the soils for vegetation should be considered separately in selecting sites for these uses.

Picnic areas are rated by the features of the soil only, but such other considerations as lakes, trees, or beauty may affect the desirability of the site.

Intensive play areas are areas used as playgrounds and for such activities as baseball, football, and badminton. Soils should be nearly level, well drained, and rock free. It is assumed that a good plant cover can be established and maintained where needed.

Paths and trails include areas for trails, cross-country hiking, bridle paths, and other nonintensive uses. It is not anticipated that the soils will have to be graded and shaped to any great extent. Ratings are based on soil features only, and do not include other factors that are important in the selection of a site for this use.

For information concerning the suitability of various soils for use as septic tank filter fields or sewage lagoons, see table 6.

Formation and Classification of the Soils

This section explains how soils form and discusses the factors that have affected the formation of soils in Ellis County. It describes briefly the current system of soil classification and places the soil series represented in the county in some classes of that system.

Factors of Soil Formation

Soil is produced by soil-forming processes acting on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate

[8] By JACK W. WALSTROM, biologist, Soil Conservation Service.

TABLE 8.—*Degree and kind of limitations affecting use of the soils for recreation*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for referring to other series that appear in the first column of this table]

Soil series and map symbols	Camp areas	Picnic areas	Intensive play areas	Paths and trails
Alluvial land: Ab	Severe: flooding	Severe: flooding	Severe: flooding	Slight: where slopes are less than 15 percent: flooding. Severe where slopes are more than 25 percent.
Ac	Severe: flooding; texture of surface layer.	Severe: flooding; texture of surface layer.	Severe: flooding; texture of surface layer.	Severe: texture of surface layer.
Ad	Sever: wetness; flooding.	Sever: wetness; flooding.	Severe: wetness; flooding.	Severe: wetness.
Anselmo: Ae	Slight	Slight	Slight where slopes are less than 2 percent. Moderate where slopes are 2 to 6 percent.	Slight.
Armo: Am, An, Ao, Ar	Slight where slopes are less than 8 percent. Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent.	Slight where slopes are less than 8 percent. Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent.	Slight where slopes are less than 2 percent. Moderate where slopes are 2 to 6 percent. Severe where slopes are more than 6 percent.	Slight where slopes are less than 15 percent. Moderate where slopes are 15 to 25 percent.
Boel: Bf	Severe: wetness; flooding.	Moderate: wetness; flooding.	Severe: wetness	Moderate: wetness.
*Bogue: Bg, Bo. For Armo part of Bo, see Armo series.	Severe: very slow permeability; clay surface layer; slopes of more than 15 percent.	Severe: clay surface layer; slopes of more than 15 percent.	Severe: very slow permeability; clay surface layer; slopes of more than 6 percent.	Severe: clay surface layer.
Brownell: Br	Slight where slopes are 0 to 8 percent. Moderate where slopes are 8 to 15 percent: gravelly surface layer.	Slight where slopes are less than 8 percent. Moderate where slopes are 8 to 15 percent: gravelly surface layer.	Moderate where slopes are 2 to 6 percent. Severe where slopes are more than 6 percent: gravelly surface layer.	Moderate: gravelly surface layer.
*Campus: Cc, Cd. For Carlson part of Cc, see Carlson series; for Penden part of Cd, see Penden series.	Slight where slopes are less than 8 percent. Moderate where slopes are more than 8 percent.	Slight where slopes are 0 to 8 percent. Moderate where slopes are 8 to 15 percent:	Moderate: slopes of 2 to 6 percent; depth to caliche is 20 to 40 inches. Severe: slopes over 6 percent.	Slight.
Canlon: Ce	Slight where slopes are 0 to 8 percent. Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent.	Slight where slopes are less than 8 percent. Moderate where slopes are 8 to 15 precent. Severe where slopes are more than 15 percent.	Severe: bedrock at a depth of less than 20 inches; slopes of more than 6 percent.	Slight where slopes are 0 to 15 percent. Moderate where slopes are 15 to 25 percent.
Carlson. Mapped only in a complex with Campus and Harney soils.	Moderate: moderately slow permeability;	Slight	Moderate where slopes are 2 to 6 percent; moderately slow permeability. Severe where slopes are more than 6 percent.	Slight.

