SOIL SURVEY OF

Cloud County, Kansas

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

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in the period 1961–70. Soil names and descriptions were approved in 1971. 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 Cloud County Soil Conservation District.

Soil maps in this survey may be copied without permission, but any enlargement of these maps could cause misunderstanding of the detail of mapping and result in erroneous interpretations. Enlarged maps do not show small areas of contrasting soils that could have been shown at a larger mapping scale.

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 of the soils of Cloud County are shown on the detailed map at 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 symbols. 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 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 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 the 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 use and management of the soils from the soil descriptions and from the discussions of capability units, range sites, and windbreak suitability groups.

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

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

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 formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers in Cloud 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 "Additional Facts About the County."

Cover: Area of Crete-Longford-Hedville association in southern part of Cloud County.

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SOIL SURVEY OF CLOUD COUNTY, KANSAS

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

CLOUD COUNTY is in the north-central part of Kansas (fig. 1). Its area is about 455,040 acres, or 711 square miles. Concordia is the county seat.

Cloud County lies in the Dissected High Plains section of the Great Plains physiographic province (*4*)[1]. The types of topography in the county are a high upland area that resembles the High Plains, which are farther west; a deeply dissected upland area; an undulating and gently rolling upland area; and very gently sloping areas on terraces and flood plains in the valleys.

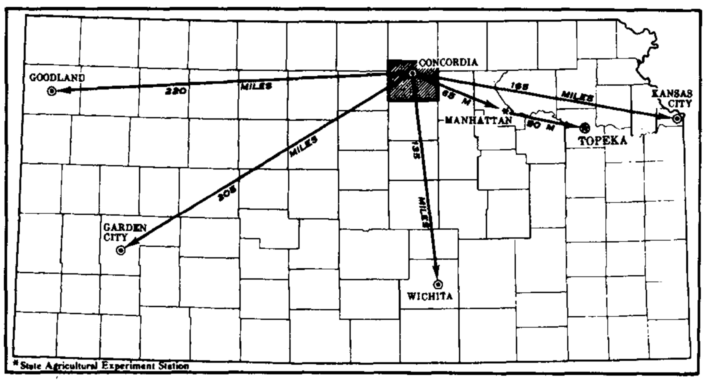

***Figure 1.*—Location of Cloud County in Kansas.**

The high upland area is gently undulating. It begins south of Concordia near the middle of the county and extends west to the county line. The deeply dissected upland area is on the rim of this high upland. It is made up of ridges of limestone and shale and of valleys that are partly filled by loess, colluvium, and alluvium. The undulating and gently rolling upland area borders the Republican River Valley and occupies the eastern and southern parts of the county. It is on lower elevations than the deeply dissected area and includes hills and ridges underlain by sandstone and shale. The very gently sloping areas on terraces and flood plains are in the Republican River, Solomon River, and Buffalo Creek Valleys and in local stream valleys throughout the county.

Farming is the main economic enterprise in Cloud County. Nearly all of the land is privately owned and is used for farms. Wheat, grain sorghum, corn, cattle, and swine are the main farm products. Alfalfa hay, soybeans, milk, poultry products, sheep, and lambs are also sources of income. Most crops are produced by dryland farming. Some crops are irrigated.

A large part of each farm is cultivated, but some native or tame grass pasture is maintained. Large areas of native grass range are maintained on shallow soils in different parts of the county.

The acreage used for irrigated corn, grain sorghum, and silage is increasing. Most irrigated land is in the Republican River Valley. Some irrigation systems have been developed east of Aurora and south of Clyde. The Glen Elder Irrigation District is being developed in the Solomon River Valley. This district will include approximately 9,500 acres in the southwestern part of Cloud County. The water to be used throughout the district will come from the Glen Elder Reservoir.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Cloud 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 nationwide, 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 texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangment, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of

[1] Italic numbers in parentheses refer to Literature Cited, p. 71.

that series was first observed and mapped. Crete and Hastings, for example, are the names of two soil series. All of 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, Crete silt loam, 1 to 3 percent slopes, is one of several phases in the Crete series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show streams, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication 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. Two such kinds of mapping units are shown on the soil map of Cloud County, the soil complex and the undifferentiated group.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size 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. Lancaster-Hedville complex, 5 to 30 percent slopes, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils or of two or more. Carr and Sarpy soils is an undifferentiated group in this county.

In most areas surveyed, there are places where the soil material is so rocky, so wet, 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. Alluvial land, wet, 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 kind 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 kind of soil. Yields under defined management are estimated for all of 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 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 consultations. 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 Cloud 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 Cloud County are discussed in the following pages.

1. Crete-Hastings-Hobbs association

Deep, nearly level to moderately sloping soils that formed in loess or local alluvium

This association consists of broad areas of nearly level to moderately sloping soils on uplands and in small drainageways. The streams are only entrenched to a shallow depth, and the adjoining side slopes are moderate.

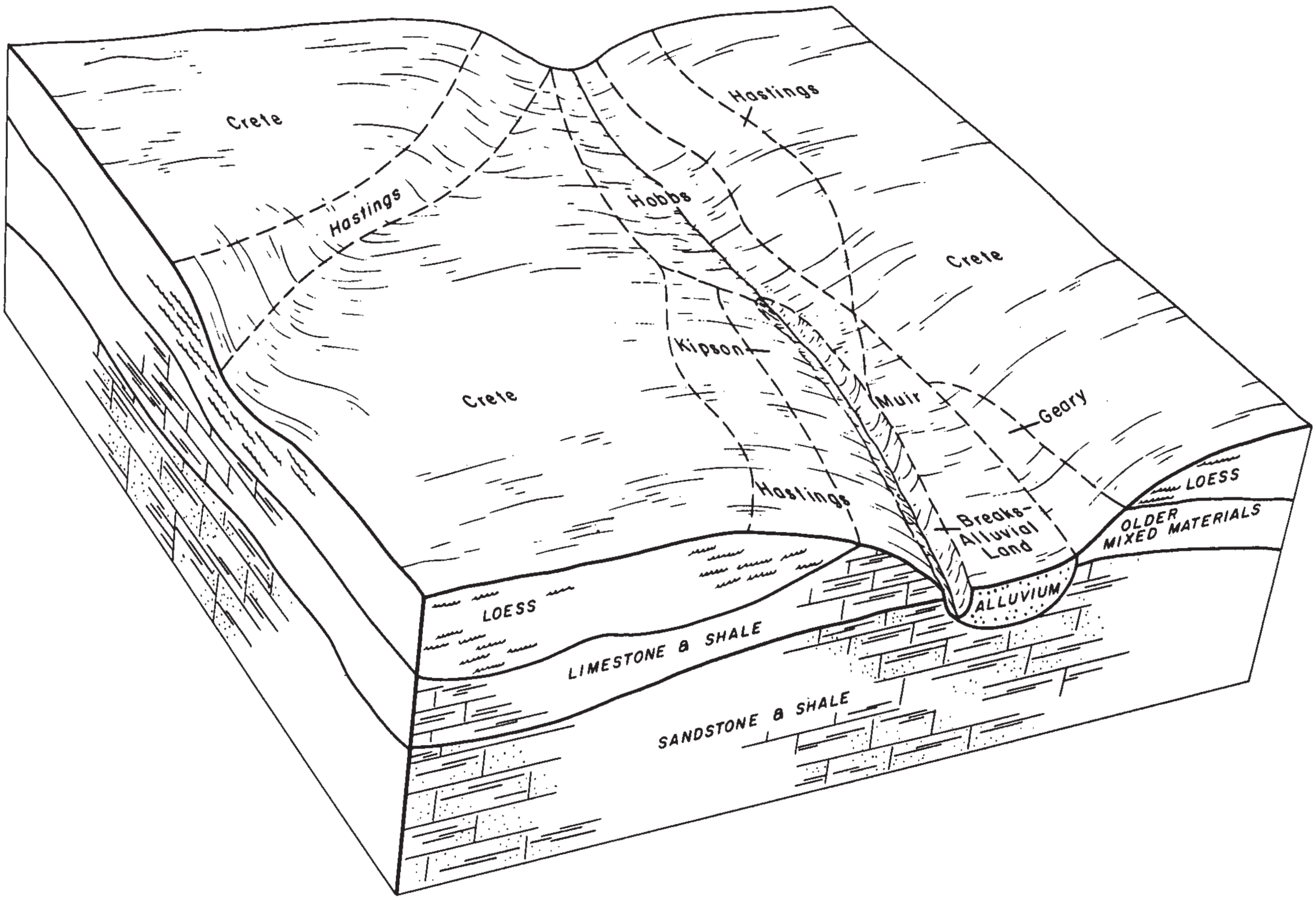

***Figure 2.*—Pattern of soils and underlying materials in Crete-Hastings-Hobbs association.**

This association covers about 16 percent of the county. About 70 percent of this association is Crete soils, 15 percent is Hastings soils, 5 percent is Hobbs soils, and 10 percent is minor soils (fig. 2).

The deep, nearly level to moderately sloping Crete soils formed in loess on uplands. These soils are moderately well drained. They have a surface layer of dark grayish-brown silt loam or grayish-brown silty clay loam. The subsoil is brown or grayish-brown silty clay. The underlying material is light grayish-brown silt loam.

The deep, gently sloping and moderately sloping Hastings soils formed in loess on uplands. These soils are well drained. They have a surface layer of dark grayish-brown silt loam or grayish-brown silty clay loam. The subsoil is brown silty clay loam. The underlying material is light-brown silt loam.

The deep, nearly level Hobbs soils are on the narrow flood plains of local drainageways. These soils are moderately well drained and frequently flooded. They have a very thick surface layer of dark grayish-brown silt loam. Below the surface layer is grayish-brown silt loam that contains thin layers of silty clay loam, loam, and sandy loam.

Minor soils in this association are Kipson, Hord, Tobin, Geary, Longford, and Muir soils and Breaks-Alluvial land complex. Where Kipson soils are in the lower areas that adjoin drainageways, Tobin and Hord soils are along the streams. Where Longford and Geary soils are in the lower areas, Muir soils are along the streams. Breaks-Alluvial land complex is along the deeply entrenched streams in all parts of this association.

Most of this association is used for all dryland crops commonly grown in the county. Wheat and grain sorghum are the main crops. Small areas are in native grass or tame grass pasture.

Wells have been developed in places to irrigate grain sorghum, corn, and silage. If the soils in this association are cultivated, the main hazard is the loss of water and soil. Controlling runoff, reducing soil loss, and maintaining tilth and fertility are the main concerns in management.

The slightly weathered loess that underlies most

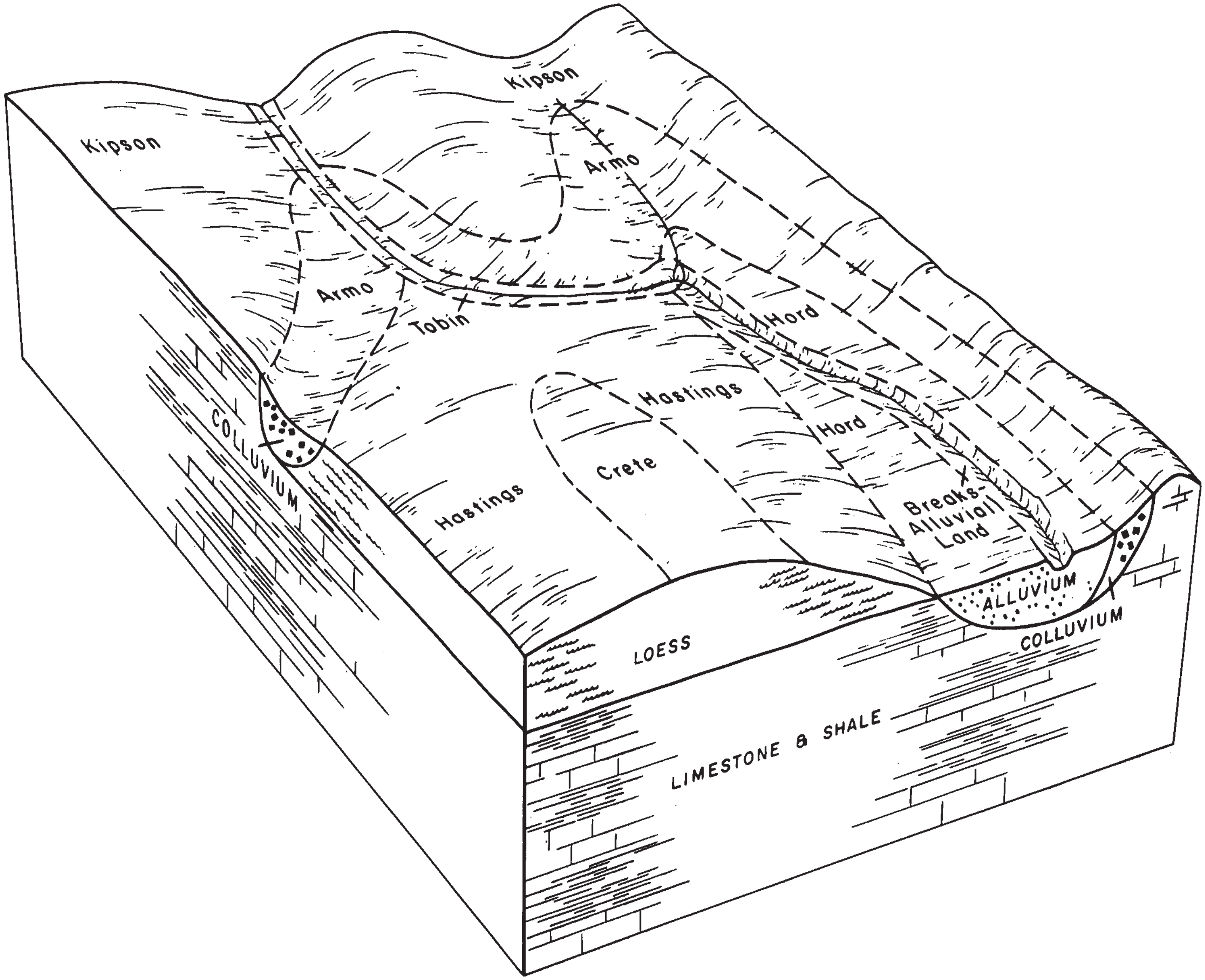

Figure 3.—**Pattern of soils and underlying materials in Kipson-Hastings-Armo association.**

areas of the soils in this association can be used as mineral filler in certain kinds of road-surfacing material (*4*).

2. *Kipson-Hastings-Armo association*

Shallow and deep, gently sloping to steep soils that formed in material weathered from limestone and shale, loess, and limy colluvium

This association consists of steep soils on limestone ridges and gently sloping or moderately sloping soils in valleys.

This association covers about 20 percent of the county. About 33 percent of this association is Kipson soils, 28 percent is Hastings soils, 17 percent is Armo soils, and 22 percent is minor soils (fig. 3).

The shallow, moderately sloping to steep Kipson soils formed on ridges in material weathered from interbedded limestone and shale. These soils are somewhat excessively drained. They have a surface layer of dark-gray channery or flaggy silt loam. This is underlain by light-gray channery light silty clay loam that grades to partly weathered limestone and shale at a depth of 15 to 20 inches.

The deep, gently sloping to moderately sloping, well-drained Hastings soils formed in loess in areas below the limy colluvium at the base of ridges. These soils have a surface layer of dark grayish-brown silt loam or grayish-brown silty clay loam. The subsoil is brown silty clay loam. The underlying material is light-brown silt loam.

The deep, moderately sloping Armo soils formed in limy colluvium at the base of limestone ridges. These soils are well drained. They have a surface layer of dark-gray silt loam. The subsoil is light silty clay loam that is dark gray in the upper part and grayish brown in the lower part. The underlying material is brown silt loam or clay loam.

Minor soils in this association are Crete, Nuckolls, Wakeen, Roxbury, New Cambria, Tobin, Hord, and Geary soils; Breaks-Alluvial land complex; and Alluvial land, loamy. The gently sloping Crete soils are on hilltops. The strongly sloping Nuckolls soils are mainly on the edge of the Republican River Valley. Geary soils are below the Hastings soils in some areas. Breaks-Alluvial land complex is along many of the deeply entrenched streams. The other soils are on low hills below the Kipson soils or at lower levels in the valleys.

The deep soils in this association are used for all dryland crops commonly grown in the county. Wheat and grain sorghum are the main crops. Nearly all areas of the Kipson soils are in native range. Breaks-Alluvial land complex is also in range or in open pastured woodlots.

If the sloping soils in this association are cultivated, the main hazard is the loss of soil and water. The development of gullies from runoff is a minor hazard. Controlling runoff, reducing soil loss, and maintaining tilth and fertility are main concerns in management.

The slightly weathered loess that underlies some of the soils can be used as mineral filler in certain kinds of road surfacing material. The limestone and shale under the Kipson soils are quarried and used as road metal. Two limestone layers are a source of structural stone.

3. *Crete-Longford-Hedville association*

Deep and shallow, nearly level to steep soils that formed in loess, material weathered from sandstone and shale and mixed with loess, or material weathered from interbedded sandstone and shale

This association consists of nearly level to steep soils at elevations between the major valleys and the limestone ridges. The drainage patterns are well developed. Streams are moderately entrenched to deeply entrenched. The larger creeks have developed first and second bottoms.

This association covers about 25 percent of the county. About 42 percent of this association is Crete soils, 28 percent is Longford soils, 5 percent is Hedville soils, and 25 percent is minor soils (fig. 4).

The deep, nearly level, gently sloping or moderately sloping Crete soils formed in loess on uplands. These soils are moderately well drained. They have a surface layer of dark grayish-brown silt loam or grayish-brown

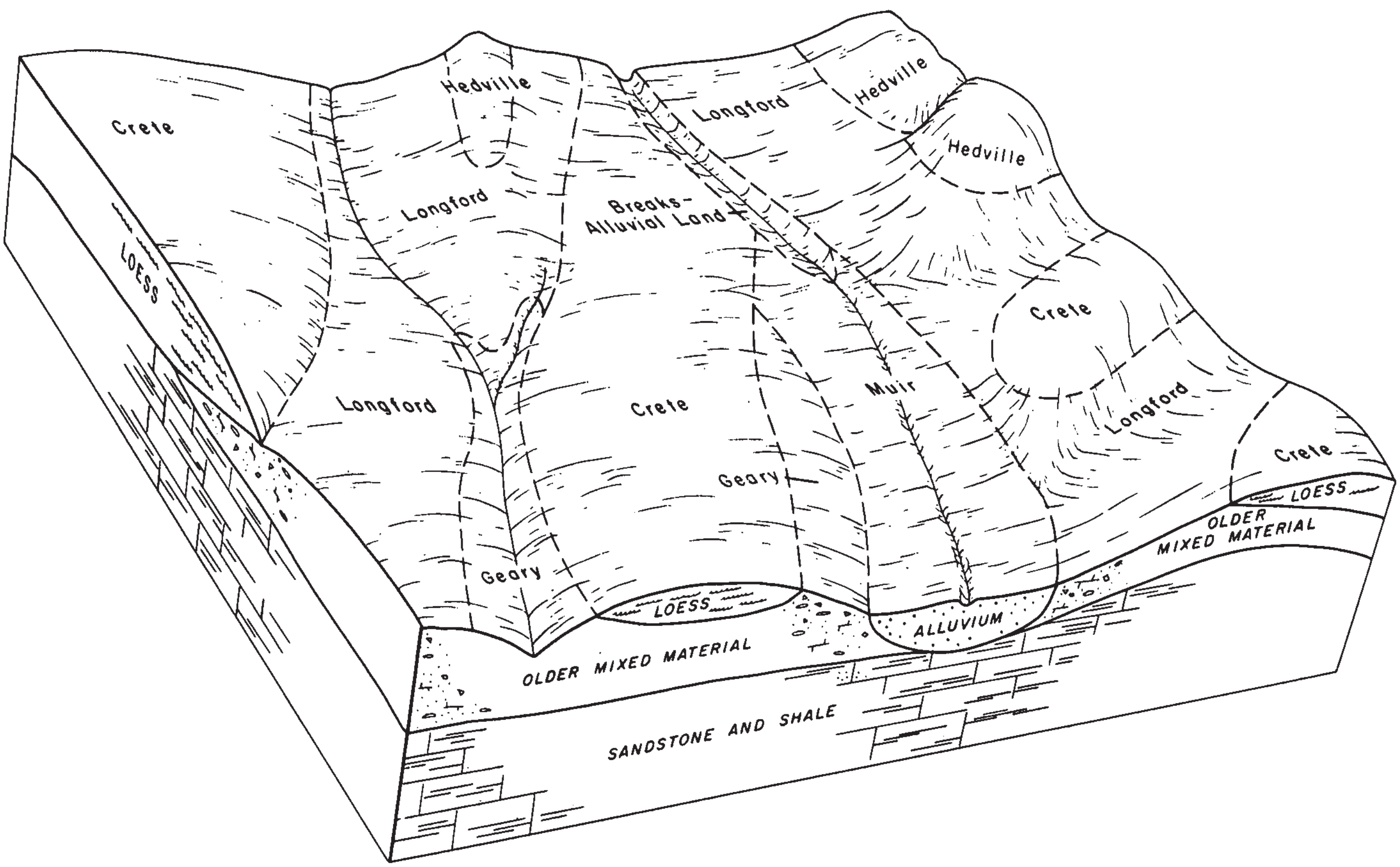

***Figure 4.*—Pattern of soils and underlying materials in Crete-Longford-Hedville association.**

silty clay loam. The subsoil is brown or grayish-brown silty clay. The underlying material is light grayish-brown silt loam.