TABLE 8.—*Degree and kind of limitations affecting use of the soils for recreation*—Continued

Soil series and map symbols	Camp areas	Picnic areas	Intensive play areas	Paths and trails
Corinth: Cm, Cn, Co	Moderate: moderately slow permeability. silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate where slopes are 2 to 6 percent; moderately slow permeability; silty clay loam surface layer; bedrock at a depth of 20 to 40 inches. Severe where slopes are more than 6 percent.	Moderate: silty clay loam surface layer.
Crete: Cr, Ct	Moderate: moderately well drained; slow permeability; silty loam surface layer.	Moderate: moderately well drained; silty clay loam surface layer.	Moderate: moderately well drained; slow permeability; silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Detroit: De	Moderate: slow permeability.	Slight	Moderate: slow permeability.	Slight.
Eltree: Ee, Ef, Eg, Eh	Slight where slopes are 0 to 8 percent. Moderate where slopes are more than 8 percent.	Slight where slopes are 0 to 8 percent; Moderate where slopes are more than 8 percent.	Slight where slopes are 0 to 2 percent. Moderate where slopes are 2 to 6 percent. Severe where slopes are more than 6 percent.	Slight.
*Harney: Ha, Hb, Hc, Hf, Hg, Hh, Hk	Moderate: moderately slow permeability.	Slight	Moderate where slopes are 2 to 6 percent: moderately slow permeability. Severe where slopes are more than 6 percent.	Slight.
Hd, He For Armo part of He, see Armo series; for Carlson part of Hf and Hg, see Carlson series; for Wakeen part of Hh and Hk, see Wakeen series.	Moderate: moderately slow permeability; silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate where slopes are 2 to 6 percent: silty clay loam surface layer; moderately slow permeability. Severe where slopes are more than 6 percent.	Moderate: silty clay loam surface layer.
*Heizer: Hl For Armo part, see Armo series.	Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent: rockiness.	Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent: rockiness.	Severe: bedrock at a depth of less than 20 inches; slopes of more than 6 percent; rockiness.	Slight where slopes are 0 to 15 percent. Moderate where slopes are 15 to 25 percent: rockiness.
Hilly land: Hn	Slight where slopes are 0 to 8 percent. Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent.	Slight where slopes are 0 to 8 percent. Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 to 25 percent.	Moderate where slopes are 2 to 6 percent. Severe where slopes are more than 6 percent.	Slight where slopes are 0 to 15 percent. Moderate where slopes are more than 15 percent.
Holdrege: Ho, Hp	Slight	Slight	Slight where slopes are 0 to 2 percent. Moderate where slopes are 2 to 6 percent.	Slight.
Hord: Hr	Slight	Slight	Slight	Slight.

TABLE 8.—*Degree and kind of limitations affecting use of the soils for recreation*—Continued

Soil series and map symbols	Camp areas	Picnic areas	Intensive play areas	Paths and trails
Inavale: In	Moderate: slopes of 8 to 15 percent; loamy sand surface layer.	Moderate: loamy sand surface layer; slope.	Moderate where slopes are less than 6 percent. Severe where slopes are more than 6 percent.	Moderate: loamy sand surface layer.
McCook: Mc, Md	Slight where not subject to flooding. Severe where subject to flooding.	Slight where not subject to flooding. Moderate where subject to flooding.	Slight where not subject to flooding. Moderate where subject to flooding.	Slight.
Mento:				
Me, Mf	Moderate: slow permeability.	Slight	Moderate: slow permeability; slopes of 2 to 6 percent.	Slight.
Mg, Mo	Moderate: slow permeability; silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate where slopes are 2 to 6 percent; slow permeability; silty clay loam surface layer. Severe where slopes are more than 6 percent.	Moderate: silty clay loam surface layer.
Munjor: Mu	Severe: flooding	Moderate: flooding	Severe: flooding	Slight.
New Cambria: Nc	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.
Nibson: Nn	Slight where slopes are 0 to 8 percent. Moderate where slopes are 8 to 15 percent.	Slight where slopes are 0 to 8 percent. Moderate where slopes are 8 to 15 percent.	Severe: bedrock at a depth of less than 20 inches; slopes of more than 6 percent.	Slight.
Penden. Mapped only in a complex with Campus soils.	Moderate: clay loam surface layer; slope.	Moderate: clay loam surface layer; slope.	Severe: slopes of more than 6 percent.	Moderate: clay loam surface layer.
Roxbury:				
Rb	Slight	Slight	Slight	Slight.
Rf	Severe: flooding	Severe: flooding	Severe: flooding	Moderate: flooding.
Rough broken land: Ro	Severe: flooding; slopes of more than 15 percent.	Severe: flooding; slopes of more than 15 percent.	Severe: flooding; slopes of more than 6 percent; bedrock at a depth of less than 20 inches.	Moderate: where slopes are 15 to 25 percent: flooding. Severe where slopes are more than 25 percent.
Wakeen: Wa, We, Wh, Wk	Slight where slopes are 0 to 8 percent. Moderate where slopes are 8 to 15 percent.	Slight where slopes are 0 to 8 percent. Moderate where slopes are 8 to 15 percent.	Moderate where slopes are 2 to 6 percent; bedrock at a depth of 20 to 40 inches. Severe where slopes are more than 6 percent.	Slight.
Wann: Wn	Moderate where wet. Severe where subject to flooding.	Moderate: flooding; wetness.	Moderate: wetness; flooding.	Moderate: wetness; flooding.

under which the soil 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 soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and in a few places may determine it almost entirely. Finally, time is needed to change the parent material into a soil profile. It may be much or little, but some time is always required for soil horizon differentiation. Usually, a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown. The five factors of soil formation as related to the soils of Ellis County are discussed in the following paragraphs.

Parent material

The soils of Ellis County formed in several kinds of parent material. The principal parent material is loess, probably Peorian Loess of Wisconsin age (*4*). In Ellis County the loess was deposited over chalky limestone, calcareous shale, unconsolidated outwash, and clay shale, and some was reworked and deposited along the streams as alluvium. The loess is high in silt, pale brown in color, calcareous, and porous. In Ellis County, Crete, Harney, Holdrege, Carlson, and Mento soils are the dominant soils formed in loess. Crete soils are the most clayey of the loess soils, then Harney, Mento, Carlson, and Holdrege soils. Carlson and Mento soils formed in thin deposits of loess. In Carlson soils calcareous unconsolidated outwash or colluvium from chalky limestone is below the subsoil. In Mento soils chalky limestone residuum mixed with loess is below the subsoil, and bedrock of chalky limestone is at a depth of 40 to 70 inches. Crete, Harney, and Holdrege soils formed in thicker deposits of loess over colluvial-alluvial sediment with admixtures of loess. They are on uplands above the soils formed in alluvium in the present stream valley.

Local colluvium from chalky limestone is second to loess in importance as parent material. Armo soils are extensive on side slopes below outcrops of Cretaceous chalky limestone in most parts of the county. Brownell soils also formed in gravelly and channery colluvial sediment and in residuum from chalky limestone.

Residual parent materials from chalky limestone, calcareous shale, clay shale, and caliche are also important. Wakeen, Nibson, and Heizer soils formed in material weathered from chalky limestone. Corinth soils formed in material from calcareous shale, and Bogue soils formed in material from clay shale. Canlon soils formed in residuum from caliche, and Campus soils formed in unconsolidated outwash and caliche. All these soils have a weakly developed profile, and all but the Bogue soils are strongly calcareous. They all formed in geologic material of the Cretaceous Period except Canlon and Campus soils, which formed in Pleistocene sediment.

The outwash or colluvial-alluvial terrace sediment occurring on the valley slopes of the Saline and Smoky Hill Rivers has a sandy to loamy texture. In some places the material has been reworked by wind. They are of Pleistocene or more recent time. Inavale, Eltree, and Anselmo soils formed in this parent material.

Alluvial parent material consists of sandy, loamy, and clayey sediment along the Saline and Smoky Hill Rivers, Big Creek, and small tributaries. The soils on flood plains include Boel, Munjor, Wann, and Inavale soils and the more silty Roxbury soils, frequently flooded. These soils formed in the most recent alluvium. On the low terraces, just above the flood plain, are McCook soils. Above McCook soils are Roxbury, Hord, and Detroit soils. New Cambria soils are on about the same terrace level as Detroit soils or slightly higher. They have the most clayey profile of the soils formed in alluvium and are adjacent to Bogue soils, which formed in material from clay shale on uplands.

Climate

Climate has played an important role in the formation of soils in Ellis County. Climate influences both physical and chemical weathering processes and the biological forces at work in soil. The climate factors are interrelated one with the other. Soil-forming processes are most active when the soil is warm and moist. Either inadequate moisture or excess moisture retards soil formation. If the supply of moisture is adequate, the soil-forming processes generally become more active as the soil temperature increases.

The downward movement of water is a major factor in transforming the parent material into a soil that has distinct horizons. The amount of water that percolates through a soil depends partly on rainfall, humidity, and the frost-free period. As water moves downward through the soil, calcium carbonate and other materials are moved in solution or suspension.

In Ellis County several of the soils, such as Roxbury silt loam, have free carbonates in the A horizon as well as in all lower horizons. Leaching has not been sufficient to move the calcium carbonate downward to any great extent. In other soils, such as Harney silt loam, calcium carbonate has been leached to a depth of 18 to 30 inches.

As water moves downward through the soil, it also carries clay particles into lower layers. The transported clay particles form a horizon of clay accumulation. This horizon indicates that weathering has removed most of the carbonates in the upper horizons and that clay is being translocated. The thickness of the clay layer and the amount of clay accumulated indicates the extent of soil profile development resulting from present or past climate influence.

Plant and animal life

Plants and animals assist in forming soil. Plants play perhaps the most important part by supplying roots and tops of plants to decay and add organic matter to the soil. They not only aid by adding organic matter, but they have a profound effect on the structure of the soil and assist in the movement of water, minerals, and clay by the root channels left after the decay of the roots.

Plants supply food for micro-organisms, and the micro-organisms, in the digestion of the plant materials, assist in the production of organic matter. Organic matter must be digested by micro-organisms to release plant food, such as nitrogen, to plants growing in the soil.