The deep, gently sloping or moderately sloping Longford soils formed on uplands in material weathered from sandstone and shale and mixed with loess. These soils are well drained. They have a surface layer of dark grayish-brown silt loam or grayish-brown silty clay loam. The subsoil is reddish-brown silty clay loam. The underlying material is reddish-yellow silty clay loam or clay loam.

The shallow, moderately sloping to steep Hedville soils formed in material weathered from sandstone. These soils are somewhat excessively drained. They have a surface layer of dark grayish-brown stony loam that is 8 to 18 inches thick over sandstone.

Minor soils in this association are Geary, Hastings, Lancaster, Muir, Hord, Detroit, Tobin, and Hobbs soils; Alluvial land, loamy; and Breaks-Alluvial land complex. Geary and Hastings soils are below Longford and Crete soils. Lancaster soils are intermingled with Hedville soils. Muir, Hord, and Detroit soils are on second bottoms, and Tobin and Hobbs soils are on flood plains. Breaks-Alluvial land complex is along many of the deeply entrenched streams in all parts of the association.

The deep soils in this association are used for all dryland crops commonly grown in the county. Wheat and grain sorghum are the main crops. Nearly all areas of the Lancaster and Hedville soils and of Breaks-Alluvial land complex are in native range.

If the sloping soils in this association are cultivated, the main hazard is the loss of water and soil. Controlling runoff, reducing soil loss, and maintaining tilth and productivity are the main concerns in management.

The sand and gravel that underlie Geary soils in the Solomon River Valley can be used as aggregate for concrete or as road metal. Ceramic raw material and road material can be obtained from the shale and sandstone underlying the Lancaster and Hedville soils.

4. Hastings-Crete-Hord association

Deep, nearly level to moderately sloping soils that formed in loess or local alluvium

This association consists of nearly level to moderately sloping soils on uplands and nearly level soils on second bottoms. The streams are moderately entrenched and in places have very narrow flood plains. This association is at lower elevations than the limestone ridges.

This association covers about 20 percent of the county. About 45 percent of this association is Hastings soils, 30 percent is Crete soils, 10 percent is Hord soils, and 15 percent is minor soils (fig. 5).

The deep, gently sloping and moderately sloping Hastings soils formed in loess on uplands. These soils are well drained. They have a surface layer of dark

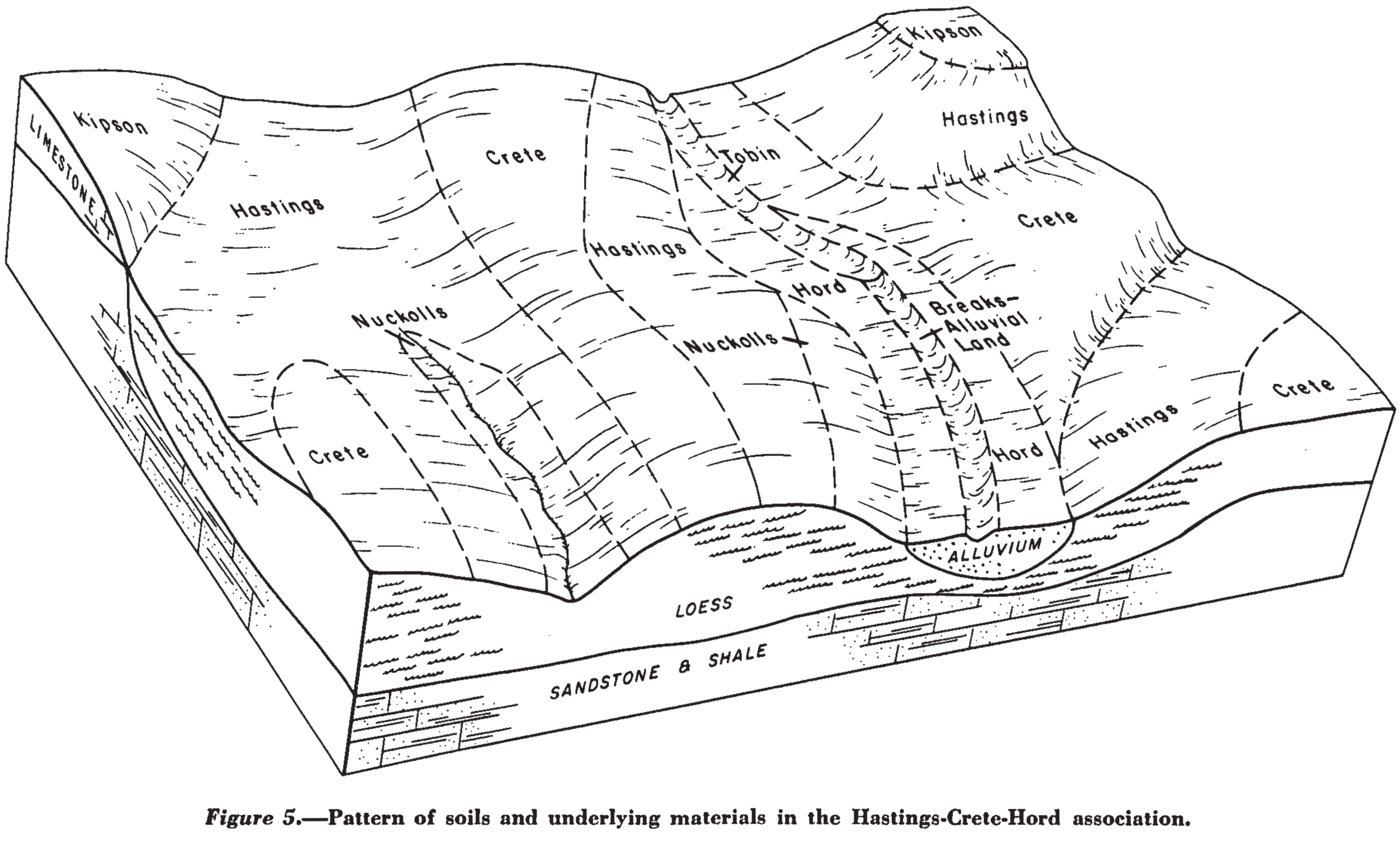

***Figure 5.*—Pattern of soils and underlying materials in the Hastings-Crete-Hord association.**

grayish-brown silt loam or grayish-brown silty clay loam. The subsoil is brown silty clay loam. The underlying material is light-brown silt loam.

The deep, nearly level to moderately sloping Crete soils formed in loess on uplands. These soils are moderately well drained. They have a surface layer of dark grayish-brown silt loam or grayish-brown silty clay loam. The subsoil is brown or grayish-brown silty clay. The underlying material is light grayish-brown silt loam.

The deep, well-drained, nearly level Hord soils are on second bottoms. These soils have a thick surface layer of dark-gray silt loam. The subsoil is light silty clay loam that is dark grayish brown in the upper part and grayish brown in the lower part. The underlying material is grayish-brown light silty clay loam.

Minor soils in this association are Armo, Kipson, Nuckolls, Geary, Longford, Tobin, Muir, and Hobbs soils and Breaks-Alluvial land complex. Armo and Kipson soils are on hills and foot slopes. The strongly sloping Nuckolls soils are mainly on the edge of the Republican River Valley. Geary and Longford soils are below Hastings or Crete soils. Tobin soils are in the drainageways that come from the limestone hills. Muir and Hobbs soils are along the streams in the uplands that are mainly Crete, Longford, and Geary soils. Breaks-Alluvial land complex is along most of the streams.

The major soils in this association are used for all dryland crops commonly grown in the county. Wheat and grain sorghum are the main crops. Corn is grown on Hord soils. Corn and grain sorghum are the main crops on irrigated Hord soils. Kipson and Armo soils and Breaks-Alluvial land complex are used for native range.

If the sloping soils in this association are cultivated, the main hazard is the loss of soil and water. In places, lateral drainageways have cut gullies across areas of Hord soils. Controlling runoff, reducing soil loss, and maintaining tilth and productivity are the main concerns in management.

5. *Lancaster-Hedville association*

Moderately deep and shallow, moderately sloping and steep soils that formed in material weathered from interbedded sandstone and shale

This association consists of ridges and hills. Slopes range from 5 to 30 percent. The drainage patterns are irregular and there are many rounded hilltops or elongated ridges. The drainageways are concave, and few have definite channels. The deeper soils formed in concave drainageways.

This association covers about 4 percent of the county. About 50 percent of this association is Lancaster soils, 20 percent is Hedville soils, and 30 percent is minor soils (fig. 6).

The moderately deep, moderately sloping and strongly sloping Lancaster soils formed in material weathered from interbedded sandstone and shale. These soils are well drained. They have a surface layer of dark grayish-brown loam or gravelly loam. The subsoil is brown or reddish-brown loam, sandy clay loam, or clay loam. The underlying material is light-brown or reddish-brown sandy loam, loam, or light clay loam. Sandstone or sandy shale is at a depth of 24 to 40 inches.

The shallow, moderately sloping to steep Hedville soils formed in material weathered from sandstone. These soils are somewhat excessively drained. They have a surface layer of dark grayish-brown stony loam 8 to 18 inches thick over sandstone.

Minor soils in this association are Longford, Geary, Crete, and Hobbs soils and Breaks-Alluvial land complex. Longford and Geary soils are at the base of slopes in small valleys. In places Crete soils are on hilltops and on lower slopes in the valleys. Hobbs soils are on bottom lands of the drainageways. Breaks-Alluvial land complex is along streams that have deeply cut channels and steep side slopes.

The soils in this association are mostly used for native range. Nearly all of the formerly cropped fields are now in tame or native grass pasture. Range management practices should be directed to maintaining or improving range condition.

Some of the shale underlying the soils in this association is a source of ceramic materials. The sandstone can be used as road metal. The quartzitelike sandstone can be used as structural stone or riprap or crushed for concrete aggregate.

6. *Muir-Carr-Humbarger association*

Deep, nearly level and gently sloping soils that formed in mixed recent and older silty alluvium

This association consists of soils on terraces and flood plains in the Republican River Valley. The nearly level soils on terraces are seldom flooded. The nearly level and gently sloping soils on flood plains are occasionally flooded. Each part ranges from one-fourth mile to more than a mile in width. Soils on the terraces formed in older silty alluvium. Those on the flood plain formed in recent mixed alluvium.

This association covers about 10 percent of the county. About 35 percent of this association is Muir soils, 25 percent is Carr soils, 10 percent is Humbarger soils, and 30 percent is minor soils (fig. 7).

The deep, nearly level and gently sloping Muir soils formed in silty alluvium. These soils are well drained. They have a thick surface layer of dark grayish-brown silt loam. The subsoil is light silty clay loam that is dark grayish brown in the upper part and grayish brown in the lower part. The underlying material is grayish-brown light silty clay loam.

The deep, nearly level or gently sloping Carr soils formed in sandy alluvium. These soils are well drained. They have a surface layer and subsoil of grayish-brown fine sandy loam. The underlying material is light-gray fine sandy loam that has layers of loam and loamy sand. Carr soils are limy at a depth of less than 10 inches.

The deep, nearly level Humbarger soils formed in loamy alluvium. These soils are moderately well drained. They have a thick surface layer of dark grayish-brown loam. The subsoil is grayish-brown clay loam. The underlying material is light brownish-gray clay loam. Humbarger soils are limy at a depth of less than 10 inches.

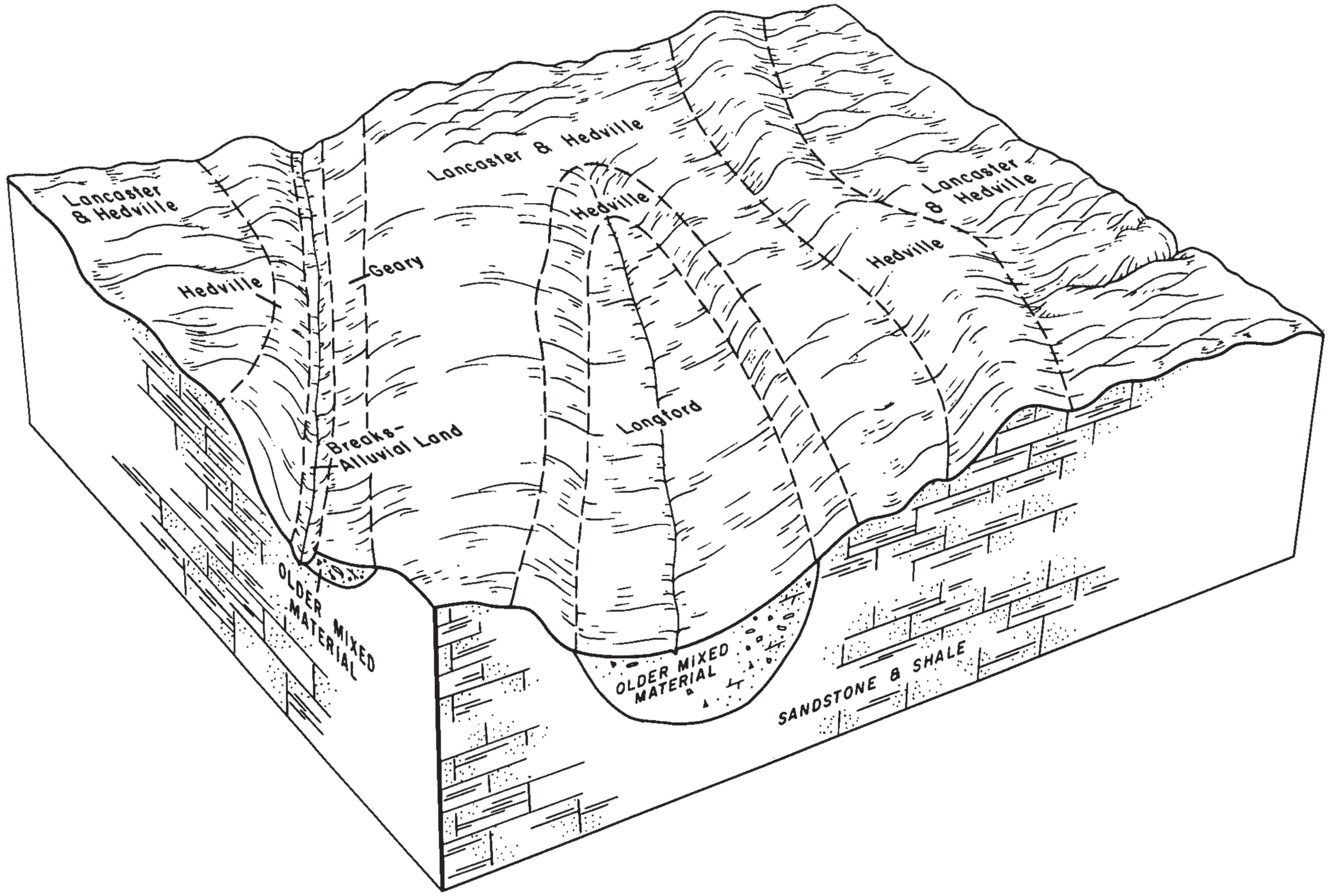

Figure 6.—**Pattern of soils and underlying materials in Lancaster-Hedville association.**

Minor soils in this association are Eudora, Hord, Detroit, Bridgeport, Hobbs, and Sarpy soils. Eudora, Hord, and Detroit soils are on second bottoms. Bridgeport, Hobbs, and Sarpy soils are on flood plains. Some of the Sarpy soils are on sand dunes.

All the soils in this association, except the Sarpy soils on sand dunes, are suited to cultivation. They are used for all dryland crops commonly grown in the county. Wheat and grain sorghum are the main crops. Corn and some specialty crops are also grown. On irrigated soils, corn, grain sorghum, and silage are the main crops.

If the soils in this association are cultivated, the main hazards are the loss of water by runoff and evaporation, flooding of the soils on bottom lands, and soil blowing. Controlling water losses, reducing soil blowing, and improving tilth and productivity are the main concerns in management.

The sand and gravel underlying the soils on the flood plain are sources of sand, concrete aggregate, and road metal.

7. *Detroit-Sutphen-Bridgeport association*

Deep, nearly level soils that formed in silty and clayey alluvium

This association consists of soils in the Buffalo Creek Valley. This valley has a broad concave shape that is very gently sloping from the sides to the low central part. Different levels have not developed. On the valley sides low, gently sloping hills blend into the flood plain of Buffalo Creek.

This association covers about 2 percent of the county. About 30 percent of this association is Detroit soils, 15 percent is Sutphen soils, 15 percent is Bridgeport soils, and 40 percent is minor soils (fig. 8).

The deep, nearly level Detroit soils formed in silty and clayey alluvium. These soils are moderately well drained. They have a thick surface layer of dark-gray silty clay loam. The subsoil is heavy silty clay loam that is dark grayish brown in the upper part and grayish brown in the lower part. The underlying material is light brownish-gray silty clay loam. This soil is limy below a depth of 30 inches.

The deep, nearly level Sutphen soils formed in clayey alluvium. These soils are somewhat poorly drained. They have a thick surface layer of dark-gray silty clay. The subsoil is grayish-brown silty clay. The underlying material is light brownish-gray heavy silty clay loam. This soil is limy below a depth of 24 inches.

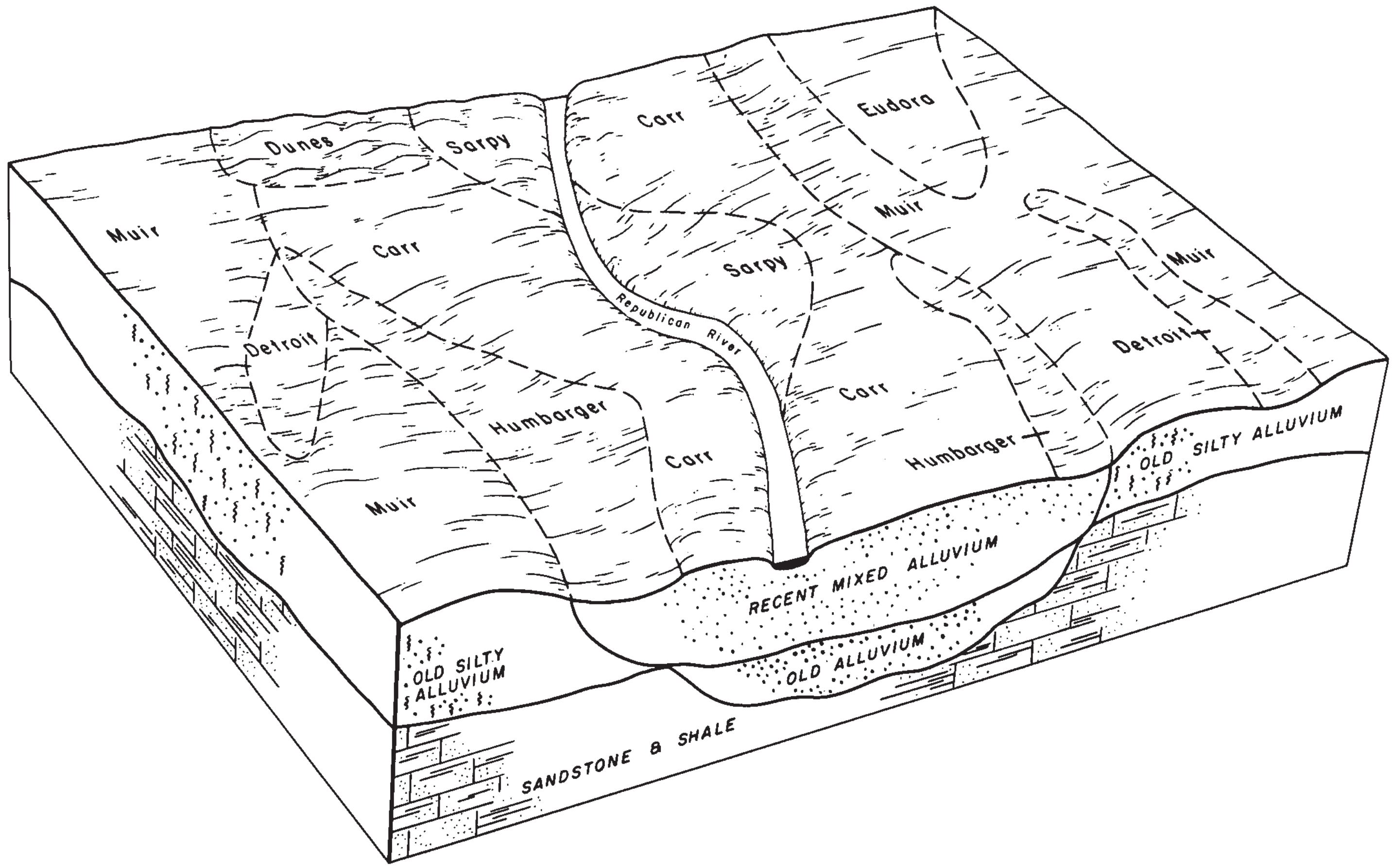

Figure 7.—**Pattern of soils and underlying materials in Muir-Carr-Humbarger association.**

The deep, nearly level Bridgeport soils formed in silty alluvium. These soils are well drained. They have a surface layer of silt loam that is dark gray in the upper part and grayish brown in the lower part. The subsoil is grayish-brown, stratified silt loam and silty clay loam. The underlying material is grayish-brown silt loam that has layers of silty clay loam. This soil is limy at a depth of less than 7 inches.