Earthworms play an important role in the formation of soils by mixing organic material and the mineral material of the soil. Earthworms are very active in calcareous soils, such as Armo, Wakeen, Campus, and Eltree soils, as well as in the soils on flood plains and terraces, such as Roxbury, Hord, and Detroit soils.

Mammals are very active in the moderately deep soils over caliche and chalky limestone and in the deep, calcareous soils. Badgers, skunks, mice, moles, and pocket gophers are notable for their activity in these moderately deep soils.

Relief

Soil formation is influenced by relief through the effects of runoff, drainage, erosion, and vegetation. Sloping, strongly sloping, and moderately steep soils have medium to rapid runoff. On these soils, unless they are very sandy, the amount of runoff may be more than the amount of water absorbed by the soil. When water is not absorbed the chemical processes of soil development are less than in similar but less sloping soils.

Permeability affects the amount of runoff. Soils that have slow or very slow permeability have greater runoff than soils that have moderate permeability. Bogue soils, for example, have very slow permeability. The runoff on Bogue soils that have slopes of 7 percent would be much greater than on Armo soils that have slopes of 7 percent, because Armo soils have moderate permeability. Steep soils tend to have a thinner dark-colored surface layer. This is because of the slower chemical weathering and the sparse vegetation produced because of a lack of moisture. If the vegetation is not dense enough to protect the steep soils, they erode.

Soils that have nearly level, depressional slopes, where runoff is slow or very slow and the surface layer and subsoil are wet for relatively long periods after rains, tend to have a gray or dark color and sometimes a mottled subsoil. Crete soils that have nearly level to depressional slopes are moderately well drained and have slow runoff and slow permeability. They are not mottled in the subsoil or substratum, but they do have dark-colored upper horizons 20 to 30 inches thick.

Time

The time required for soil formation depends upon the parent material, the climate, the plant and animal life, and the relief. A soil needs more time to develop in material weathered from rock than in a friable loess. A soil needs more time to develop in drier climate than in more humid climates in the same parent material. A soil needs more time to develop on steep slopes than on nearly level slopes.

Among the more strongly developed soils in Ellis County are Crete and Harney soils, which formed in loess. The amount of time needed to produce these soils in loess is not known exactly, but studies indicate it could have been as little as 1,000 years to as much as 10,000 years.

The soils that formed in residual material tend to be somewhat resistant to soil formation because of a high carbonate content. Examples are Wakeen, Nibson, Campus, Canlon, Corinth, Brownell, and Heizer soils. Of the soils that formed in alluvium, the least developed soils are on the flood plains. They have rather indistinct horizons. Of the soils on terraces, McCook soils are the least developed. Hord soils are intermediate, and Detroit soils have the most developed profile of the soils formed in alluvium. They rival Crete soils of the uplands in profile development. Again, the time required for the development of Detroit soils is not known, but the time required for Detroit soils is less than for Crete soils.

Classification of the Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

Thus, in classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and used in managing farms, fields, and woodland; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

The system of classification now followed was adopted for general use by the National Cooperative Soil Survey in 1965. The system is under continual study. Therefore, readers interested in developments of the system should search the latest literature available (*8, 10*). In table 9 the soil series of Ellis County are placed in some categories of the system.

The system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped together. Most of the classes of the current system are briefly defined in the following paragraphs.

ORDER: Ten soil orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate these soil orders are those that tend to give broad climatic groupings of soils.

TABLE 9.—*Classification of soil series*

Series	Family	Subgroup	Order
Anselmo	Coarse-loamy, mixed, mesic	Typic Haplustolls	Mollisols.
Armo	Fine-loamy, mixed, mesic	Typic Haplustolls	Mollisols.
Boel	Sandy, mixed, mesic	Aquic Haplustolls	Mollisols.
Bogue	Very fine, montmorillonitic, mesic	Udorthentic Pellusterts	Vertisols.
Brownell	Loamy-skeletal, carbonatic, mesic	Typic Haplustolls	Mollisols.
Campus	Fine-loamy, mixed, mesic	Typic Calciustolls	Mollisols.
Canlon	Loamy, mixed, calcareous, mesic	Lithic Ustorthents	Entisols.
Carlson	Fine, montmorillonitic, mesic	Typic Argiustolls	Mollisols.
Corinth	Fine, mixed, mesic	Typic Ustochrepts	Inceptisols.
Crete	Fine, montmorillonitic, mesic	Pachic Argiustolls	Mollisols.
Detroit	Fine, montmorillonitic, mesic	Pachic Argiustolls	Mollisols.
Eltree	Fine-silty, mixed, mesic	Pachic Haplustolls	Mollisols.
Harney	Fine, montmorillonitic, mesic	Typic Argiustolls	Mollisols.
Heizer	Loamy-skeletal, carbonatic, mesic, shallow	Lithic Haplustolls	Mollisols.
Holdrege	Fine-silty, mixed, mesic	Typic Argiustolls	Mollisols.
Hord	Fine-silty, mixed, mesic	Pachic Haplustolls	Mollisols.
Inavale	Mixed, mesic	Typic Ustipsamments	Entisols.
McCook	Coarse-silty, mixed, mesic	Fluventic Haplustolls	Mollisols.
Mento	Fine, montmorillonitic, mesic	Typic Argiustolls	Mollisols.
Munjor	Coarse-loamy, mixed, calcareous, mesic	Typic Ustifluvents	Entisols.
New Cambria	Fine, montmorillonitic, mesic	Cumulic Haplustolls	Mollisols.
Nibson	Loamy, carbonatic, mesic, shallow	Typic Haplustolls	Mollisols.
Penden	Fine-loamy, mixed, mesic	Typic Calciustolls	Mollisols.
Roxbury	Fine-silty, mixed, mesic	Cumulic Haplustolls	Mollisols.
Wakeen	Fine-silty, carbonatic, mesic	Typic Haplustolls	Mollisols.
Wann	Coarse-loamy, mixed, mesic	Fluvaquentic Haplustolls	Mollisols.

The two exceptions to this are the Entisols and Histosols, which are in many different kinds of climate. The four soil orders in Ellis County are Entisols, Inceptisols, Mollisols, and Vertisols.

Entisols are light-colored soils that do not have natural genetic horizons or that have only very weakly expressed horizons. These soils do not have traits that reflect soil mixing caused by shrinking and swelling.

Inceptisols typically are on flood plains and other recent surfaces. They generally have a light-colored surface layer and lack a high percentage of swelling clays (montmorillonite).

Mollisols formed under grass and have a thick, dark-colored surface horizon containing colloids dominated by bivalent cations. The soil material in these soils has not been mixed by shrinking and swelling.

Vertisols are soils that have enough swelling clay (montmorillonite) to cause cracking, shearing, and mixing of the soil material when there is alternate wetting and drying of the soil mass.

SUBORDER: Each order is divided into suborders, primarily on the basis of the soil characteristics that seem to produce classes that have the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging or soil differences resulting from the climate or vegetation.

GREAT GROUP: Suborders are divided into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated or those that contain a pan that interferes with the growth of roots or movement of water. The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown in table 9, because it is the last word in the name of the subgroups.

SUBGROUP: Great groups are divided into subgroups one representing the central (typic) segment of the group and others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the great group name.

FAMILY: Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence.

General Nature of the County

Some of the general characteristics of the county are discussed in this section. These are history and population, relief and drainage, climate, water supply, farming, industry, transportation and markets, and community facilities.

History and Population

Before 1867 the area that is now Ellis County was inhabited mostly by Indians and a few traders. In October 1865 Fort Fletcher was established, but it was abandoned in May 1866. Five months later the post was reestablished and the name was changed from Fort Fletcher to Fort Hays.

On June 7, 1867, a flood on Big Creek nearly destroyed the fort. The fort was moved to its present site, and on July 4, 1867, the United States flag was first raised over Fort Hays, a military reservation of 7,500 acres of rolling land.

The settlement of Ellis County began in 1867. Most of the inhabitants settled in Rome, which was across Big Creek from the present site of Hays. Hays City, later to become the county seat, was established very soon thereafter, following an outbreak of cholera at Rome. Hays City and Fort Hays were named in honor of General Alexander Hays. In 1885 Hays City was incorporated under the name of the city of Hays.

In 1870 the population of the county was 1,445. By 1930 it was 15,907. Thirty years later it had increased to 22,440, and by 1970 it was 24,730. The county seat, Hays, increased in population from 11,947 in 1960 to 15,396 in 1970.

Relief and Drainage

Ellis County lies in the Rolling Plains and Breaks section on the eastern edge of the High Plains in the Great Plains physiographic province. The county occupies nearly level to sloping tablelands and sloping to moderately steep broken lands dissected by the Saline River on the north, Big Creek in the middle, and the Smoky Hill River on the south.

Elevation ranges from about 2,370 feet in the west-central part of the county to about 1,700 feet in the southeastern part in the streambed of the Smoky Hill River. The soils generally slope to the east, and elevation drops at an average of about 20 feet per mile. There are, however, some areas that drop 50 to 100 feet per mile and other areas that drop less than 10 feet per mile.

The Saline River rises in Sherman County, Kansas, and flows into northern Ellis County from the west. The Smoky Hill River rises in eastern Colorado and flows into the southern part of the county from the west. Big Creek enters the county from the west.

The valleys of the Smoky Hill and Saline Rivers are not wide. They range from less than ¼ mile to as much as 2 miles in width. Big Creek Valley, however, has a more constant width than the valleys of either of the rivers. The divides between streams are narrow, or less than 1 mile to as much as 5 miles wide. Consequently, most of the smaller drainageways flow mostly north or south.

Climate [9]

Ellis County, in western Kansas, has a typical continental climate characterized by abundant sunshine, low humidity, moderate winds, cold winters, warm to hot summers, light winter precipitation, and a pronounced rainfall peak late in spring and in summer.