Minor soils in this association are Crete, Muir, Hord, McCook, and Tobin soils; Alluvial land, loamy; and Alluvial land, wet. Most of these soils are on low hills or alluvial fans on the sides of the valley. Alluvial land, wet, is on the south end of the State Lake.

The soils in this association are used for all dryland crops commonly grown in the county. Wheat and grain sorghum are the main crops. The acreage of soybeans has increased slightly. Some areas of Sutphen soils are in native range.

If the soils in this association are cultivated, the main hazards are loss of crops by flooding, excess surface water, and soil blowing in dry springs. Controlling flooding, improving soil drainage, and improving tilth and fertility are the main concerns in management.

8. Roxbury-New Cambria-McCook association

Deep, nearly level and gently sloping soils that formed in calcareous silty and clayey alluvium

This association consists of nearly level to gently sloping soils on first and second bottoms in the Solomon River Valley. The first bottom is a narrow strip along the Solomon River. The second bottom generally is a mile or more wide on each side of the river.

This association covers about 3 percent of the county. About 40 percent of this association is Roxbury soils, 10 percent is New Cambria soils, 10 percent is McCook soils, and 40 percent is minor soils (fig. 9).

The deep, nearly level and gently sloping Roxbury soils formed in silty alluvium. These soils are well drained. They have a thick surface layer of dark-gray silt loam. The subsoil is dark-gray silty clay loam. The underlying material is pale-brown or light-gray silt loam or light silty clay loam. Roxbury soils are limy at a depth of less than 10 inches.

The deep, nearly level New Cambria soils formed in clayey alluvium. These soils are moderately well drained. They have a surface layer of dark-gray silty clay loam. The subsoil is dark-gray silty clay. The underlying material is brown or grayish-brown silty clay loam or silty clay. New Cambria soils are limy at a depth of less than 10 inches.

The deep, nearly level or gently sloping McCook soils formed in silty alluvium. These soils are well drained. They have a surface layer of grayish-brown light silty loam. The subsoil is light-gray, soft loam. The under-

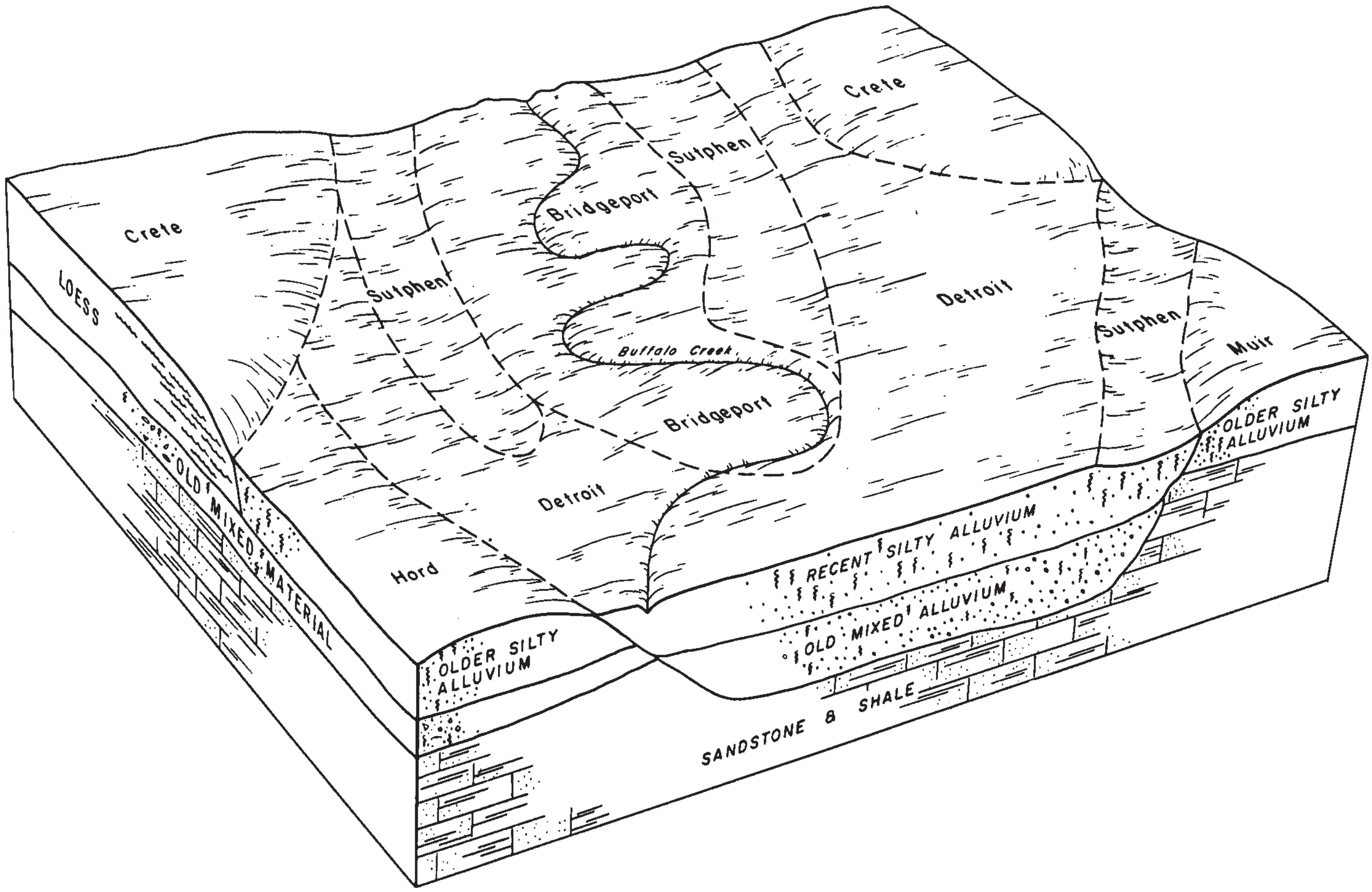

***Figure 8.*—Pattern of soils and underlying materials in Detroit-Sutphen-Bridgeport association.**

lying material is light-gray, loose loam that has layers of very fine sandy loam and fine sandy loam. McCook soils are limy at a depth of less than 10 inches.

Minor soils in this association are Muir, Hord, Detroit, Sutphen, and Bridgeport soils; Alluvial land, loamy; and Alluvial land, wet. Muir, Hord, and Detroit soils are on the sides of the valley near the base of upland slopes. Sutphen soils are in depressions and are associated with New Cambria soils. Bridgeport soils and Alluvial land, loamy, are in small areas along the larger streams. Alluvial land, wet, is along a small lateral drainageway west of Glasco.

Most areas of the soils in this association are suitable for all crops commonly grown in the county. Wheat and grain sorghum are the main crops. Corn is grown in some areas of Bridgeport soils. Some small areas of native range are on Sutphen soils. A large acreage of this association is in the proposed Glen Elder Irrigation District. The soils in this area except Alluvial land, loamy, and Alluvial land, wet, are suited to irrigation.

If the soils in this association are cultivated, the main hazards are soil blowing in dry periods and loss of water by runoff and evaporation. Using crop residue and special cultivation practices and increasing fertilization are the main concerns in management.

Descriptions of the Soils

This section describes the soil series and mapping units in Cloud 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, which 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 differs from the one described for the series, the differences are stated in describing the mapping unit, or the differences are

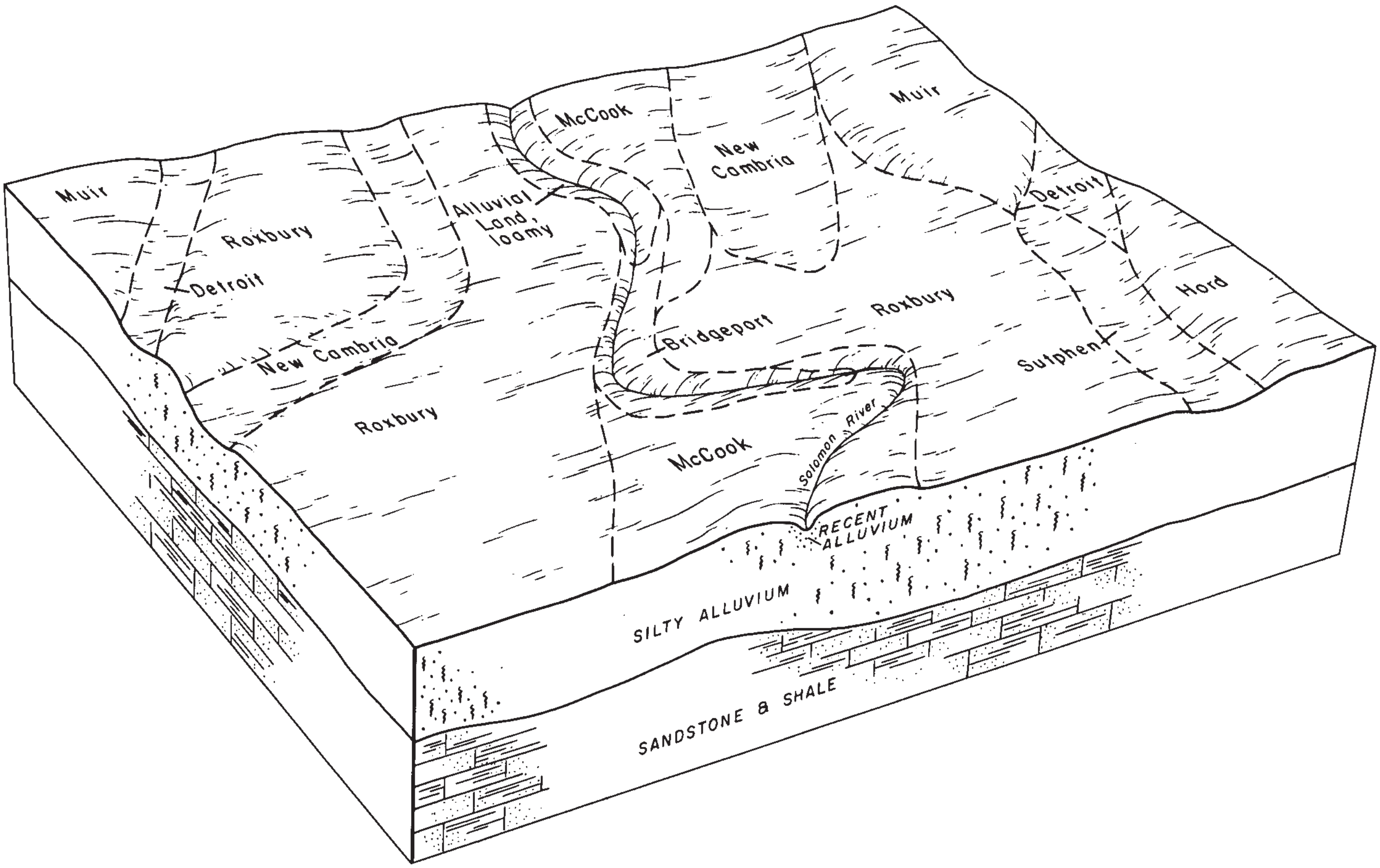

Figure 9.—**Pattern of soils and underlying materials in Roxbury-New Cambria-McCook association.**

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. Alluvial land, for example, is not a soil series, but nevertheless is listed in alphabetic order along with the soil series.

Following the name of each mapping unit is a soil 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 are the dryland and irrigated capability units, range site, and windbreak suitability group in which the mapping unit has been placed. The pages on which the range sites are described are given in the "Guide to Mapping Units" at the back of this survey.

Rock outcrops affect the use of soils and are shown on the map by a spot symbol. Each symbol represents an area as much as 2 acres in size. Rock outcrops are shown in areas of soils that do not normally have outcrops of bedrock.

The acreage and proportionate extent of each mapping 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 (*7*).

Alluvial Land

Alluvial land consists of material deposited by streams. The material generally is variable. The soils generally have not been in place long enough to form distinct horizons.

Alluvial land, loamy (Aa).—This land type consists of gently sloping areas on flood plains and moderately sloping to moderately steep areas on the adjoining side slopes. These areas are along the streams in all parts of the county.

Where this land type is on flood plains, it has a thick surface layer of dark grayish-brown loam, silt loam, or silty clay loam over grayish-brown or gray silty clay loam or stratified silt loam and silty clay loam. In some places a recent deposit of grayish-brown silt loam or silty clay loam covers the older surface layer. In places sandy or gravelly layers are on or beneath the surface layer. In most areas the profile is slightly acid throughout. In some areas free carbonates are at a depth of less than 10 inches. Slopes are 0 to 2 percent.

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

Soil	Acres	Percent	Soil	Acres	Percent
Alluvial land, loamy	5,750	1.3	Kipson soils, 5 to 30 percent slopes	30,700	6.7
Alluvial land, wet	610	.1	Lancaster-Hedville complex, 5 to 30 percent slopes	13,300	2.9
Armo silt loam, 2 to 7 percent slopes	16,100	3.5	Longford silt loam, 1 to 3 percent slopes	1,000	.2
Breaks-Alluvial land complex	21,950	4.8	Longford silt loam, 3 to 7 percent slopes	9,650	2.1
Bridgeport silt loam	1,950	.4	Longford silty clay loam, 3 to 7 percent slopes, eroded	22,900	5.0
Carr fine sandy loam	11,100	2.4	McCook silt loam	1,800	.4
Carr fine sandy loam, high	900	.2	Muir silt loam	16,800	3.7
Carr and Sarpy soils	2,000	.4	New Cambria silty clay loam	1,800	.4
Crete silt loam, 0 to 1 percent slopes	4,100	.9	Nuckolls silt loam, 4 to 12 percent slopes	750	.2
Crete silt loam, 1 to 3 percent slopes	49,450	10.9	Nuckolls silt loam, 4 to 12 percent slopes, eroded	2,100	.5
Crete silt loam, 3 to 6 percent slopes	8,000	1.8	Roxbury silt loam	5,950	1.3
Crete silty clay loam, 2 to 6 percent slopes, eroded	70,800	15.6	Sarpy loamy sand	3,450	.8
Detroit silty clay loam	3,900	.8	Sarpy loamy sand, duned	650	.1
Eudora silt loam, thick surface variant	2,700	.6	Sutphen silty clay	1,550	.3
Geary silt loam, 3 to 7 percent slopes	700	.1	Tobin silt loam	3,150	.7
Geary silty clay loam, 3 to 7 percent slopes, severely eroded	5,700	1.2	Wakeen silty clay loam, 3 to 6 percent slopes	3,500	.8
Hastings silt loam, 1 to 3 percent slopes	8,150	1.8	Republican River	1,210	.3
Hastings silt loam, 3 to 7 percent slopes	8,450	1.9	State Lake	400	.1
Hastings silty clay loam, 2 to 6 percent slopes, eroded	67,800	14.9	Ponds	240	.1
Hedville stony loam, 5 to 30 percent slopes	6,850	1.5	Sand pits	320	.1
Hobbs silt loam	9,400	2.1	Clay pits	310	.1
Hord silt loam	21,650	4.8			
Humbarger loam	5,500	1.2	Total	455,040	100.0

Where this land type is on side slopes, it has a surface layer of dark grayish-brown silt loam that grades into gray or grayish-brown, stratified silt loam and silty clay loam. In places sand or gravel layers outcrop on the lower part of the steeper slopes. Free carbonates are at a depth of less than 15 inches. Slopes are 8 to 20 percent.

Alluvial land, loamy, is used for pasture, woodlots, and wildlife habitat. The size of areas of this land type, frequent flooding, and meandering channels make cultivation impractical. Capability unit VIIe-1; Loamy Lowland range site; windbreak suitability group 1.

Alluvial land, wet (Ah).—This land type consists of poorly drained areas on bottom lands. Most of these areas are south of State Lake.

In most places the surface layer is dark grayish-brown silty clay loam that grades to grayish heavy silty clay loam or silty clay. In some places the surface layer is silt loam and is underlain by silt loam, silty clay loam, or silty clay. In a few places texture is silty clay throughout. Faint to distinct, brown and yellowish-brown mottles are below the surface layer. In some areas fine iron concretions are below the surface layer. Slopes are 0 to 1 percent.

The water table generally is within 5 feet of the surface during the growing season. In most places free carbonates are at a depth of less than 10 or 15 inches. In some places small areas of salt-tolerant grasses indicate the presence of sodium compounds that restrict plant growth.

Alluvial land, wet, is suitable for native range, wildlife habitat, or recreational areas. Capability unit Vw-1; Subirrigated range site; windbreak suitability group 1.

Armo Series

The Armo series consists of deep, well-drained, moderately sloping soils at the base of limestone and shale hills on uplands. These soils formed in calcareous colluvium weathered from limestone, shale, and loess.

In a representative profile the surface layer is dark-gray, calcareous silt loam about 10 inches thick. The subsoil is calcareous light silty clay loam about 30 inches thick. It is dark gray in the upper part and grayish brown in the lower part. The underlying material is calcareous, brown silt loam.

Runoff and internal drainage are medium. Permeability is moderate. Available water capacity is high.

Representative profile of Armo silt loam, 2 to 7 percent slopes, in a cultivated field, 2,100 feet north and 75 feet east of the southwest corner of sec. 8, T. 7 S., R. 5 W.:

Ap—0 to 10 inches, dark-gray (10YR 4/1) silt loam, very dark gray (10YR 3/1) moist; moderate, fine, granular structure; slightly hard, friable; numerous worm casts; slightly effervescent, mildly alkaline; gradual boundary.

B1—10 to 18 inches, dark-gray (10YR 4/1) light silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, subangular blocky structure; hard, friable; numerous worm casts and fine pores; strongly effervescent, moderately alkaline; gradual boundary.

B2ca—18 to 40 inches, grayish-brown (10YR 5/2) light silty clay loam, dark grayish brown and brown (10YR 4/2 and 5/3) moist; moderate, fine, subangular blocky structure; hard, friable; numerous worm casts and fine pores; common, white, soft lime accumulations; violently effervescent, moderately alkaline; gradual boundary.

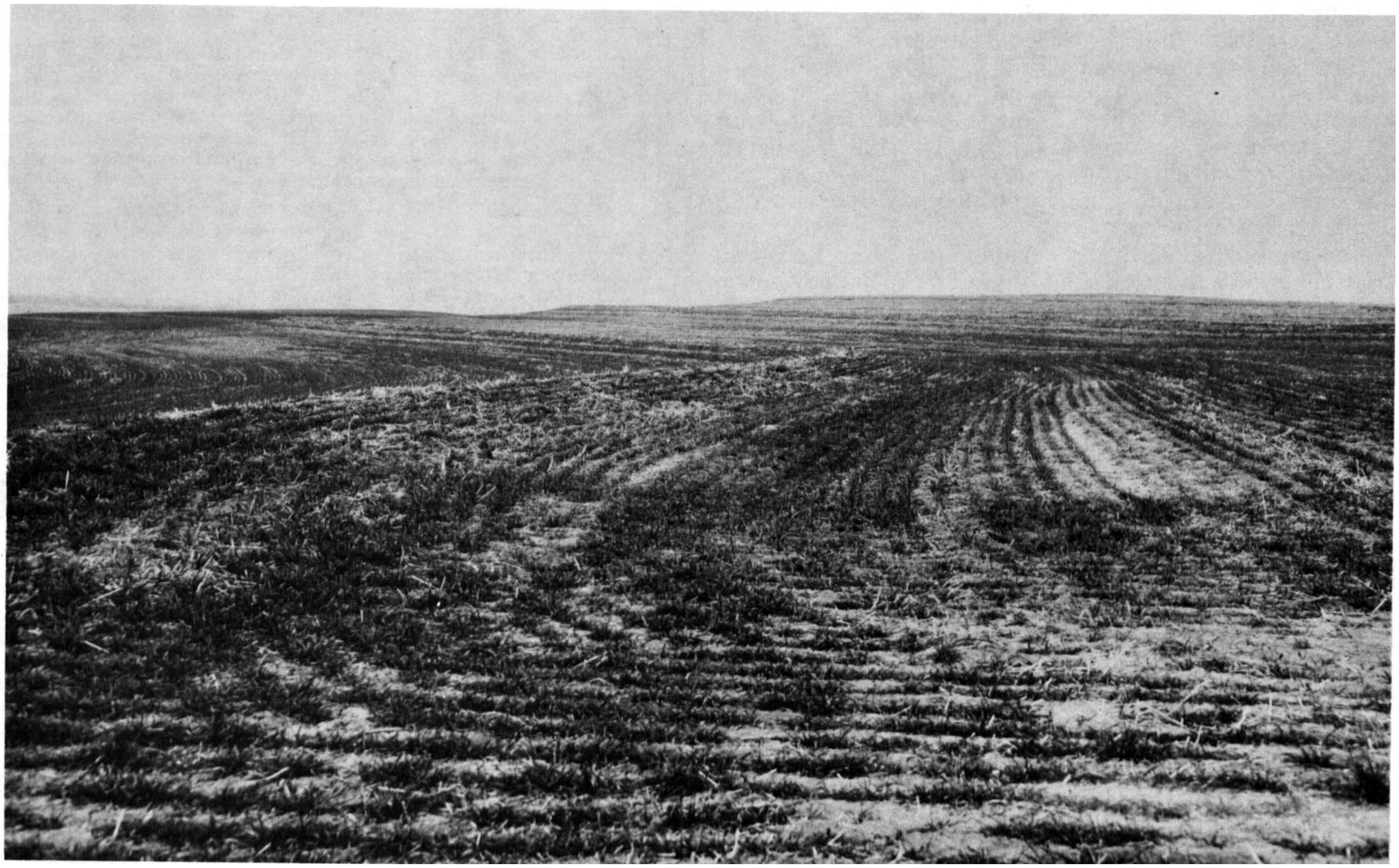

Figure 10.—**Terraces and contour-planted wheat on Armo silt loam, 2 to 7 percent slopes, in capability unit IIIe-1, dryland.**

Cca—40 to 60 inches, brown (10YR 5/3) heavy silt loam, dark brown (10YR 4/3) moist; weak, fine, granular structure; hard, friable; some worm casts and numerous fine pores; common, white, soft lime accumulations; violently effervescent, moderately alkaline.

The combined thickness of the A and B horizons ranges from 24 to 40 inches. The thickness of the upper horizons that are dark gray or darker ranges from 7 to 20 inches.

The A horizon ranges from 8 to 14 inches in thickness and is silty clay loam in some places. In some places it is noncalcareous to a depth of 7 inches. In places small, brittle shale and limestone fragments are in and beneath the A horizon. The B horizon ranges from 16 to 30 inches in thickness.

Armo soils are near Kipson, Wakeen, Hord, and Hastings soils. They are deeper to the underlying limestone and shale than Kipson and Wakeen soils. They have less clay in the B horizon than Hastings soils. They have thinner upper layers that are dark gray or darker than Hord soils. They are shallower to free carbonates than Hord and Hastings soils.

Armo silt loam, 2 to 7 percent slopes (Ar).—This soil is at the base of limestone and shale hills on uplands. Surface runoff is medium. Included with this soil in mapping are small areas of Kipson, Wakeen, Hastings, and Hord soils.

This soil is suited to all crops commonly grown in the county. If this soil is cropped, the main limitations are erosion and loss of moisture by runoff and evaporation. Tilth in the plow layer has been reduced in some cultivated fields. The use of contour farming, terraces, and grassed waterways reduces moisture and soil losses (fig. 10). Good management of crop residue reduces evaporation and runoff and improves tilth. If this soil is adequately protected and fertilized, the intensity of row cropping can be increased. This soil is suitable for irrigation if water of good or better quality is available. The irrigation system needs to control the movement of all water, and it requires special practices to fit each location. Capability units IIIe-1, dryland, and IIIe-3, irrigated; Limy Upland range site; windbreak suitability group 3.

Breaks-Alluvial Land Complex

Breaks-Alluvial land complex (Ba) consists of areas in which the drainage system has cut deeply entrenched stream channels on uplands. The areas include the stream channel, the soils on the flood plain, and the soils on the steep, broken, adjoining side slopes.

The soils on the flood plains have a thick surface layer of dark grayish-brown loam or silt loam. The subsoil is grayish-brown loam, silt loam, or silty clay loam. In some areas the surface layer is recently deposited grayish-brown loam or silt loam. In other areas gravel is on or in the soil. These soils are slightly acid throughout or have free carbonates below a depth of 10 to 30 inches. Slopes are 0 to 3 percent.

The soils on the steep adjoining side slopes have a surface layer of dark grayish-brown loam, silt loam, or silty clay loam. The subsoil is brownish silt loam, silty clay loam, or clay loam. These soils formed in loess, in mixed sandstone and shale, or in mixed colluvium. They are deep and well drained. Slopes range from 10 to 25 percent.

In some areas soils that are shallow over limestone and shale or sandstone and shale are included in this soil complex. These soils are slightly acid throughout or have free carbonates below a depth of 24 inches.

Breaks-Alluvial land complex is suited to native range, windbreaks, woodlots, wildlife habitat, and recreation. Both parts are in capability unit VIe-1; Breaks part is in Loamy Upland range site and windbreak suitability group 3; Alluvial land part is in Loamy Lowland range site and windbreak suitability group 1.

Bridgeport Series

The Bridgeport series consists of deep, nearly level, well-drained soils on flood plains in the Buffalo Creek and Solomon River Valleys. These soils formed in calcareous, silty and clayey alluvium.

In a representative profile the surface layer is dark-gray, calcareous silt loam about 14 inches thick. The next layer is grayish-brown, friable light silty clay loam about 8 inches thick. The underlying material is layers of grayish-brown, calcareous silt loam and silty clay loam.

Surface runoff is slow, and internal drainage is medium. Permeability is moderate. Available water capacity is high. The water table generally is below a depth of 5 feet, except during periods of high stream flow. These soils are frequently flooded.

Representative profile of Bridgeport silt loam, in a cultivated field, 1,600 feet south and 50 feet west of the northeast corner of sec. 16, T. 5 S., R. 5 W.:

Ap—0 to 8 inches, dark-gray (10YR 4/1) silt loam, very dark gray (10YR 3/1) moist; thin, irregular, light-colored streaks of recently deposited silt; weak, fine, granular structure; slightly hard, very friable; numerous worm casts, fine roots, and insect holes; slightly effervescent, mildly alkaline; clear boundary.

A1—8 to 14 inches, grayish-brown and dark-gray (10YR 5/2 and 4/1) silt loam, very dark grayish brown and very dark gray (10YR 3/2 and 3/1) moist; thin, irregular, light-colored streaks of recent silt deposits; moderate, fine, granular structure; hard, friable; numerous worm casts, fine roots, insect holes, and fine pores; strongly effervescent, moderately alkaline; gradual boundary.

AC—14 to 22 inches, grayish-brown (10YR 5/2) light silty clay loam, dark grayish brown (10YR 4/2) moist; stratified silt loam and silty clay loam; moderate, fine, granular structure; hard, friable; numerous worm casts, fine roots, insect holes, and fine pores; strongly effervescent, moderately alkaline; gradual boundary.

C1—22 to 40 inches, grayish-brown and pale-brown (10YR 5/2 and 6/3) silt loam, dark grayish brown and brown (10YR 4/2 and 4/3) moist; thin strata of silty clay loam; weak, fine, granular structure; slightly hard, friable; few worm casts and many fine pores; soft white carbonate accumulations; violently effervescent, moderately alkaline; gradual boundary.

C2—40 to 60 inches, grayish-brown (10YR 5/2) light silty clay loam, dark grayish brown (10YR 4/2) moist; strata of silt loam and silty clay loam; faint, fine, brownish mottles; weak, fine, granular structure; slightly hard, friable; a few worm casts and many fine pores; soft white carbonate accumulations; strongly effervescent, moderately alkaline.

The combined thickness of the A and AC horizons generally is about 24 inches but ranges from 18 to 30 inches. The thickness of the upper soil layers that are grayish brown or gray or darker ranges from 12 to 18 inches.

The Ap horizon ranges from silt loam to silty clay loam in texture and from 6 to 10 inches in thickness. In some places brownish mottles are not in the C horizon.

Bridgeport soils in Cloud County have thin, irregular, grayish-brown strata in the layers that are grayish brown or gray or darker, which is not within the range defined for the Bridgeport series. This difference, however, does not alter the usefulness and behavior of these soils.

Bridgeport soils are near Sutphen, New Cambria, Detroit, McCook, and Roxbury soils. Bridgeport soils have less clay throughout the profile than Sutphen, New Cambria, and Detroit soils. They have more clay throughout the profile than McCook soils. They have thinner dark upper layers than Roxbury, New Cambria, Detroit, and Sutphen soils. Bridgeport soils are shallower to free carbonates than Detroit and Sutphen soils. They are more stratified and are in lower lying areas than Roxbury soils.

Bridgeport silt loam (0 to 1 percent slopes) (Br).—This nearly level soil is on the flood plains of Buffalo Creek and Solomon River. Surface runoff is slow. Included with this soil in mapping are small areas of Detroit, New Cambria, and Sutphen soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, silage or forage crops, and wheat. Excess surface water can be slowly removed by properly directed crop rows and by drainage ditches. Good management of crop residue and fertilization help to maintain or improve tilth and productivity. Cropping systems can be adjusted to meet individual farm needs. Flood-control practices are needed to reduce crop losses and soil damage. This soil is suitable for irrigation if water of good or excellent quality is available. The irrigation system needs to assure equal distribution of water and the removal of excess surface water by drainage ditches. Capability units IIw-2, dryland, and IIw-4, irrigated; Loamy Lowland range site; windbreak suitability group 1.

Carr Series

The Carr series consists of deep, well-drained, nearly level and gently sloping soils on the flood plain in the Republican River Valley. These soils formed in calcareous sandy loam alluvium that has strata of finer and coarser texture.

In a representative profile the surface layer is grayish-brown, calcareous fine sandy loam about 12 inches thick. The next layer is grayish-brown and pale-brown, calcareous, very friable fine sandy loam about 6 inches thick. The underlying material is light-gray, calcareous fine sandy loam stratified with fine sand and loam in the upper part; and it is stratified fine sandy loam and loamy fine sand in the lower part.

Surface runoff is slow, and internal drainage is medium. Permeability is moderate. Available water capacity is moderate.

Representative profile of Carr fine sandy loam in a cultivated field, 2,300 feet south and 20 feet east of the northwest corner of sec. 19, T. 5 S., R. 3 W.:

Ap—0 to 7 inches, grayish-brown (10YR 5/2) fine sandy loam, dark grayish brown (10YR 4/2) moist; weak, fine, granular structure; loose; many fine roots, insect holes, and worm casts; moderately alkaline; clear boundary.

A1—7 to 12 inches, grayish-brown and light brownish-gray (10YR 5/2 and 6/2) fine sandy loam, dark grayish brown and grayish brown (10YR 4/2 and 5/2) moist; weak, fine, granular structure; slightly hard, friable; many fine roots, insect holes, worm casts, and fine pores; slightly effervescent, moderately alkaline; gradual boundary.

AC—12 to 18 inches, grayish-brown and pale-brown (10YR 5/2 and 6/3) fine sandy loam, dark grayish brown and brown (10YR 4/2 and 5/3) moist; weak, fine, granular structure; slightly hard, very friable; few fine roots, insect holes, worm casts, and many fine pores; slightly effervescent, moderately alkaline; gradual boundary.

C1—18 to 48 inches, light-gray (10YR 7/2) fine sandy loam, grayish brown (10YR 5/2) moist; stratified fine sandy loam, fine sand, and loam; structureless, single grained; slightly hard, loose; few coarse roots below a depth of 36 inches, few fine and medium pores; strongly effervescent, moderately alkaline; gradual boundary.

C2—48 to 60 inches, light-gray (10YR 7/2) stratified fine sandy loam and loamy fine sand, grayish brown and pale brown (10YR 5/2 and 6/3) moist; structureless, single grained; soft, loose; few, fine, brownish mottles; strongly effervescent, moderately alkaline.

The combined thickness of the A and AC horizons generally is 18 to 24 inches but ranges from 14 to 30 inches.

The A horizon is noncalcareous to a depth of 7 to 10 inches in places. It generally is grayish brown or pale brown, but in places part of this horizon is very dark grayish brown. It ranges from 6 to 18 inches in thickness and is loam or loamy fine sand in places. In places, strata that are more sandy or more clayey are at any depth beneath the A horizon. Average texture is fine sandy loam to a depth of 30 or 40 inches. In places, sand or sand and gravel are at a depth of 30 to 36 inches. Yellow and brown mottles are below a depth of 30 inches in places.

Carr soils are near Humbarger, Hobbs, Eudora, Muir, Detroit, Hord, and Sarpy soils. Carr soils are more sandy throughout the profile than Humbarger, Hobbs, Eudora, Muir, Detroit, and Hord soils. They are less sandy and have less coarse sand than Sarpy soils. They have upper layers that are not so dark as those in Humbarger, Hobbs, Eudora, Muir, Detroit, and Hord soils. They are shallower to free carbonates than Eudora, Muir, Detroit, Hord, and Sarpy soils.

Carr fine sandy loam (0 to 2 percent slopes) (Ca).—This soil is on the flood plain of the Republican River. It has the profile described as representative of the series. Surface runoff is slow. Included with this soil in mapping are small areas of Humbarger, Sarpy, and Eudora soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, corn, silage, wheat, and alfalfa. If this soil is cropped, the main limitations are loss of moisture by leaching and evaporation, soil blowing, and flooding. Good management of crop residue reduces soil blowing and evaporation. Use of alternate fields of close-growing crops and row crops in large fields also reduces soil blowing and snow drifting. Adequate fertilization increases production and residue. Cropping systems can be changed to meet individual farm needs. In the lower lying areas, use of flood-control measures reduces crop loss and soil damage. This soil is suitable for irrigation if water of acceptable or better quality is available. If this soil is to be leveled, the depth to the underlying loose sand should be determined. Capability units IIs-3, dryland, and IIs-4, irrigated; Sandy Lowland range site; windbreak suitability group 2.

Carr fine sandy loam, high (0 to 3 percent slopes) (Cb).—This soil is on the terraces, or second bottoms, in the Republican Valley. This soil has a profile similar to that described as representative of the series, but it is not stratified in the upper 40 inches and does not have free carbonates in the upper 40 inches. Included with this soil in mapping are small areas of Muir, Detroit, and Eudora soils.

This soil is suited to all crops commonly grown in the county. Grain sorghum, silage or forage crops, wheat, and alfalfa are the main crops. If this soil is cropped, the main limitations are soil blowing and loss of moisture by runoff, leaching, and evaporation. Good management of crop residue and adequate fertilization help to reduce soil blowing and loss of moisture by runoff and evaporation. Cropping systems can be adjusted to meet individual farm needs. Emergency tillage to reduce soil blowing is needed at times. This soil is suitable for irrigation if water of acceptable or better quality is available. Capability units I-2, dryland, and I-3, irrigated; Sandy Terrace range site; windbreak suitability group 2.

Carr and Sarpy soils (1 to 4 percent slopes) (Cf).—This mapping unit consists of irregularly shaped, closely associated soils on the Republican River flood plain. These soils are undulating or billowy and are on the inside of river bends and along some old channels of the Republican River. Carr fine sandy loam makes up about 40 to 50 percent of the acreage, Sarpy loamy sand about 30 to 40 percent, and inclusions 10 to 30 percent. These Carr and Sarpy soils are more stratified than is typical for the series and overlie coarse sand.

Included with these soils in mapping are Humbarger loam, Bridgeport silt loam, and sandbars. Humbarger loam and Bridgeport silt loam are in narrow depressions. The sandbars are flat or ridged areas in the river bends. In places the coarse sand is at a depth of 12 to 20 inches.

Carr and Sarpy soils are used mainly for pastured woodlots, woodlots, wildlife habitat, and recreation. Capability unit VIIw-1; Sandy Lowland range site; windbreak suitability group 1.

Crete Series

The Crete series consists of deep, moderately well drained, nearly level to moderately sloping soils on uplands in all parts of the county. These soils formed in calcareous silty loess.

In a representative profile the surface layer is dark-gray silt loam about 10 inches thick. The subsoil is about 30 inches thick. It is dark grayish-brown, friable silty clay loam in the upper 4 inches; dark grayish-brown and grayish-brown, very firm silty clay in the middle 20 inches; and light brownish-gray, firm silty clay loam in the lower 6 inches (fig. 11). The underlying material

Figure 11.—**Profile of a Crete silt loam. This soil has a thick, dark-colored zone and angular blocky structure.**

is light-gray silty clay loam. It has distinct, yellowish-brown mottles and white, soft and hard lime concretions.

Surface runoff is slow to medium, and internal drainage is medium. Permeability is moderately slow. Available water capacity is high.

Representative profile of Crete silt loam, 1 to 3 percent slopes, in a cultivated field, 1,300 feet east and 75 feet north of the southwest corner of sec. 33, T. 6 S., R. 5 W.:

Ap—0 to 10 inches, dark-gray (10YR 4/1) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; slightly hard, friable; many fine roots, insect holes, worm casts, and fine pores; slightly acid; gradual boundary.

B1—10 to 14 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, subangular blocky structure; hard, friable; many fine roots, insect holes, worm casts and fine pores; slightly acid; gradual boundary.

B21t—14 to 24 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) moist; strong, fine, angular blocky structure; very hard, very firm; thick, continuous, dark clay films; many fine roots, worm casts, and fine pores; slightly acid; gradual boundary.

B22t—24 to 34 inches, grayish-brown (10YR 5/2) silty clay, dark grayish brown (10YR 4/2) moist; strong, fine and medium, angular blocky structure; extremely hard, very firm; thick continuous clay films; a few worm casts and very fine pores; neutral; gradual boundary.

B3ca—34 to 40 inches, light brownish-gray (2.5Y 6/2) silty clay loam, grayish brown (2.5Y 5/2) moist; thin, moist, dark-gray, vertical streaks; few, fine, dark-brown and yellowish-brown mottles; moderate, fine and medium, subangular blocky structure; very hard, firm; some peds have clay films on vertical faces; few worm casts and fine pores; fine, very dark brown iron concretions; white, hard carbonate concretions; mildly alkaline; gradual boundary.

C—40 to 60 inches, light-gray (2.5Y 7/2) light silty clay loam, grayish brown (2.5Y 5/2) moist; common, fine, distinct, yellowish-brown mottles; massive; hard, friable; fine, dark-brown iron concretions; few fine and medium pores; white, soft and hard carbonate accumulations and concretions; moderately alkaline.

The combined thickness of the A and B horizons ranges from 30 to 44 inches. The depth to free carbonates ranges from 28 to 40 inches. The thickness of the upper horizons that are grayish brown or darker ranges from 20 to 28 inches.

The A horizon ranges from dark-gray silt loam 6 to 12 inches thick to grayish-brown silty clay loam 4 to 8 inches thick. The B2t horizon ranges from 16 to 26 inches in thickness. The C horizon is silt loam in some places.