Western Kansas is in the rain shadow of the Rocky Mountains. This massive mountain barrier is an important climatic control along the western border of the State, but its effect gradually diminishes eastward. Thus, average annual precipitation increases from 16 inches over extreme western parts of Kansas to more than 40 inches in the southeastern corner of Kansas (*3*). Ellis County, which has an average of 23 inches of precipitation, is located in the drier part of the State.

The seasonal distribution of the rainfall is of great significance to farming. About 77 percent of the average annual precipitation falls during the growing season, April through September. The peak rainfall is in May, June, and July; precipitation averages more than 3 inches in each of those months. After the peak early in summer, precipitation gradually declines, and reaches a minimum average of 0.48 inch in January. Winter is very dry; only 9 percent of the annual precipitation occurs in December, January, and February.

As in most dry climates, precipitation in Ellis County is undependable. Rainfall varies widely from month to month and from year to year. Between 1868 and 1968, annual precipitation ranged from 9.21 inches in 1956 to 43.34 inches in 1951. Some months during the period of record received no measurable precipitation, but a few months had more than 10 inches. Dry periods of several months are not uncommon, and droughts extending over a period of years may occur at irregular intervals. Droughts were especially devastating in Ellis County in the 1930's and from 1952 through 1956.

Much of the moisture falls during showers late in the afternoon or at night and during thundershowers in the warmer part of the year. Thunderstorms can be violent at times and are accompanied by heavy rain, large hailstones, strong winds, and tornadoes. Severe storms, however, are generally local, are short, and produce damage in a variable and spotted pattern. Hail damage, which varies widely from year to year, can be extensive if the hail occurs in May or June, before harvest. The heaviest hail generally occurs in wet years when the potential wheat yield is highest.

Because of the continental climate and dry air, daily and annual temperature ranges are rather wide (table 10). The dry air allows rapid rise in temperature during periods of sunshine and marked cooling at night. Occasional surges of cold, arctic air in winter contribute to the wide annual temperature range. Average monthly temperature at Hays varies from 29.0° F. in January to 78.9° in July. Temperature extremes for the period of record at Hays have ranged from –24° to 117°.

The probabilities for the last freeze in spring and the first in fall in central Ellis County are given for five temperatures in table 11. The freeze-free period averages 171 days and extends from April 27 to October 15 (*2*). There is little crop loss from freezing weather in most years, but freezes late in spring occasionally damage winter wheat.

Snowfall is light, averaging about 20 inches per year. Winter snowfall has been as much as 58 inches, but more than 35 inches is unusual.

The prevailing wind is southerly. Average windspeed which is moderately strong in all seasons, reaches a maximum in spring. Average hourly windspeed in the windiest month, March, is about 15 miles per hour.

[9] By MERLE J. BROWN, climatologist for Kansas, National Weather Service, U.S. Department of Commerce.

TABLE 10.—*Temperature and precipitation*

[From records at Hays, Kans.]

Month	Temperature				Precipitation				
	Average daily maximum [1]	Average daily minimum [1]	Two years in 10 will have at least 4 days with—		Average total [2]	One year in 10 will have—		Days with snow cover of 1.0 inch or more [3]	Average depth of snow on days that have a snow cover [3]
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—		
	°F	°F	°F	°F	Inches	Inches	Inches	Number	Inches
January	42.0	16.0	61	−4	.48	.02	1.24	8	3
February	46.0	18.6	67	2	.79	.11	1.80	6	4
March	55.9	27.0	77	8	1.05	.08	2.13	6	6
April	67.2	38.7	85	25	2.22	.48	4.39	1	2
May	75.6	49.4	91	37	3.46	1.41	6.44	0	0
June	86.2	59.7	102	49	3.60	.81	6.86	0	0
July	93.0	64.8	106	57	3.12	.72	6.76	0	0
August	92.0	63.7	106	55	2.98	.94	5.19	0	0
September	83.7	54.5	99	40	2.27	.43	4.91	0	0
October	71.6	41.6	89	29	1.44	.17	2.95	0	0
November	55.7	27.2	72	11	.81	.01	2.09	2	3
December	44.6	18.8	64	6	.68	.04	1.61	7	3
Year	67.8	40.0	[4] 107	[5] −12	22.90	16.01	29.94	30	4

[1] Period 1897–1960.
[2] Period 1868–1960.
[3] Period 1943–1967.
[4] Average annual highest temperature for the period 1893–1967.
[5] Average annual lowest temperature for the period 1893–1967.

TABLE 11.—*Probabilities of last freezing temperatures in spring and first in fall*

[Data for Hays, Kans.]