Crete soils are near Hastings, Geary, Longford, Detroit, and New Cambria soils. They have dark grayish-brown or darker upper layers that are thicker than those in Hastings, Geary, and Longford soils. They are more clayey throughout the profile than Hastings, Geary, and Longford soils. They have a more clayey B2t horizon than Detroit soils. They are deeper to free carbonates than New Cambria soils.

Crete silt loam, 0 to 1 percent slopes (Cr).—This soil is on broad divides and on gently undulating areas of the uplands. It has a profile similar to that described as representative of the series, but the dark grayish-brown or darker surface layer and subsoil are slightly thicker; the clay content of the subsoil is somewhat greater; and gray coatings, or spots, are common in the lower part of the surface layer when the soil is dry. Surface runoff is slow, and the slight depressions pond. Included with this soil in mapping are small areas of a soil that is similar to this Crete soil but that has a thin gray layer in the lower part of the surface layer.

This soil is suited to all crops commonly grown in the county. Corn is not so well adapted to this soil as is grain sorghum. The main limitations are water erosion on the longer slopes and soil blowing in areas left bare. Good management of crop residue helps to maintain or improve tilth and organic-matter content and increases moisture intake and reduces water erosion and soil blowing. On the longer slopes, tilling on the contour reduces water erosion. In places depressions need drainage ditches to improve workability and productivity. This soil is suitable for irrigation if water of good or excellent quality is available. Capability units, IIs-1, dryland, and IIs-2, irrigated; Clay Upland range site; windbreak suitability group 3.

Crete silt loam, 1 to 3 percent slopes (Cs).—This soil is on hilltops and side slopes and in gently undulating areas of the uplands in all parts of the county. It has the profile described as representative of the series. Runoff is slow. Included with this soil in mapping are small areas of Hastings, Geary, and Longford soils.

This soil is suited to all crops commonly grown in the county. Corn is not so well suited to this soil as is grain sorghum. A small acreage of this soil is used as pasture or native range. The main limitations are loss of moisture and erosion in unprotected areas. Use of contour farming, terraces, and grassed waterways reduces losses of moisture and soil. Good management of crop residue helps to maintain or improve tilth, improve organic-matter content and moisture intake, and reduce soil blowing. Row cropping in the usual cropping systems is moderately intensive. If this soil is adequately protected and fertilized, the intensity of row cropping generally can be increased. This soil is suitable for irrigation if water of good or excellent quality is available. Capability units IIe-1, dryland, and IIe-3, irrigated; Clay Upland range site; windbreak suitability group 3.

Crete silt loam, 3 to 6 percent slopes (Ct).—This soil is below the hilltops, on side slopes above the local drainageways, and in undulating areas of the uplands in all parts of the county. It has a profile similar to that described as representative of the series, but the surface layer and subsoil are not so thick. Surface runoff is medium. Included with this soil in mapping are small areas of Hastings, Geary, Longford, and Kipson soils.

This soil is suited to all crops commonly grown in the county. Corn is not so well suited to this soil as is grain sorghum. A large acreage of this soil is in native range. If this soil is cropped, the main limitations are erosion and loss of moisture. Use of contour farming, terraces, and grassed waterways reduces losses of moisture and soil. Good management of crop residue helps to maintain or improve tilth, organic-matter content, and moisture intake and reduces loss of moisture. This soil is suitable for irrigation if water of good or excellent quality is available. Special practices are needed to control erosion and to assure efficient use of water. Capability units IIIe-1, dryland, and IIIe-3, irrigated; Clay Upland range site; windbreak suitability group 3.

Crete silty clay loam, 2 to 6 percent slopes, eroded (Cu).—This soil is below the hilltops, on side slopes above the local drainageways, and in undulating areas of the uplands in all parts of the county. It has a profile similar to that described as representative of the series, but erosion has removed part of the original surface layer and the present surface layer is a mixture of the remaining surface layer and part of the subsoil. The present surface layer generally is silty clay loam, but in places it is silty clay. It generally is dark grayish brown to grayish brown, but small gray spots are on the lower parts of some slopes. Surface runoff is medium. Included with this soil in mapping are small areas of Hastings, Geary, Longford, and Kipson soils.

This soil is suited to all crops commonly grown in the county. Corn is not so well suited to this soil as is grain sorghum. If this soil is cropped, the main hazard is erosion. Use of contour farming, terraces, and grassed waterways reduces losses of moisture and soil. Good management of crop residue improves tilth and organic-matter content and reduces loss of moisture. Adequate fertilization increases crop production and residue. This soil is suitable for irrigation if water of good or excellent quality is available. Special practices are needed to control erosion and to assure efficient use of water. Capability units IIIe-2, dryland, and IIIe-3, irrigated; Clay Upland range site; windbreak suitability group 3.

Detroit Series

The Detroit series consists of deep, moderately well drained, nearly level soils on terraces in larger valleys in all parts of the county. These soils formed in calcareous, silty and clayey alluvium.

In a representative profile the surface layer is dark-gray light silty clay loam about 12 inches thick. The subsoil is firm silty clay loam about 28 inches thick. It is dark gray and dark grayish brown in the upper part, grayish brown in the middle part, and light brownish gray in the lower part. The underlying material is light brownish-gray silty clay loam. It contains fine, dark-brown iron concretions and many, white, soft calcium carbonate accumulations.

Surface runoff is slow, and internal drainage is medium. Slight depressions pond in places. Permeability is slow. Available water capacity is high.

Representative profile of Detroit silty clay loam, in a cultivated field, 1,000 feet west and 2,400 feet south of the northeast corner of sec. 30, T. 5 S., R. 4 W.:

Ap—0 to 6 inches, dark-gray (10YR 4/1) light silty clay loam, very dark gray (10YR 3/1) moist; weak, fine, granular structure; hard, friable; many fine roots, insect holes, and worm casts; slightly acid, clear boundary.

A1—6 to 12 inches, dark-gray (10YR 4/1) light silty clay loam, very dark gray (10YR 3/1) moist; moderate, fine, granular structure; hard, friable; many fine roots, insect holes, worm casts, and fine pores; slightly acid; gradual boundary.

B21t—12 to 24 inches, dark-gray and dark grayish-brown (10YR 4/1 and 4/2) heavy silty clay loam, very dark grayish brown and very dark gray (10YR 3/2 and 3/1) moist; strong, fine, angular blocky structure; very hard, firm; thin dark clay films on some peds; many fine roots, worm casts, and fine pores; neutral, gradual boundary.

B22t—24 to 36 inches, grayish-brown (10YR 5/2) heavy silty clay loam, dark grayish brown (10YR 4/2) moist; strong, fine, angular blocky structure; very hard, firm; thin clay films on most peds; few roots, worm casts, and fine pores; neutral; gradual boundary.

B3ca—36 to 40 inches, light brownish-gray (10YR 6/2) silty clay loam, dark grayish brown (10YR 4/2) moist; few, faint, brownish mottles; moderate, fine, subangular blocky structure; hard, firm; few roots, worm casts, and many fine pores; white soft calcium carbonate accumulations; slightly effervescent, mildly alkaline; gradual boundary.

C—40 to 60 inches, light brownish-gray (10YR 6/2) light silty clay loam, grayish brown (10YR 5/2) moist; common, fine, brown mottles; weak, fine, subangular blocky structure; hard, firm; fine dark-brown iron concretions; white soft calcium carbonate accumulations; strongly effervescent, mildly alkaline.

The combined thickness of the A and B horizons ranges from 30 to 48 inches. The depth to free carbonates ranges from 30 to 40 inches. The thickness of the upper horizons that are dark grayish brown or darker ranges from 20 to 36 inches.

In places the A horizon is silt loam. The B2t horizon ranges from 16 to 24 inches in thickness and in places is silty clay. Brownish mottles in the C horizon range from few and faint to common and distinct and are below a depth of 40 inches.

Detroit soils are near Muir, Hord, Roxbury, McCook, Bridgeport, Eudora, New Cambria, Sutphen, and Crete soils. They have a higher clay content throughout the profile than Muir, Hord, Roxbury, McCook, Bridgeport, and Eudora soils. They are deeper to free carbonates than Roxbury, New Cambria, Bridgeport, and McCook soils. They have a lower clay content throughout the profile than New Cambria and Sutphen soils. They have a lower clay content in the B2t horizon than Crete soils.

Detroit silty clay loam (0 to 1 percent slopes) (De).—This soil is on terraces in the larger valleys in all parts of the county. Surface runoff is slow, and depressions pond in places. Included with this soil in mapping are small areas of Muir, Hord, Roxbury, New Cambria, and Sutphen soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, corn, silage or forage crops, wheat, and alfalfa. The main limitations of this soil for crops are slow surface drainage, ponding, flooding, and soil blowing during dry periods. Development of drainage ditches and proper direction of plowing improve surface runoff. Drainage of ponded areas improves workability and productivity. Diversion terraces that intercept runoff from higher lying areas, waterways, and ditches help to remove excess surface water. Good management of crop residue improves tilth and reduces soil blowing. The cropping system can be changed to meet individual farm needs. This soil is suitable for irrigation if water of good or excellent quality is available. If this soil is irrigated, drainage ditches need to be developed to remove excess surface water. Capability units I-1, dryland, and I-3, irrigated; Loamy Terrace range site; windbreak suitability group 1.

Eudora Series, Thick Surface Variant

The Eudora series, thick surface variant, consists of deep, well-drained, nearly level or gently sloping soils on terraces, or second bottoms, in the Republican River Valley. These soils formed in coarse, silty alluvium.

In a representative profile the surface layer is about 30 inches thick. The upper 20 inches of the surface layer is gray or dark-gray light silt loam, and the lower 10 inches is dark grayish-brown loam. The next layer is grayish-brown and dark grayish-brown, very friable loam about 10 inches thick. The underlying material is light brownish-gray, calcareous loam stratified with fine sandy loam and sandy loam.

Surface runoff is slow, and internal drainage is medium. Permeability is moderate. Available water capacity is high.

Representative profile of Eudora silt loam, thick surface variant, in a cultivated field, 1,200 feet east and 150 feet south of northwest corner of sec. 22, T. 5 S., R. 4 W.:

Ap—0 to 10 inches, gray (10YR 5/1) light silt loam, very dark gray (10YR 3/1) moist; weak, fine, granular structure; soft, very friable; many fine roots, insect holes, and worm casts; neutral; clear boundary.

A11—10 to 20 inches, dark-gray (10YR 4/1) light silt loam, very dark gray (10YR 3/1) moist; moderate, fine, granular structure; soft, very friable; many fine roots, insect holes, worm casts, and fine pores; neutral; gradual boundary.

A12—20 to 30 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; slightly hard, very friable; a few fine roots and worm casts, and many fine and medium pores; mildly alkaline; gradual boundary.

AC—30 to 40 inches, grayish-brown and dark grayish-brown (10YR 5/2 and 4/2) loam, dark grayish brown and very dark grayish brown (10YR 4/2 and 3/2) moist; moderate, fine, granular structure; slightly hard, very friable; a few roots and worm casts, and many fine and medium pores; mildly alkaline; gradual boundary.

C—40 to 60 inches, light brownish-gray (10YR 6/2) loam, grayish brown (10YR 5/2) moist; strata of fine sandy loam and sandy loam; weak, fine, granular structure in upper part, massive in lower part; slightly hard, friable; a few roots and worm casts, and many fine and medium pores; few, fine, white, soft calcium carbonate accumulations; slightly effervescent, mildly alkaline.

The combined thickness of the A and AC horizons generally is 36 inches but ranges from 30 to 44 inches. The depth to free carbonates ranges from 36 to 48 inches. The thickness of the upper horizons that are dark grayish brown or gray or darker ranges from 30 to 40 inches.

The A horizon ranges from 24 to 36 inches in thickness and is loam in places. The AC horizon ranges from 8 to 12 inches in thickness and is silt loam in places. The C horizon ranges from loam to fine sandy loam.

The Eudora series, thick surface variant, in Cloud County has dark grayish-brown or darker upper layers that are thicker than is defined as within the range for the Eudora series. This difference does not alter usefulness and behavior of the soils.

Eudora soils, thick surface variant, are near Hord, Muir, Roxbury, Bridgeport, Detroit, Carr, Humbarger, McCook, and Nuckolls soils. They have lower clay content throughout the profile than Hord, Muir, Roxbury, Bridgeport, and Detroit soils. They are deeper to free carbonates than Bridgeport, Roxbury, Carr, Humbarger, and McCook soils. They are shallower to free carbonates than Muir soils. They have thicker, dark upper layers than McCook and Nuckolls soils. They are less sandy than Carr and Humbarger soils.

Eudora silt loam, thick surface variant (0 to 2 percent slopes) (Eu).—This soil is on terraces in the Republican River Valley. Surface runoff is slow. Included with this soil in mapping are small areas of Carr, Detroit, Hord, and Muir soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, corn, silage or forage crops, wheat, and alfalfa. The main limitations for crops are loss of moisture and soil blowing. Tilling on the contour or across the slope reduces runoff. In large areas, alternate fields of close-growing crops and row crops reduce snow drifting and soil blowing. Good management of crop residue and adequate fertilization are needed to improve tilth and reduce moisture loss and soil blowing. Cropping systems can be changed to meet individual farm needs. This soil is suitable for irrigation if water of good or excellent quality is available. Capability units I-2, dryland, and I-3, irrigated; Loamy Terrace range site; windbreak suitability group 1.

Geary Series

The Geary series consists of deep, well-drained, moderately sloping soils on uplands. These soils formed in deep, mixed material weathered from local formations and modified by loess deposits.

In a representative profile the surface layer is dark grayish-brown silt loam about 12 inches thick. The subsoil is about 38 inches thick. The upper 6 inches is brown, friable light silty clay loam; the next 24 inches is brown and light-brown, firm silty clay loam; and the lower 8 inches is reddish-yellow, friable light silty clay loam. The underlying material is reddish-yellow light clay loam.

Surface runoff and internal drainage are medium. Permeability is moderate. Available water capacity is high.

Representative profile of Geary silt loam, 3 to 7 percent slopes, in a meadow, 2,500 feet south and 800 feet east of the northwest corner of sec. 27, T. 6 S., R. 2 W.:

A1—0 to 12 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; hard, friable; many fine roots, insect holes, worm casts, and fine pores; slightly acid; gradual boundary.

B1—12 to 18 inches, brown (10YR 4/3) light silty clay loam, dark brown (10YR 3/3) moist; moderate, fine, subangular blocky structure; hard, friable; many fine roots, insect holes, worm casts, and fine pores; slightly acid; gradual boundary.

B21t—18 to 24 inches, brown (7.5YR 5/4) silty clay loam, dark brown (7.5YR 4/2) moist; strong, fine, angular blocky structure; hard, firm; thin, continuous, brown clay films; many roots, worm casts, and fine pores; slightly acid; gradual boundary.

B22t—24 to 42 inches, light-brown (7.5YR 6/4) silty clay loam, brown (7.5YR 5/4) moist; strong, medium and fine, angular blocky structure; very hard, firm; continuous clay films; a few worm casts and fine pores; slightly acid; gradual boundary.

B3—42 to 50 inches, reddish-yellow (7.5YR 6/6) light silty clay loam, strong brown (7.5YR 5/6) moist; moderate, medium and fine, subangular blocky structure; hard, friable; thin clay films on faces of some peds; fine dark-brown iron concretions; common fine pores; neutral; gradual boundary.

C—50 to 60 inches, reddish-yellow (7.5YR 6/6) light clay loam, strong brown (7.5YR 5/6) moist; weak, fine and medium, subangular blocky structure; hard, friable; clay films on vertical faces of a few peds; common, fine and medium, dark-brown iron concretions; few, white, soft and hard calcium carbonate accumulations; mildly alkaline.

The combined thickness of the A and B horizons ranges from 40 to 54 inches. The depth to free carbonates is more than 48 inches. The thickness of the upper horizons that are grayish brown or darker ranges from 12 to 18 inches.

The A horizon is silty clay loam in places and ranges from 10 to 14 inches in thickness. The B2t horizon ranges from 20 to 30 inches in thickness. The C horizon is light silty clay loam in places.

The surface layer of the soil in mapping unit Gs is lighter colored than is defined as within the range for the Geary series. This difference, however, does not alter the usefulness or behavior of the soil.

Geary soils are near Longford, Hastings, Crete, Nuckolls, Lancaster, and Hedville soils. They have a lower clay content in the B horizon than Longford, Hastings, and Crete soils. They have more clay throughout the profile than Nuckolls soils. They have a redder B horizon than Nuckolls, Crete, and Hastings soils. They are deeper to free carbonates than Nuckolls, Crete, and Hastings soils. They have more clay throughout the profile and are deeper to underlying bedrock than Lancaster and Hedville soils.

Geary silt loam, 3 to 7 percent slopes (Ge).—This soil is on side slopes and below loess-capped hills on uplands. It has the profile described as representative of the series. Surface runoff is medium.

Included with this soil in mapping are small areas of Longford, Hastings, Crete, Lancaster, and Hedville soils. Also included, in the Solomon River Valley, is a soil in which the surface layer and the upper part of the subsoil are similar to those in the representative profile but in which the lower layers contain limestone gravel and free carbonates at a depth of 30 inches. The lower layers are yellowish-brown gravelly silty clay loam. In places, areas of gravel or of sand and gravel are on the surface.

This soil is suited to all crops commonly grown in the county. A large acreage of this soil is in native range. If this soil is cropped, the main limitations are losses of moisture and of soil. Contour farming, terraces, and grassed waterways are needed to reduce losses of moisture and soil. Good management of crop residue helps to maintain tilth and organic-matter content and to reduce moisture loss. This soil is suitable for irrigation if water of good or excellent quality is available. Special practices are needed to control erosion and to assure efficient use of water. Capability units IIIe-1, dryland, and IIIe-3, irrigated; Loamy Upland range site; windbreak suitability group 3.

Geary silty clay loam, 3 to 7 percent slopes, severely eroded (Gs).—This soil is on side slopes and below loess-capped hills on uplands. It has a profile similar to that described as representative of the series, but erosion has removed part of the original surface layer; the present surface layer is a mixture of the remaining surface layer and part of the subsoil. The present surface layer is mainly grayish-brown, brown, or dark-brown silty clay loam, but in places it is light-brown light silty clay loam. Surface runoff is medium.

Included with this soil in mapping are small areas of Longford, Hastings, Crete, Lancaster, and Hedville soils. Also included in the Solomon River Valley is a soil in which the surface layer and the upper part of the subsoil are brownish. The lower layers contain limestone gravel and free carbonates at a depth of 24 inches and are yellowish-brown gravelly silty clay loam. In some places gravel or sand and gravel are on the surface.

This soil is suited to all crops commonly grown in the county. If it is cropped, the main limitations are losses of moisture and of soil. Use of contour farming, terraces, and grassed waterways reduces losses of moisture and soil. A cropping system that includes no more than 2 years of row crops also reduces losses of moisture and soil. Good management of crop residue helps to maintain or improve tilth and organic-matter content and reduces loss of moisture. The soil is suitable for irrigation if water of good or excellent quality is available. Special practices are needed to control erosion and to assure efficient use of water. Capability units IIIe-2, dryland, and IIIe-3, irrigated; Loamy Upland range site; windbreak suitability group 3.

Hastings Series

The Hastings series consists of deep, well-drained, gently sloping to moderately sloping soils on uplands. These soils formed in calcareous silty loess.

In a representative profile the surface layer is dark grayish-brown and grayish-brown silt loam about 12 inches thick. The subsoil is about 32 inches thick. The upper 6 inches is dark grayish-brown and brown, friable light silty clay loam; the next 8 inches is brown, friable silty clay loam; the next 12 inches is pale-brown, firm silty clay loam; and the lower 6 inches is pale-brown and very pale brown, friable light silty clay loam. The underlying material is very pale brown silt loam. Many, white, soft carbonate accumulations are present below a depth of 40 inches (fig. 12).

Surface runoff is slow to medium, and internal drainage is medium. Permeability is moderately slow. Available water capacity is high.

Representative profile of Hastings silt loam, 1 to 3 percent slopes, in a cultivated field, 1,480 feet south and 400 feet west of the northeast corner of sec. 1, T. 6 S., R. 2 W.:

Ap—0 to 7 inches, dark grayish-brown and grayish-brown (10YR 4/2 and 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; slightly hard, friable; many fine roots, insect holes, and worm casts; slightly acid; clear boundary.

A1—7 to 12 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; strong, fine, granular structure; slightly hard, friable; many fine roots, insect holes, worm casts, and fine pores; slightly acid; gradual boundary.

B1—12 to 18 inches, dark grayish-brown and brown (10YR 4/2 and 5/3) light silty clay loam, very dark grayish brown (10YR 3/2) moist; strong, fine, subangular blocky structure; hard, friable; few insect holes and worm casts, and many fine roots and fine pores; thin dark-colored clay films on a few peds; slightly acid; gradual boundary.

B21t—18 to 26 inches, brown (10YR 5/3) silty clay loam, brown (10YR 4/3) moist; thin vertical streaks of very dark grayish brown (10YR 3/2) moist; strong, fine, angular blocky structure; hard, friable; thin continuous clay films; few worm casts and fine pores; slightly acid; gradual boundary.

B22t—26 to 38 inches, pale-brown (10YR 6/3) silty clay loam, brown (10YR 5/3) moist; strong, medium and fine, angular blocky structure; very hard, firm; thin continuous clay films; few fine pores; neutral; gradual boundary.

B3—38 to 44 inches, pale-brown and very pale brown (10YR 6/3 and 7/3) light silty clay loam, brown (10YR 5/3) moist; moderate, fine, subangular blocky structure; hard, friable; thin clay films on a few peds; many fine pores; few fine calcium carbonate accumulations; neutral; gradual boundary.

Cca—44 to 60 inches, very pale brown (10YR 7/3) silt loam, pale brown (10YR 6/3) moist; weak, fine, granular structure in upper part, massive in lower part; slightly hard, very friable; common, white, soft calcium carbonate accumulations; strongly effervescent, mildly alkaline.

The combined thickness of the A and B horizons ranges from 36 to 50 inches. The depth to free carbonates ranges from 36 to 50 inches. The thickness of the upper horizons that are grayish brown or darker ranges from 12 to 18 inches.

The A horizon ranges from dark grayish-brown silt loam 8 to 12 inches thick to grayish-brown silty clay loam 4 to 8 inches thick. The B2t horizon ranges from 16 to 20 inches in thickness. The B22t horizon ranges from silty clay loam to light silty clay. Yellow and brown mottles are below a depth of 40 to 48 inches.

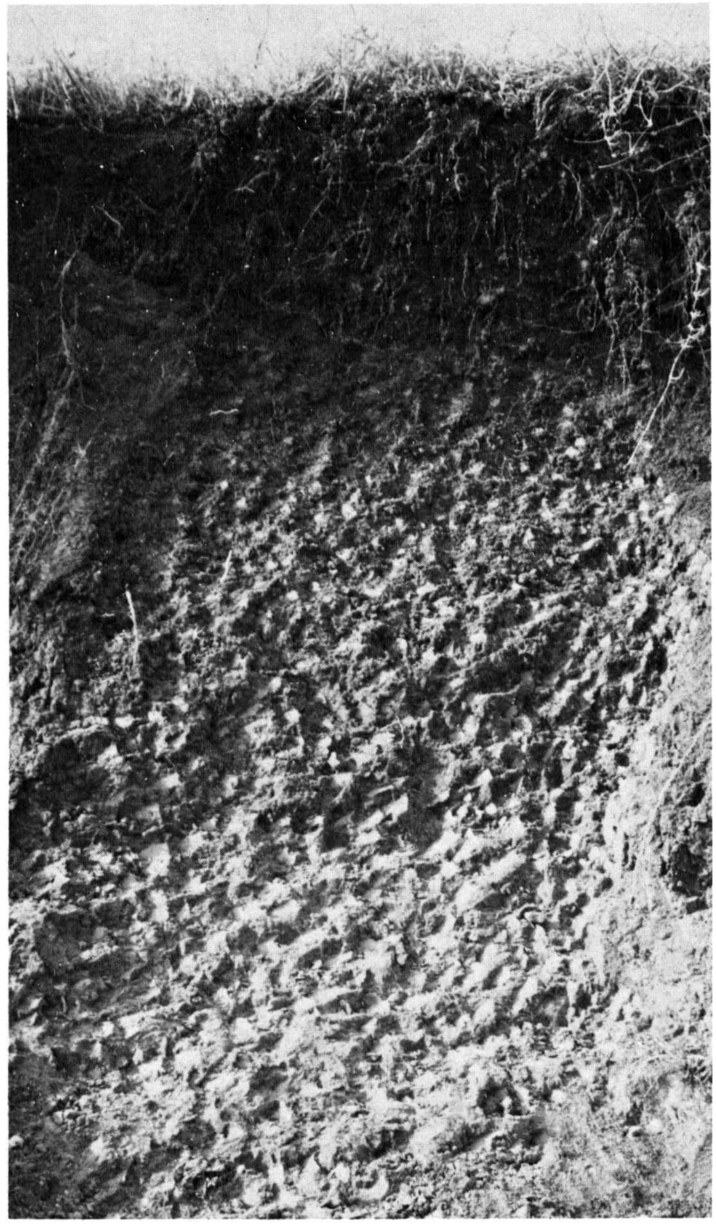

Figure 12.—**Profile of a Hastings silt loam. This soil has a dark-colored, granular surface layer and a brown, angular blocky subsoil.**

Hastings soils are near Geary, Nuckolls, Armo, Crete, and Longford soils. They are more clayey than Geary, Nuckolls, and Armo soils. They are less clayey than Crete soils. They are deeper to free carbonates than Crete, Nuckolls, and Armo soils. They have a less reddish B2 horizon than Geary and Longford soils and are not so deep to free carbonates.

Hastings silt loam, 1 to 3 percent slopes (Hb).—This soil is on convex hilltops on gently rolling uplands. It has the profile described as representative of the series. Surface runoff is medium. Included with this soil in mapping are small areas of Crete and Geary soils.

This soil is suited to all crops commonly grown in the county. If it is cropped, the main limitations are water erosion on the longer slopes and soil blowing in areas that have been left bare. Use of contour farming, terraces, and grassed waterways reduces loss of moisture and soil. Good management of crop residue reduces moisture loss and soil blowing. Moderately intensive row cropping is common on this soil. If this soil is adequately protected and fertilized, the intensity of row cropping can be increased. This soil is suitable for irrigation if water of good or excellent quality is available. Capability units IIe-2, dryland, and IIe-3, irrigated; Loamy Upland range site; windbreak suitability group 3.

Hastings silt loam, 3 to 7 percent slopes (Hc).—This soil is on hillsides, on side slopes above local drainageways, and on steeper slopes in undulating areas on uplands. It has a profile similar to that described as representative of the series, but the surface layer and the subsoil are not so thick. Near the base of the limestone and shale hills, this soil is calcareous at a depth of 36 to 40 inches. Surface runoff is medium. Included with this soil in mapping are small areas of Crete, Geary, Longford, and Armo soils.

This soil is suited to all crops commonly grown in the county. A large acreage of this soil is used as native range. If this soil is cropped, the main limitation is water erosion. Contour farming, terraces, and grassed waterways are needed to reduce moisture and soil losses. Good management of crop residue helps to maintain good tilth and to reduce moisture loss. Adequate conservation practices and fertilization help to maintain or improve productivity. This soil is suitable for irrigation if water of good or excellent quality is available. Special practices are needed to control soil and water losses and to assure efficient use of water. Capability units IIIe-1, dryland, and IIIe-3, irrigated; Loamy Upland range site; windbreak suitability group 3.

Hastings silty clay loam, 2 to 6 percent slopes, eroded (Hd).—This soil is on hillsides, on side slopes above local drainageways, and in undulating areas on uplands. It has a profile similar to that described as representative of the series, but erosion has removed part of the original surface layer; the present surface layer is a mixture of the remaining surface layer and part of the subsoil. It is dark grayish brown, grayish brown, or brown. The areas of this soil near the base of the limestone and shale hills are calcareous at a depth of 30 to 36 inches. Surface runoff is medium. Included with this soil in mapping are small areas of Crete, Geary, Longford, Armo, and Kipson soils.

This soil is suited to all crops commonly grown in the county. If this soil is cropped, the main hazard is water erosion. Use of contour farming, terraces, and grassed waterways reduces moisture and soil losses. A cropping system that limits row cropping to 2 successive years also reduces moisture and soil losses. If this soil is adequately protected by crop residue and fertilized, the intensity of row cropping can be increased. This soil is suitable for irrigation if water of good or excellent quality is available. Special practices are needed to control erosion and to assure efficient use of water. Capability units IIIe-2, dryland, and IIIe-3, irrigated; Loamy Upland range site; windbreak suitability group 3.

Figure 13.—**Profile of Hedville stony loam, 5 to 30 percent slopes. This soil has a dark-colored stony loam surface layer that is underlain by sandstone.**

Hedville Series

The Hedville series consists of shallow, somewhat excessively drained, moderately sloping to steep soils. These soils formed in material weathered from sandstone and sandy shale on uplands.

In a representative profile the surface layer is dark grayish-brown and brown stony loam about 16 inches thick. It is underlain by brown, weathered sandstone (fig. 13).

Surface runoff is medium or rapid, and internal drainage is medium. Permeability is moderate. Available water capacity is low.

Representative profile of Hedville stony loam, 5 to 30 percent slopes, in native range, 1,900 feet north and 300 feet east of the southwest corner of sec. 16, T. 8 S., R. 2 W.:

A11—0 to 12 inches, dark grayish-brown (10YR 4/2) stony loam, very dark brown (10YR 2/2) moist; moderate, fine, granular structure, upper 1 inch is very fine; slightly hard, very friable; many fine roots, many insect burrows and pores; many, gravelly and angular, cobbly sandstone fragments; slightly acid; gradual, wavy boundary.

A12—12 to 16 inches, brown (7.5YR 4/2) stony loam, dark brown (7.5YR 3/2) moist; weak, fine, granular structure; slightly hard, very friable; many fine roots, many insect burrows; pebbles and angular cobblestones of weathered sandstone fragments make up 20 percent of the soil mass; medium acid; clear, irregular boundary extending into cracks and holes in sandstone bedrock.

R—16 inches, brown, weathered sandstone.

The thickness of the A horizon generally is 16 to 18 inches but ranges from 6 to 20 inches. The thickness of the dark upper layers corresponds to the thickness of the A horizon. The A horizon is loam, stony loam, sandy loam, or stony sandy loam in places. Outcrops of sandstone bedrock are common.

Hedville soils are near Lancaster, Geary, Longford, and Kipson soils. They do not have the B2 horizon of Lancaster, Geary, and Longford soils. They are shallower to bedrock than Lancaster, Geary, and Longford soils. They are noncalcareous throughout the profile, whereas Kipson soils are calcareous throughout the profile.

Hedville stony loam, 5 to 30 percent slopes (He).—This soil is on uplands. Surface runoff is medium or rapid. Included with this soil in mapping are small areas of Lancaster, Longford, Geary, and Hobbs soils.

This soil is suited to native range and wildlife habitat. Capability unit VIIe-1; Shallow Over Sandstone range site; windbreak suitability group 4.

Hobbs Series

The Hobbs series consists of deep, moderately well drained, nearly level soils on flood plains of creeks and smaller streams. These soils formed in noncalcareous silty alluvium.

In a representative profile the surface layer is about 40 inches thick. The upper 20 inches of the surface layer is light brownish-gray and dark-gray silt loam that contains thin layers of silty clay loam; and the lower 20 inches is dark-gray silty clay loam that contains thin layers of silt loam. The next layer is dark-gray and light brownish-gray, friable silty clay loam about 20 inches thick.

Surface runoff is slow, and internal drainage is medium. Permeability is moderate. Available water capacity is high. The water table generally is below a depth of 6 feet during the growing season. These soils are frequently flooded, but floodwaters usually recede in a short time.

Representative profile of Hobbs silt loam, in a cultivated field, 2,000 feet west and 300 feet south of the northeast corner of sec. 10, T. 7 S., R. 2 W.:

A11—0 to 20 inches, light brownish-gray and dark-gray (10YR 6/2 and 4/1) silt loam, very dark grayish brown and grayish brown (10YR 3/2 and 5/2) moist; stratified silt loam and silty clay loam; weak, fine, granular structure; hard, friable; many roots, insect holes, worm casts, and fine and medium pores; slightly acid; gradual boundary.

A12—20 to 40 inches, dark-gray (10YR 4/1) light silty clay loam, very dark grayish brown (10YR 3/2) moist; silty clay loam with strata of gray silt loam; moderate, fine, granular structure; hard, friable; a few worm casts and many fine pores; slightly acid; gradual boundary.

AC1—40 to 50 inches, dark-gray and light brownish-gray (10YR 4/1 and 6/2) silty clay loam, very dark grayish brown and dark grayish brown (10YR 3/2 and 4/2) moist; moderate, fine, granular structure; hard, friable; a few worm casts and many fine pores; neutral; gradual boundary.

AC2—50 to 60 inches, dark-gray (10YR 4/1) silty clay loam, very dark grayish brown (10YR 3/2) moist; weak, fine, granular structure; hard, friable; neutral.

The combined thickness of the A and AC horizons generally is about 50 inches but ranges from 40 to 60 inches. The depth to free carbonates ranges from 40 to 60 inches. Thickness of the upper horizons that are grayish brown or darker ranges from 30 to 48 inches.

The A horizon ranges from 24 to 48 inches in thickness and is silty clay loam in places. In places, few and faint or common and distinct, brown and yellowish-brown mottles are in the AC or C horizons at a depth of 40 inches or more.

Hobbs soils are near Detroit, Eudora, Carr, Sarpy, Humbarger, Hord, Tobin, and Muir soils. They have less clay throughout the profile than Detroit soils. They have more clay throughout the profile than Eudora soils. They are less sandy than Carr, Sarpy, and Humbarger soils. Hobbs soils have a thicker, dark upper layer than Carr and Sarpy soils. They are deeper to free carbonates than Carr. Humbarger, Sarpy, Eudora, Hord, Detroit, and Tobin soils. They are more stratified and are on lower elevations than Muir and Hord soils.

Hobbs silt loam (0 to 2 percent slopes) (Ho).—This soil is on the flood plains of creeks and smaller streams. Surface runoff is slow. Included with this soil in mapping are small areas of Tobin, Muir, and Hord soils.

This soil is suited to all crops commonly grown in the county. The principal crops are grain sorghum, corn, silage or forage crops, and wheat. If this soil is cropped, the main limitations are loss of moisture through runoff and evaporation, flooding, and soil blowing during dry seasons. Tilling on the contour or across the slope reduces runoff. Good management of crop residue and fertilization reduce evaporation and soil blowing. Cropping systems can be adjusted to meet individual farm needs. Where they can be applied, flood-control practices reduce crop losses. In some low areas, drainage ditches are needed to remove excess surface water. This soil is suitable for irrigation if water of good or excellent quality is available. Capability units IIw-2, dryland, and IIw-4, irrigated; Loamy Lowland range site; windbreak suitability group 1.

Hord Series

The Hord series consists of deep, well-drained, nearly level soils on terraces, or second bottoms, in most valleys in the county. These soils formed in calcareous silty alluvium.

In a representative profile the surface layer is dark-gray silt loam about 22 inches thick. The subsoil is about 20 inches thick. The upper 6 inches of the subsoil is dark grayish-brown, friable light silty clay loam, and the lower 14 inches is grayish-brown and brown, firm silty clay loam. The underlying material is grayish-brown, calcareous light silty clay loam.

Surface runoff is slow, and internal drainage is medium. Permeability is moderate. Available water capacity is high.

Representative profile of Hord silt loam, in a cultivated field, 2,000 feet west and 100 feet south of the northeast corner of sec. 23, T. 6 S., R. 4 W.:

Ap—0 to 10 inches, dark-gray (10YR 4/1) silt loam, very dark grayish brown (10YR 3/2) moist; weak, fine, granular structure; slightly hard, very friable; many fine roots, insect holes, and worm casts; neutral; clear boundary.

A1—10 to 22 inches, dark-gray (10YR 4/1) silt loam, very dark brown (10YR 2/2) moist; moderate, fine, granular structure; slightly hard, friable; many fine roots, insect holes, and worm casts, and many medium and fine pores; neutral; gradual boundary.

B1—22 to 28 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, friable; many fine roots, insect holes, worm casts, and fine and medium pores; slightly effervescent at a depth of 24 inches, mildly alkaline; gradual boundary.

B2—28 to 42 inches, grayish-brown and brown (10YR 5/2 and 5/3) silty clay loam, dark grayish brown and brown (10YR 4/2 and 4/3) moist; moderate, fine, angular blocky structure; hard, firm; few worm casts and fine pores; white soft calcium carbonate accumulations; strongly effervescent, moderately alkaline; gradual boundary.

C—42 to 60 inches, grayish-brown (10YR 5/2) light silty clay loam, dark grayish brown (10YR 4/2) moist; weak, fine, granular structure; slightly hard, friable; few worm casts and many fine and medium pores; white soft calcium carbonate accumulations; strongly effervescent, moderately alkaline.

The combined thickness of the A and B horizons ranges from 36 to 50 inches. The depth to free carbonates ranges from 24 to 40 inches. Thickness of the upper horizons that are dark grayish brown or darker ranges from 20 to 30 inches.

The A horizon ranges from 14 to 24 inches in thickness and is silty clay loam in places. The B horizon ranges from 18 to 30 inches in thickness and is silt loam in places. The C horizon is silt loam in places.

Hord soils are near Detroit, Sutphen, Eudora, Bridgeport, Roxbury, Muir, Hobbs, and Tobin soils. They have less clay throughout the profile than Detroit and Sutphen soils. They have more clay in the B horizon than Eudora soils. They have thicker dark upper layers than Bridgeport soils. Hord soils are deeper to free carbonates than Bridgeport or Roxbury soils. They are shallower to free carbonates than Muir or Hobbs soils. They are less stratified and are at higher elevations than Bridgeport, Tobin, and Hobbs soils.

Hord silt loam (0 to 2 percent slopes) (Hr).—This soil is on terraces of tributary and major streams. Surface runoff is slow. Included with this soil in mapping are small areas of Muir, Detroit, Roxbury, and Tobin soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, corn, silage or forage crops, wheat, and alfalfa. If this soil is cropped, the main limitations are soil blowing and loss of moisture by runoff and evaporation. Contour or across-slope tillage helps to reduce runoff. Good management of crop residue and fertilization reduce evaporation and soil blowing. In large fields, alternate strips of close-growing crops and row crops reduce soil blowing and snow drifting. If this soil is adequately protected, row crops can be grown for many years in succession. Cropping systems can be changed to meet individual farm needs. This soil is suitable for irrigation if water of good or excellent quality is available. Capability units I-1, dryland, and I-3, irrigated; Loamy Terrace range site; windbreak suitability group 1.

Humbarger Series

The Humbarger series consists of deep, moderately well drained, nearly level soils on the Republican River flood plain. These soils formed in calcareous, loamy alluvium.

In a representative profile the surface layer is about 22 inches thick. The upper 10 inches of the surface layer is grayish-brown, calcareous loam, and the lower 12 inches is dark-gray and grayish-brown, calcareous heavy silt loam. The next layer is about 18 inches thick. The upper 6 inches is light brownish-gray and grayish-brown, calcareous, friable light clay loam, and the lower 12 inches is dark-gray, calcareous, friable clay loam. The underlying material is light-gray and grayish-brown, calcareous clay loam that overlies loose loamy fine sand at a depth of 48 inches.

Surface runoff is slow, and internal drainage is medium. Permeability is moderate. Available water capacity is high. These soils are occasionally flooded.

Representative profile of Humbarger loam, in a cultivated field, 1,200 feet north and 100 feet west of southeast corner of sec. 30, T. 5 S., R. 2 W.:

Ap—0 to 10 inches, grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; weak, fine, granular structure; slightly hard, very friable; many fine roots, insect holes, and worm casts; slightly effervescent, mildly alkaline; clear boundary.

A1—10 to 22 inches, dark-gray and grayish-brown (10YR 4/1 and 5/2) heavy silt loam, very dark gray (10YR 3/1) moist; moderate, fine, granular structure; hard, friable; many fine roots, insect holes, worm casts, and fine pores; slightly effervescent, mildly alkaline; clear boundary.

AC1—22 to 28 inches, light brownish-gray and grayish-brown (10YR 6/2 and 5/2) light clay loam, very dark grayish brown and dark grayish brown (10YR 3/2 and 4/2) moist; thinly stratified with fine and very fine sandy loam; moderate, fine, granular structure; hard, friable; few worm casts and many fine pores; strongly effervescent, moderately alkaline; clear boundary.

AC2—28 to 40 inches, dark-gray (10YR 4/1) clay loam, very dark gray (10YR 3/1) moist; weak, fine, subangular blocky structure; hard, friable; few worm casts and many fine pores; strongly effervescent, moderately alkaline; gradual boundary.