Probability	Dates for given probability and temperature				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:					
1 year in 10 later than	April 4	April 13	April 19	April 30	May 12
2 years in 10 later than	March 29	April 7	April 14	April 25	May 7
5 years in 10 later than	March 17	March 28	April 5	April 15	April 27
Fall:					
1 year in 10 earlier than	November 5	October 28	October 21	October 13	October 1
2 years in 10 earlier than	November 11	November 2	October 25	October 18	October 5
5 years in 10 earlier than	November 23	November 13	November 3	October 27	October 15

Except for an inadequate amount of rainfall in most growing seasons and occasional late-spring freezes, climatic conditions in Ellis County are generally favorable for successful crop production. The percentage of possible sunshine, the growing season temperature, and the seasonal distribution of precipitation all contribute to a high production potential for the area.

Water Supply

The municipal water supply of most cities and towns in Ellis County is from wells drilled along Big Creek or the Smoky Hill River. Although water supplies can be found along the Saline River, there are no municipalities along the river in Ellis County. Many of the upland areas of the county lack sufficient water, and wells are drilled into the alluvium of small streams that incise the uplands. Small amounts of water, enough for cattle and farmhouses, are generally found along these small drainageways. Areas underlain by clayey shale have little water at a shallow depth. Some deep wells have been drilled 100 to 500 feet into the Dakota Formation. These wells generally have water of poor quality that is poorly suited for livestock water. Good wells from the Dakota Formation can be obtained in some places.

A large number of large and small impoundments of water for livestock are in the county. There are many good sites available for ponds. Where wells are not easily drilled, the water in the ponds is the only source of water for livestock.

Farming

In the early 1870's Martin Allen, a horticulturist of some renown, planted the first large field of wheat in Ellis County. This was the beginning of wheat as the major crop in the county. Since that time no other crop has come close to being the major crop. In 1958, 143,000 acres of wheat was harvested. At that time wheat produced about 55 percent of the farm income in Ellis County. The sorghum harvest was 44,000 acres. Other crops produced were barley, oats, corn, and rye; sorghum for silage; and alfalfa and prairie grass for forage. The income from livestock and livestock products produced in 1958 represented about 33 percent of the total farm income (*5*).

In 1968, 141,000 acres of wheat was harvested, and this made up only 30 percent of the total farm income. About 13,000 acres of grain sorghum was harvested. The trend in farming in Ellis County is toward raising livestock, and about 54.5 percent of the total farm income is derived from the sale of livestock and livestock products and 45.5 percent from farm crops (*6*). The number of livestock, mainly feeder-stocker beef cattle, has been increasing, and the number of cattle fed out for the fat cattle market has increased. One large feedlot was started in 1968, northwest of Hays, and several smaller yards are in operation.

Feed supplies of alfalfa hay, sorghum and corn for silage, and sorghum for forage have been increased to take care of the increasing number of livestock. Wheat and sorghum stubble is used as supplemental forage in winter.

Less than 2 percent of the cultivated land is irrigated. Most of this land has been planted to corn for grain, corn and sorghum for silage, and sorghum for grain. In 1966, in the Cedar Bluffs Irrigation District, Irish potatoes were tried as a cash crop, but production was too low and they failed to be profitable. Sprinkler irrigation outside the irrigation district is used mostly for alfalfa.

In August 1945 the farmers and landowners organized the Ellis County Soil Conservation District. The district was formed to promote practices that conserve soil and water, such as terracing, contour farming, stubble mulching, and using irrigation properly.

In 1954, 1,065 farms were in Ellis County, and the average size was about 540 acres. By 1964, the number of farms had decreased to 851 and the average size had increased to 680 acres.

Farming in this area has been aided by the Fort Hays Branch, Kansas Agricultural Experiment Station, which tests and approves new species of plants for use in the general area. Many new varieties of sorghum and some varieties of wheat have been developed by the experiment station.

Industry

Hays, the county seat, has mostly a farming community economy, but the economy is backed by the buying power of the students from Fort Hays Kansas State College. The enrollment at the college in 1970 was about 5,500 students.

The main nonfarm enterprises since the 1930's have been oil production, separation of oil and water at the pumping site, and transportation of crude oil. New industries include a medical products factory and a hydraulic cylinder factory.

Transportation and Markets

Improved roads run throughout the county. They are mostly surfaced with sand and gravel or crushed limestone.

Interstate Highway 70 and U.S. Highway 40 cross the county from east to west, and U.S. Highway 183 crosses the county from north to south. All highways intersect at Hays. Other surfaced roads join small communities to the main highways. A major railroad passes through Ellis, Hays, Victoria, Walker and Toulon.

Most of the grain is marketed locally, and Ellis, Hays, Victoria, Toulon, Yocemento, and Walker have facilities for storing grain. The grain is shipped to terminal elevators by railroad and truck.

Hays has a sales barn where many of the beef cattle, dairy cattle, and hogs are marketed.

Community Facilities

About 16 elementary schools, 5 high schools, and 1 college are in the county. In June 1902 Fort Hays Normal School, the forerunner of Fort Hays Kansas State College, opened. The college has about 3,600 acres of land in Ellis County, part of the old Fort Hays Military Reservation. The rest of the land of the former reservation is occupied by the Fort Hays Branch, Kansas Agricultural Experiment Station, which is one of the largest dryland experimental stations in the world.