C1—40 to 48 inches, light-gray and grayish-brown (10YR 7/2 and 5/2) clay loam, dark grayish brown and grayish brown (10YR 4/2 and 5/2) moist; moderate, fine, subangular blocky structure; hard, friable; many fine and medium pores; violently effervescent, moderately alkaline; clear boundary.

IIC2—48 to 60 inches, light-gray (10YR 7/2) loamy fine sand, light brownish gray (10YR 6/2) moist; single grained; strongly effervescent, moderately alkaline.

The combined thickness of the A and AC horizons generally is 30 to 36 inches but ranges from 24 to 45 inches. In a few places the depth to free carbonates is 7 to 10 inches. The upper soil layers that are grayish brown or darker range from 22 to 45 inches in thickness.

In places the A horizon is light clay loam. In some places, faint to distinct, dark-brown and yellowish-brown mottles are in the lower part of the AC horizon and in the C horizon. Depth to the underlying loose sand ranges from 40 to 60 inches. Lighter colored and more sandy strata or darker colored and more clayey strata are at any depth below 20 inches in places.

Humbarger soils are near Detroit, Carr, Sarpy, Eudora, Muir, and Hobbs soils. They have less clay throughout the profile than Detroit soils. They have more clay throughout the profile than Carr, Sarpy, and Eudora soils. They have more sand throughout the profile than Detroit, Muir, Eudora, and Hobbs soils. Humbarger soils have thicker dark upper layers than Carr and Sarpy soils. They are shallower to free carbonates than Detroit, Eudora, Muir, and Hobbs soils. They are more stratified and are at lower elevations than Detroit, Muir, and Eudora soils.

Humbarger loam (0 to 1 percent slopes) (Hu).—This soil is on flood plains in the Republican River Valley. Surface runoff is slow. Included with this soil in mapping are small areas of Carr, Sarpy, Bridgeport, and Hobbs soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, corn, silage or forage crops, and wheat. If this soil is cropped, the main limitations are loss of moisture by runoff and evaporation, flooding, and soil blowing in dry periods. Good management of crop residue and fertilization help to improve tilth and help to reduce moisture loss and soil blowing. In larger fields, alternate strips of close-growing crops and row crops reduce soil blowing and snow drifting. Cropping systems can be adjusted to meet individual farm needs. Some depressions need drainage ditches to improve workability and productivity. Where feasible, flood-control measures need to be used to reduce crop losses and soil damage. This soil is suitable for irrigation if water of good or excellent quality is available. Capability units IIw-1, dryland, and IIw-3, irrigated; Loamy Lowland range site; windbreak suitability group 1.

Kipson Series

The Kipson series consists of shallow, somewhat excessively drained, moderately steep to steep soils on uplands. These soils formed in material weathered from limestone and calcareous shale.

Figure 14.—**Profile of a Kipson soil. This is dark-colored stony silt loam underlain by weathered limestone and shale.**

In a representative profile the surface layer is dark grayish-brown, calcareous stony silt loam about 10 inches thick. The underlying material is about 6 inches of light-gray, calcareous channery light silty clay loam in the upper part and about 4 inches of white, calcareous channery light silty clay loam in the lower part. This material is underlain by thin-bedded limestone and soft, calcareous shale (fig. 14).

Surface runoff is medium to rapid, and internal drainage is medium. Permeability is moderate. Available water capacity is low.

Representative profile of Kipson soils, 5 to 30 percent slopes, in a native grass meadow, 600 feet north and 300 feet west of the southeast corner of sec. 8, T. 6 S., R. 3 W.:

A1—0 to 10 inches, dark grayish-brown (10YR 4/2) stony silt loam, very dark grayish brown (10YR 3/2) moist; strong, fine, granular structure; slightly hard, very friable; many fine roots, insect holes, worm casts, and fine pores; strongly effervescent, moderately alkaline; gradual boundary.

C1—10 to 16 inches, light-gray (10YR 7/2) channery light silty clay loam, light brownish gray (10YR 6/2) moist; moderate, fine, granular structure; slightly hard, very friable; many fine roots, worm casts, and few fine pores; 15 percent of soil mass is flaggy limestone fragments; violently effervescent, strongly alkaline; gradual boundary.

C2—16 to 20 inches, white (10YR 8/2) channery light silty clay loam, light gray and light yellowish brown (10YR 7/2 and 6/4) moist; weak, fine, granular structure in the upper part and thin, platy structure in the lower part; slightly hard, very friable; few roots and worm casts; 15 to 20 percent of soil mass is flaggy limestone fragments; violently effervescent, strongly alkaline; clear boundary.

C3—20 inches, white (10YR 8/2), thin-bedded limestone and light yellowish-brown (10YR 6/4), soft, calcareous shale; coarse, platy structure; upper 12 inches fractured; violently effervescent.

All horizons contain free carbonates. Depth to limestone and shale generally is 10 to 16 inches but ranges from 6 to 20 inches. Thickness of the upper horizons that are dark grayish brown or darker ranges from 6 to 15 inches.

The A horizon ranges from 6 to 15 inches in thickness. In places it is stony or flaggy light silty clay loam or loam. A mixed dark and light AC horizon, 4 to 8 inches thick, is present in places. The lower part of the C2 horizon has thin to thick, platy structure determined by the rock strata. Limestone outcrops are common.

Kipson soils are near Armo, Wakeen, Crete, Hastings, and Hedville soils. They have less clay throughout the profile and are shallower to limestone and shale bedrock than Armo, Wakeen, Crete, and Hastings soils. They are shallower to free carbonates than Crete and Hastings soils. They are calcareous throughout the profile, whereas Hedville soils are noncalcareous throughout.

Kipson soils, 5 to 30 percent slopes (Kp).—This soil is in hilly areas on uplands. Surface runoff is medium to rapid. Included with this soil in mapping are small areas of Armo, Crete, Hastings, Hord, Tobin, and Wakeen soils.

This soil is suited to native range, wildlife habitat, and recreation. Capability unit VIe-1; Limy Upland range site; windbreak suitability group 4.

Lancaster Series

The Lancaster series consists of moderately deep, well-drained, moderately sloping to strongly sloping soils on uplands. These soils formed in material weathered from sandy shale and sandstone. Lancaster soils are mapped only in a complex with Hedville soils.

In a representative profile the surface layer is dark grayish-brown loam about 10 inches thick. The reddish-yellow subsoil is about 18 inches thick. It is very friable loam in the upper 10 inches and friable light clay loam in the lower 8 inches. The underlying material is very pale brown and reddish-yellow loam. Beneath this is sandy shale and sandstone at a depth of 36 inches (fig. 15).

Runoff is medium to rapid, and internal drainage is medium. Permeability is moderate. Available water capacity is moderate.

Representative profile of a Lancaster loam in an area of Lancaster-Hedville complex, 5 to 30 percent slopes, in native range, 2,100 feet north and 50 feet east of the southwest corner of sec. 23, T. 8 S., R. 2 W.:

A1—0 to 10 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; slightly hard, very friable; many fine roots, insect holes, worm casts, and fine pores; 10 to 15 percent of soil mass is fine sandstone gravel; slightly acid; gradual boundary.

B1—10 to 20 inches, reddish-yellow (7.5YR 6/6) loam, strong brown (7.5YR 5/8) moist; moderate, fine, granular structure; slightly hard, very friable; many fine roots, insect holes, worm casts, and fine pores; a few sandstone pebbles; slightly acid; gradual boundary.

B2t—20 to 28 inches, reddish-yellow (7.5YR 6/6) light clay loam, strong brown (7.5YR 5/6) moist; moderate, fine, subangular blocky structure; hard, friable; many fine pores; slightly acid; gradual boundary.

C1—28 to 36 inches, very pale brown and reddish-yellow (10YR 7/4 and 7.5YR 7/6) loam, light yellowish brown and reddish yellow (10YR 6/4 and 7.5YR 6/6) moist; moderate, thin, platy structure parting to weak, fine, granular; hard, friable; many fine pores; common, fine, dark-brown iron stains; clear boundary.

C2—36 inches, slightly weathered, yellowish-brown and brown sandy shale and thin, brown sandstone; thin, platy rock structure; upper 6 inches fractured.

The combined thickness of the A and B horizons ranges from 20 to 35 inches. The depth to underlying bedrock ranges from 24 to 40 inches. The thickness of the upper horizons that are dark grayish brown or darker ranges from 8 to 16 inches.

The A horizon ranges from 6 to 12 inches in thickness and in some places is sandy loam or gravelly loam. In some places the B2t horizon is yellowish-brown or strong-brown sandy clay loam. The C horizon ranges from 4 to 10 inches in thickness, and in some places it is gravelly sandy loam.

Lancaster soils are near Longford, Geary, and Hedville soils. They have less clay and more sand throughout the profile and are shallower to bedrock than Longford and Geary soils. They have more clay throughout the profile and are deeper to sandstone and shale bedrock than Hedville soils.

Lancaster-Hedville complex, 5 to 30 percent slopes (Lh).—This complex consists of moderately deep and shallow soils that formed in material weathered from interbedded sandstone and shale. The Lancaster and Hedville soils are so intermingled that it is not practical to map them separately. Lancaster soils make up about 70 percent of this complex, and Hedville soils make up about 30 percent. A Lancaster soil in this mapping unit has the profile described as representative of the Lancaster series. Surface runoff is medium to rapid.

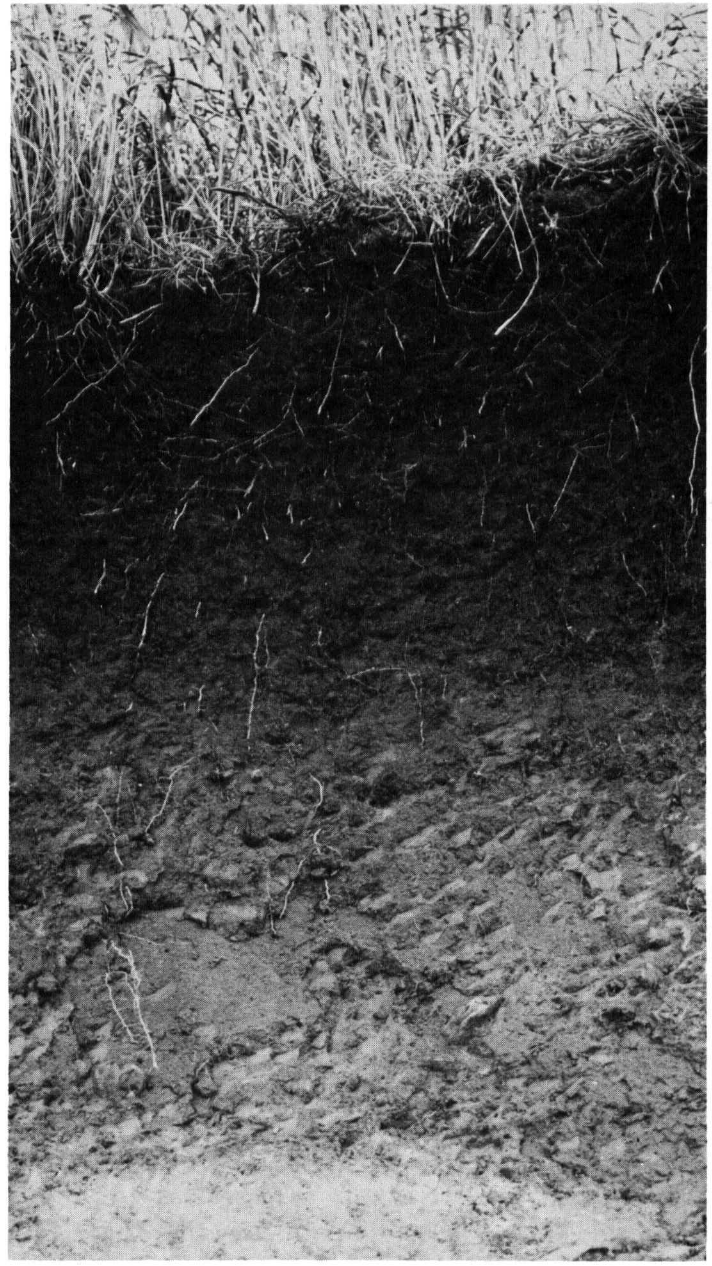

Figure 15.**—Profile of a Lancaster loam in Lancaster-Hedville complex, 5 to 30 percent slopes. This soil has a dark-colored surface layer and a reddish subsoil. Sandstone and shale are at a depth of 36 inches.**

Included with these soils in mapping are small areas of Crete, Longford, Geary, and Hobbs soils. Also included are areas of shallow soils that formed in sandy and silty shale, silty shale, and clayey shale.

The soils in this complex are suited to native range, wildlife habitat, and recreational uses. Nearly all of the acreage is used as native range. Both soils are in capability unit VIe-1; Lancaster soils are in Loamy Upland range site and windbreak suitability group 3; Hedville soils are in Shallow Over Sandstone range site and windbreak suitability group 4.

Figure 16.—**Profile of a Longford silt loam. This soil has a dark-colored, granular surface layer and a blocky subsoil.**

Longford Series

The Longford series consists of deep, well-drained, gently sloping and moderately sloping soils on uplands. These soils are on ridgetops and adjoining side slopes and on lower slopes of loess-capped hills. They formed in deep, mixed material weathered from sandstone and shale and some loess.

In a representative profile the surface layer is dark grayish-brown silt loam about 10 inches thick. The subsoil is about 36 inches thick. The upper 12 inches of the subsoil is dark grayish-brown and brown, friable silty clay loam; the next 18 inches is yellowish-red, firm heavy silty clay loam; and the lower 6 inches is reddish-yellow, friable light silty clay loam. The underlying material is reddish-yellow light clay loam (fig. 16).

Surface runoff and internal drainage are medium. Permeability is moderately slow. Available water capacity is high.

Representative profile of Longford silt loam, 3 to 7 percent slopes, in pasture, 2,100 feet west and 300 feet south of the northeast corner of sec. 31, T. 8 S., R. 1 W.:

A1—0 to 10 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; strong, fine, granular structure; slightly hard, friable; many fine roots, insect holes, worm casts, and fine pores; slightly acid; gradual boundary.

B1—10 to 16 inches, dark grayish-brown (10YR 4/2) light silty clay loam, very dark grayish brown (10YR 3/2) moist; strong, fine, subangular blocky structure; slightly hard, friable; many fine roots, insect holes, worm casts, and fine pores; slightly acid; gradual boundary.

B21t—16 to 22 inches, brown (7.5YR 5/4) and dark grayish-brown (10YR 4/2) silty clay loam, brown (7.5YR 4/4) and very dark grayish brown (10YR 3/2) moist, brown (7.5YR 4/2) when rubbed moist; strong, fine, subangular blocky structure; hard, friable; clay films on faces of peds; few fine roots, insect holes, worm casts, and fine pores; slightly acid; gradual boundary.

B22t—22 to 40 inches, yellowish-red (5YR 5/6) heavy silty clay loam, yellowish red (5YR 4/6) moist; strong, fine and medium, blocky structure; very hard, firm; clay films on faces of peds; few coarse roots, worm casts, and fine pores; slightly acid; gradual boundary.

B3—40 to 46 inches, reddish-yellow (5YR 6/6) light silty clay loam, yellowish red (5YR 5/6) moist; moderate, fine and medium, subangular blocky structure; hard, friable; thin discontinuous clay films on vertical faces of peds; few fine pores; fine iron concretions and very fine sandstone gravel; slightly acid; gradual boundary.

C—46 to 60 inches, reddish-yellow (5YR 6/6) light clay loam, yellowish red (5YR 5/6) moist; weak, fine and medium, granular structure; hard, friable; fine and medium pores; fine and medium iron concretions and fine sandstone gravel; neutral.

The combined thickness of the A and B horizons ranges from 40 to 50 inches. In some places a few hard carbonate concretions are below a depth of 50 inches. The thickness of the upper horizons that are grayish brown or darker ranges from 14 to 18 inches.

The A horizon ranges from dark grayish-brown silt loam 8 to 12 inches thick to grayish-brown silty clay loam 4 to 8 inches thick. The B2t horizon ranges from 20 to 30 inches in thickness. In some places the C horizon is silty clay loam or loam.

Longford soils are near Geary, Hastings, Crete, Lancaster, and Hedville soils. They have a higher clay content in the B2 horizon than Geary soils. They have a redder B2 horizon than Hastings soils. They have a lower clay content in the B2 horizon than Crete soils. Longford soils are deeper to free carbonates than Geary, Hastings, and Crete soils. They have a higher clay content throughout the profile and are deeper to underlying sandstone and shale than Lancaster and Hedville soils.

Longford silt loam, 1 to 3 percent slopes (Lm).—This soil is on ridgetops on gently rolling uplands. This soil has a profile similar to the one described as representative of the series, but the surface layer is slightly darker and thicker, and the upper part of the subsoil is slightly more clayey. Surface runoff is medium. Included with this soil in mapping are small areas of Crete, Hastings, and Geary soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, forage sorghum, and wheat. A small acreage is used as native range. If this soil is cropped, the main limitations are losses of moisture and soil by water erosion. Contour farming, terraces, and grassed waterways reduce losses of moisture and soil. Good management of crop residue helps to maintain or improve tilth, improve moisture intake, and reduce evaporation. If this soil is adequately protected and fertilized, the intensity of row cropping can be increased. This soil is suitable for irrigation if water of good or excellent quality is available. Capability units IIe-2, dryland, and IIe-3, irrigated; Loamy Upland range site; windbreak suitability group 3.

Longford silt loam, 3 to 7 percent slopes (Ln).—This soil is on side slopes and on the lower parts of loess-capped hills on uplands. It has the profile described as representative of the series. Surface runoff is medium. Included with this soil in mapping are small areas of Crete, Hastings, Geary, Hedville, and Lancaster soils.

This soil is suited to all crops commonly grown in the county. A large acreage of this soil is in native range. If this soil is cropped, the main limitations are loss of moisture and soil by erosion. Use of contour farming, terraces, and grassed waterways reduces loss of moisture and soil. Good management of crop residue helps to maintain or improve tilth, moisture intake, and moisture retention. This soil is suitable for irrigation if water of good or excellent quality is available. Special practices are needed to control erosion and to assure efficient use of water. Capability units IIIe-1, dryland, and IIIe-3, irrigated; Loamy Upland range site; windbreak suitability group 3.

Longford silty clay loam, 3 to 7 percent slopes, eroded (Lo).—This soil is on side slopes and on the lower parts of loess-capped hills on uplands. It has a profile similar to that described as representative of the series, but erosion has removed part of the original surface layer, and the present surface layer is a mixture of material from the remaining surface layer and the subsoil. The present surface layer is grayish-brown, dark-brown, or reddish-brown silty clay loam. Surface runoff is medium to rapid. Included with this soil in mapping are small areas of Crete, Hastings, Geary, Hedville, and Lancaster soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, forage sorghum, and wheat. If this soil is cropped, the main hazard is water erosion. Use of contour farming, terraces, and grassed waterways reduces loss of water and soil by erosion. Good management of crop residue improves tilth, organic-matter content, water intake, and moisture retention. Adequate use of fertilizer increases crop production and the amount of residue. This soil is suitable for irrigation if water of good or excellent quality is available. Special practices are needed to control erosion and to assure efficient use of water. Capability units IIIe-2, dryland, and IIIe-3, irrigated; Loamy Upland range site; windbreak suitability group 3.

McCook Series

The McCook series consists of deep, well-drained, nearly level and gently sloping soils on terraces, or second bottoms, in the Solomon River Valley. These soils formed in calcareous, silty alluvium.

In a representative profile the surface layer is grayish-brown calcareous silt loam about 15 inches thick. The next layer is light-gray and gray, calcareous, very friable loam about 5 inches thick. The underlying material is light-gray, calcareous loam stratified with silt loam, very fine sandy loam, and fine sandy loam.

Surface runoff is slow, and internal drainage is medium. Permeability is moderate. Available water capacity is high.

Representative profile of McCook silt loam, in a cultivated field, 250 feet north and 250 feet east of the southwest corner of sec. 14, T. 8 S., R. 5 W.:

Ap—0 to 10 inches, grayish-brown (10YR 5/2) light silt loam, very dark grayish brown (10YR 3/2) moist; weak, fine, granular structure; soft; many fine roots, insect holes, worm casts, and fine pores; slightly effervescent, mildly alkaline; clear boundary.