Churches are located at Hays, Schoenchen, Ellis, Pfeifer, Victoria, Catharine, Severin, and Walker. Two hospitals are in Hays.

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Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Caliche. A more or less cemented deposit of calcium carbonate in many soils of warm-temperate areas, as in the Southwestern States. The material may consist of soft, thin layers in the soil or of hard, thick beds just beneath the solum, or it may be exposed at the surface by erosion.

Channery soil. A soil that contains thin, flat fragments of sandstone, limestone, or schist, as much as 6 inches in length along the longer axis. A single piece is called a fragment.

Chalk. Very soft, white to light-gray, unindurated limestone.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Chlorosis. Yellowing between veins on upper foilage resulting from chlorophyll deficiency. Many factors, including heredity, cause chlorosis.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

Fallow. Cropland left idle in order to restore productivity, mainly through accumulation of water, nutrients, or both. Summer fallow is a common stage before cereal grain in regions of limited rainfall. The soil is tilled for at least one growing season to control weeds, to aid decomposition of plant residues, and to encourage the storage of moisture for the succeeding grain crop.

Fragipan. A loamy, brittle, subsurface horizon that is very low in organic-matter content and clay but is rich in silt or very fine sand. The layer is seemingly cemented. When dry, it is hard or very hard and has a high bulk density in comparison with the horizon or horizons above it. When moist, the fragipan tends to rupture suddenly if pressure is applied, rather than to deform slowly. The layer is generally mottled, is slowly or very slowly permeable to water, and has few or many bleached fracture planes that form polygons. Fragipans are a few inches to several feet thick; they generally occur below the B horizon, 15 to 40 inches below the surface.

Gravelly. Containing from 15 to 50 percent, by volume, rounded or angular rock fragments that are not prominently flattened and are up to 3 inches in diameter.

Ground water (geology). Water that fills all the unblocked pores of underlying material below the water table, which is the upper limit of saturation.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these;

(2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Intake rate. The rate at which water enters the soil.

Internal soil drainage. The downward movement of water through the soil profile. The rate of movement is determined by the texture, structure, and other characteristics of the soil profile and underlying layers, and by height of the water table, either permanent or perched. Relative terms for expressing internal drainage are *none, very slow, slow, medium, rapid,* and *very rapid.*

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are—

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Basin.—Water is applied rapidly to relatively level plots surrounded by levees or dikes.

Controlled flooding.—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops, or in orchards, to confine the flow of water to one direction.

Furrow.—Water is applied in small ditches made by cultivation implements used for tree and row crops.

Sprinkler.—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation.—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding.—Irrigation water, released at high points, flows onto the field without controlled distribution.

Leveling (of land). The reshaping, or modification, of the soil surface to a planned grade to permit uniform distribution of irrigation water without erosion or to provide proper surface drainage.

Leaching. The removal of soluble materials from soils or other material by percolating water.

Limestone. A rock which consists dominantly of calcium carbonate. Numerous kinds exist in accordance with impurities present, physical variations in texture, and hardness.

Loam. The textural class of soil that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

Loess. Fine-grained material, dominantly of silt-sized particles, that has been deposited by wind.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

pH value. A numerical means for designating acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

Poorly graded. A soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles in poorly graded soil material, density can be increased only slightly by compaction.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour", soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Saline soil. A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable sodium.

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Shale. A sedimentary rock formed by the hardening of clay deposits.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of every fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles, less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows: *Very coarse sand* (2.0 to 1.0 millimeter); *coarse sand* (1.0 to 0.5 millimeter); *medium sand* (0.5 to 0.25 millimeter); *fine sand* (0.25 to 0.10 millimeter); *very fine sand* (0.10 to 0.05 millimeter); *silt* (0.05 to 0.002 millimeter); and *clay* (less than 0.002 millimeter). The separates recognized by the International Society of Soil Science are as follows: I (2.0 to 0.2 millimeter); II (0.2 to 0.02 millimeter); III (0.02 to 0.002 millimeter); IV (less than 0.002 millimeter).

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular. Structureless* soils are either *single grain* (each grain by itself, as in dune saind) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Surface layer. A term used in nontechnical soil descriptions for one or more layers above the subsoil. Includes the A horizon and part of the B horizon; has no depth limit.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Topsoil. A presumed fertile soil or soil material, or one that responds to fertilization, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Underlying material. Layers below the subsoil; roughly the C horizon and below.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

Weathering. All physical and chemical changes produced in rocks at or near the earth's surface by atmospheric agents. These changes result in more or less complete disintegration and decomposition of the rock.

Well-graded soil. A soil or soil material consisting of particles that are well distributed over a wide range in size or diameter. Such a soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Workability, soil. The relative amount of work required to till the soil and the relative difficulty in using farm machinery.

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