A1—10 to 15 inches, grayish-brown (10YR 5/2) light silt loam, very dark grayish brown (10YR 3/2) moist, spots and streaks of light gray (10YR 7/2) dry; weak, fine, granular structure; slightly hard, very friable; many fine roots, insect holes, worm casts, and fine pores; slightly effervescent, mildly alkaline; gradual boundary.

AC—15 to 20 inches, light-gray and gray (10YR 7/2 and 5/1) loam, grayish brown and very dark grayish brown (10YR 5/2 and 3/2) moist; weak, fine, granular structure; slightly hard, very friable; many fine roots, worm casts, and fine pores; strongly effervescent, moderately alkaline; gradual boundary.

C1—20 to 40 inches, light-gray (10YR 7/2) loam, grayish brown (10YR 5/2) moist; thinly stratified silt loam, loam, very fine sandy loam, and fine sandy loam; weak, fine, granular structure; slightly hard, very friable; few worm casts and many fine pores; strongly effervescent, moderately alkaline; gradual boundary.

C2—40 to 60 inches, light-gray (10YR 7/2) loam, light brownish gray and grayish brown (10YR 6/2 and 5/2) moist; thinly stratified loam, very fine sandy loam, and fine sandy loam; massive; slightly hard, very friable; few fine pores; strongly effervescent, moderately alkaline.

The combined thickness of the A and AC horizons generally is 24 inches but ranges from 18 to 30 inches. In places, the A horizon is noncalcareous to a depth of 7 inches. Thickness of the A horizon that is grayish brown or darker ranges from 10 to 20 inches.

The A horizon ranges from 12 to 20 inches in thickness and is loam or fine sandy loam in places. The AC horizon generally is loam, but it is silt loam in places. The C horizon ranges from loam to fine sandy loam, depending on the texture and thickness of the strata. In places, dark grayish-brown silty or clayey layers are below a depth of 40 to 48 inches.

McCook soils are near Roxbury, New Cambria, Sutphen, Bridgeport, Detroit, and Hord soils. They have less clay throughout the profile than Roxbury, New Cambria, Sutphen, Bridgeport, Detroit, and Hord soils. They have thinner dark upper horizons than Roxbury, New Cambria, Sutphen, Detroit, and Hord soils. They are shallower to free carbonates than Detroit, Hord, and Sutphen soils.

McCook silt loam (0 to 2 percent slopes) (Mc).—This soil is on the terraces in the Solomon River Valley. Surface runoff is slow. Included with this soil in mapping are small areas of Roxbury and New Cambria soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, silage or forage crops, wheat, and alfalfa. If this soil is cropped, the main limitations are soil blowing and loss of moisture by evaporation and runoff. Good management of crop residue and adequate fertilization improve tilth and reduce soil blowing and evaporation. On large fields, alternate strips of close-growing crops and row crops reduce soil blowing and snow drifting. On longer slopes, tilling on the contour reduces loss of moisture and soil. Cropping systems can be changed to meet individual farm needs. This soil is suitable for irrigation if water of good or excellent quality is available. Capability units I-2, dryland, and I-3, irrigated; Loamy Terrace range site; windbreak suitability group 1.

Muir Series

The Muir series consists of deep, well-drained, nearly level and gently sloping soils on terraces, or second bottoms, in most valleys in the county. These soils formed in silty alluvium.

In a representative profile the surface layer is about 18 inches thick. The upper 10 inches of the surface layer is gray silt loam, and the lower 8 inches is dark-gray heavy silt loam. The subsoil is about 24 inches thick. The upper 8 inches of the subsoil is dark grayish-brown light silty clay loam, and the lower 16 inches is grayish-brown, friable silty clay loam (fig. 17). The underlying material is light brownish-gray silt loam that is stratified with fine sandy loam.

Surface runoff is slow, and internal drainage is medium. Permeability is moderate. Available water capacity is high.

Representative profile of Muir silt loam, in a cultivated field, 1,300 feet west and 300 feet north of the southeast corner of sec. 18, T. 5 S., R. 3 W.:

Ap—0 to 10 inches, gray (10YR 5/1) silt loam, very dark gray (10YR 3/1) moist; weak, fine, granular structure; slightly hard, very friable; many fine roots, insect holes, and worm casts; slightly acid; clear boundary.

A1—10 to 18 inches, dark-gray (10YR 4/1) heavy silt loam, very dark gray (10YR 3/1) moist; moderate, fine, granular structure; hard, friable; many fine roots, insect holes, worm casts, and fine pores; slightly acid; gradual boundary.

B1—18 to 26 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, friable; few insect holes and worm casts, many fine roots and fine pores; slightly acid; gradual boundary.

B2—26 to 34 inches, grayish-brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, subangular blocky structure; hard, friable; few worm casts and fine pores; neutral; gradual boundary.

B3—34 to 42 inches, grayish-brown (10YR 5/2) light silty clay loam, dark grayish brown (10YR 4/2) moist; moderate, fine, granular structure; hard, friable; many fine pores; neutral; gradual boundary.

C—42 to 60 inches, light brownish-gray (10YR 6/2) silt loam, grayish brown (10YR 5/2) moist; stratified with fine sandy loam; massive; slightly hard, very friable; some fine and medium pores; neutral.

The combined thickness of the A and B horizons ranges from 30 to 48 inches. The depth to free carbonates is more than 48 inches. Thickness of the upper horizons that are gray or grayish brown or darker ranges from 24 to 40 inches.

The A horizon ranges from 16 to 20 inches in thickness and is silty clay loam in places. The B horizon ranges from 20 to 30 inches in thickness and is silt loam in places. The C horizon is silt loam or silty clay loam. In places, more sandy or clayey strata are below a depth of 40 inches.

Muir soils are near Detroit, Eudora, Hord, Carr, Humbarger, Sarpy, and Hobbs soils. They have less clay throughout the profile than Detroit soils. They have more clay in the B horizon than Eudora soils. They are deeper to free carbonates than Detroit, Eudora, and Hord soils. They are deeper to free carbonates and have less sand throughout the profile than Carr, Humbarger, and Sarpy soils. They are less stratified and are at higher elevations than Hobbs soils.

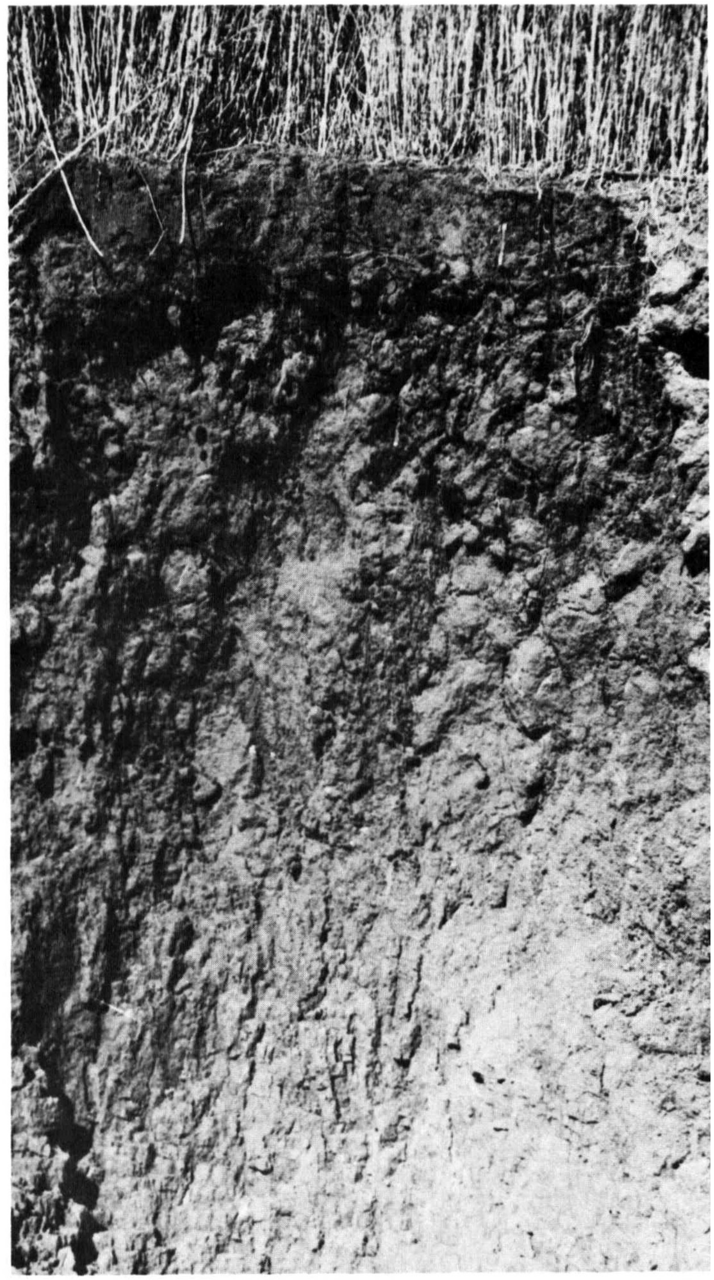

Figure 17.—**Profile of Muir silt loam. This soil is dark colored in the surface layer and in the upper part of the subsoil.**

Muir silt loam (0 to 2 percent slopes) (Mr).—This soil is on the terraces of tributary and major streams. Surface runoff is slow. Included with this soil in mapping are small areas of Detroit, Eudora, Hord, and Hobbs soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, corn, silage or forage crops, wheat, and alfalfa. If this soil is cropped, the main limitations are soil blowing and loss of moisture by runoff and evaporation. On the longer slopes, contour or cross-slope tillage reduces runoff. Good management of crop residue and fertilization

Figure 18.—**Irrigated corn on Muir silt loam.**

improve tilth and reduce moisture loss and soil blowing. In large fields, alternate strips of close-growing crops and row crops reduce soil blowing and snow drifting. If this soil is adequately protected and fertilized, row crops can be grown many years in succession. Cropping systems can be changed to meet individual farm needs. This soil is suitable for irrigation if water of good or excellent quality is available (fig. 18). Capability units I-1, dryland, and I-3, irrigated; Loamy Terrace range site; windbreak suitability group 1.

New Cambria Series

The New Cambria series consists of deep, moderately well drained, nearly level soils on terraces in the Solomon River Valley. They formed in calcareous, silty and clayey alluvium.

In a representative profile the surface layer is dark-gray, calcareous silty clay loam about 12 inches thick. The subsoil is gray, calcareous, firm and very firm silty clay about 28 inches thick. The underlying material is grayish-brown, calcareous heavy silty clay loam.

Surface runoff is slow, and internal drainage is moderately slow. Permeability is slow. Available water capacity is high.

Representative profile of New Cambria silty clay loam, in a cultivated field, 2,300 feet west and 300 feet north of the southeast corner of sec. 10, T. 8 S., R. 5 W.:

Ap—0 to 6 inches, dark-gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) moist; moderate, fine, subangular blocky structure; hard, friable; many fine roots, insect holes, and worm casts; slightly effervescent, mildly alkaline; clear boundary.

A1—6 to 12 inches, dark-gray (10YR 4/1) heavy silty clay loam, very dark gray (10YR 3/1) moist; strong, fine, subangular blocky structure; hard, friable; many fine roots, insect holes, worm casts, and fine pores; slightly effervescent, mildly alkaline; gradual boundary.

B21—12 to 22 inches, gray (10YR 5/1) silty clay, very dark gray (10YR 3/1) moist; strong, fine, angular blocky structure; very hard, firm, few roots, insect holes, worm casts, and fine pores; slightly effervescent, moderately alkaline; gradual boundary.

B22—22 to 40 inches, gray (10YR 5/1) silty clay, dark gray (10YR 4/1) moist, streaks of very dark gray (10YR 3/1) moist; strong, fine and medium, angular blocky structure; extremely hard, very firm; few worm casts and fine pores; white, soft, fine calcium carbonate accumulations; strongly effervescent, moderately alkaline; gradual boundary.

C1—40 to 50 inches, grayish-brown (10YR 5/2) heavy silty clay loam, dark grayish brown (10YR 4/2) moist; moderate, medium, angular blocky structure; very hard, firm; few fine pores; white, soft and hard calcium carbonate accumulations; violently effervescent, moderately alkaline; gradual boundary.

C2—50 to 60 inches, grayish-brown (10YR 5/2) heavy silty clay loam, dark grayish brown (10YR 4/2) moist; weak, medium, subangular blocky structure; very hard, firm; few fine pores; white, soft and hard calcium carbonate accumulations; violently effervescent, moderately alkaline.

The combined thickness of the A and B horizons ranges from 30 to 45 inches. The depth to free carbonates is 7 to 10 inches in places. The thickness of the upper horizons that are gray or darker ranges from 22 to 40 inches.

The A horizon ranges from 10 to 15 inches in thickness. The B horizon ranges from 20 to 32 inches in thickness. In places, the lower part of the C horizon is silty clay loam. Faint brown mottles are below a depth of 40 inches in places.

New Cambria soils are near Detroit, Hord, Roxbury, McCook, Bridgeport, and Sutphen soils. They have more clay throughout the profile than Detroit, Hord, Roxbury, McCook, and Bridgeport soils. They have less clay throughout the profile and are better drained than Sutphen soils. New Cambria soils are shallower to free carbonates than Detroit, Hord, and Sutphen soils. They have thicker, dark upper layers than McCook and Bridgeport soils. They are less stratified and are at higher elevations than Bridgeport soils.

New Cambria silty clay loam (0 to 1 percent slopes) (Nc).—This soil is on terraces in the Solomon River Valley. Surface runoff is slow, and depressions pond. Included with this soil in mapping are small areas of Roxbury, Sutphen, and Detroit soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, silage or forage crops, wheat, and soybeans. If this soil is cropped, the main limitations are excess surface water, ponding, and soil blowing in dry periods. Development of drainage ditches and proper direction of plowing improve surface drainage. Drainage of ponded areas improves workability and productivity. Diversion terraces to intercept runoff from higher lying areas and ditches help to remove excess surface water. Good management of crop residue improves tilth and reduces soil blowing. In large fields, alternate close-growing crops and row crops help to reduce soil blowing and snow drifting. Cropping systems can be changed to meet individual farm needs. This soil is suitable for irrigation if water of good or excellent quality is available. Capability units IIs-1, dryland, and IIs-2, irrigated; Clay Terrace range site; windbreak suitability group 1.

Nuckolls Series

The Nuckolls series consists of deep, well-drained to somewhat excessively drained, moderately sloping to strongly sloping soils on uplands. These soils formed in calcareous silty loess.

In a representative profile the surface layer is grayish-brown silt loam about 12 inches thick. The subsoil is about 26 inches thick. The upper part of the subsoil is grayish-brown, very friable silt loam about 6 inches thick; and the lower part is pale-brown, friable light silty clay loam about 20 inches thick. The underlying material is pale brown and very pale brown light silty clay loam and silt loam.

Surface runoff is medium to rapid, and internal drainage is medium. Permeability is moderate. Available water capacity is high.

Representative profile of Nuckolls silt loam, 4 to 12 percent slopes, in a native grass meadow, 1,600 feet west and 100 feet south of the northeast corner of sec. 6, T. 6 S., R. 3 W.:

A1—0 to 12 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; slightly hard, very friable; many fine roots, insect holes, worm casts, and fine pores; neutral; gradual boundary.

B1—12 to 18 inches, grayish-brown (10YR 5/2) silt loam, dark brown (10YR 3/3) moist; moderate, fine, granular structure; slightly hard, very friable; many fine roots, insect holes, worm casts, and fine pores; neutral; gradual boundary.

B2—18 to 38 inches, pale-brown (10YR 6/3) light silty clay loam, brown (10YR 4/3) moist; moderate, fine, granular structure; hard, friable; few roots, worm casts, and fine pores; neutral; gradual boundary.

C1—38 to 46 inches, pale-brown (10YR 6/3) light silty clay loam, brown (10YR 4/3) moist; weak, fine, granular structure; slightly hard, friable; few worm casts, many fine and medium pores; mildly alkaline; gradual boundary.

C2—46 to 60 inches, very pale brown (10YR 7/3) silt loam, brown (10YR 5/3) moist; weak, fine, granular structure; slightly hard, very friable; many fine and medium pores; white soft calcium carbonate accumulations; strongly effervescent, moderately alkaline.

The combined thickness of the A and B horizons ranges from 24 to 40 inches. The depth to free carbonates is about 40 inches. The thickness of the upper horizons that are grayish brown or darker ranges from 10 to 18 inches.

The A horizon ranges from dark grayish-brown silt loam to grayish-brown light silty clay loam and from 6 to 14 inches in thickness. The B horizon is strong-brown silt loam in places. In places the C horizon is strong brown and is stratified with fine sandy loam.

Nuckolls soils are near Geary, Crete, Hastings, Hedville, and Eudora soils. They have less clay throughout the profile than Geary, Crete, and Hastings soils. They are deeper to bedrock than the shallow Hedville soils that formed in material weathered from sandstone. They have thinner dark upper layers than Crete and Eudora soils. They are steeper than Eudora soils.

Nuckolls silt loam, 4 to 12 percent slopes (Nu).—This soil is on uplands bordering the Republican River Valley in lower lying areas than Hastings soils. It has the profile described as representative of the series. Surface runoff is medium. Included with this soil in mapping are small areas of Hastings, Geary, Hobbs, and Hedville soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, silage or forage crops, wheat, and alfalfa. A large acreage of this soil is in native range. If this soil is cropped, the main limitations are losses of moisture and soil by erosion. Contour farming, terraces, and grassed waterways help to reduce losses of moisture and soil. A good cropping system limits row crops and silage or forage crops to 1 or 2 years. If this soil is adequately protected and fertilized, the intensity of row cropping and silage cropping can be increased. Good management of crop residue reduces soil blowing and helps to maintain or improve tilth. Capability unit IVe-1; Loamy Upland range site; windbreak suitability group 3.

Nuckolls silt loam, 4 to 12 percent slopes, eroded (Nx).—This soil is on uplands bordering the Republican River Valley in lower lying areas than Hastings soils. It has a profile similar to that described as representative of the series, but erosion has removed part of the original surface layer; the present surface layer is a mixture of the remaining surface layer and the upper part of the subsoil. The surface layer ranges from grayish brown to light brownish gray and includes small brown areas in places. It generally is silt loam, but in places it is light silty clay loam. Surface runoff is medium to rapid. Included with this soil in mapping are small areas of Hastings, Geary, Hobbs, and Hedville soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, silage or forage crops, wheat, and alfalfa. If this soil is cropped, the main limitations are losses of moisture and soil by erosion. Use of contour cultivation, terraces, and grassed waterways reduces losses of moisture and soil (fig. 19).

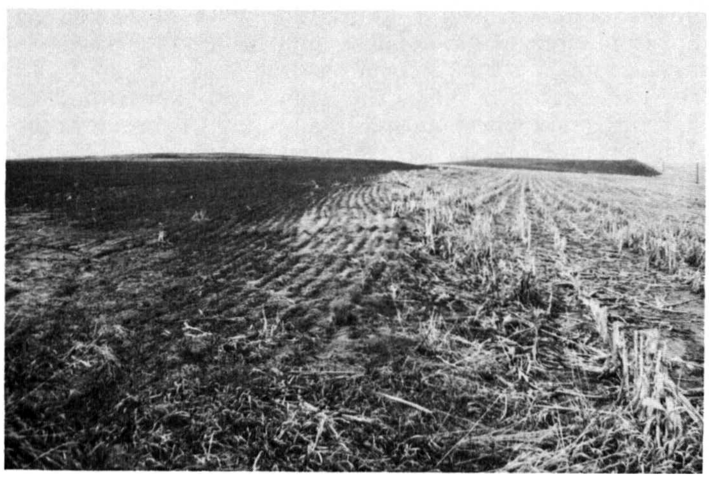

Figure 19.—**Terraces and contour-planted wheat and grain sorghum on Nuckolls silt loam, 4 to 12 percent slopes, eroded. This soil is in capability unit IVe-1, dryland.**

A good cropping system limits row crops and silage or forage to 1 or 2 years. If this soil is adequately protected and fertilized, the intensity of row cropping and silage cropping can be increased. Good management of crop residue reduces soil blowing and improves tilth. Capability unit IVe-1; Loamy Upland range site; windbreak suitability group 3.

Roxbury Series

The Roxbury series consists of deep, well-drained, nearly level and gently sloping soils on terraces in the Solomon River Valley. These soils formed in calcareous, silty alluvium.

In a representative profile the surface layer is gray, calcareous silt loam about 20 inches thick. The subsoil is dark-gray, calcareous, friable silty clay loam about 16 inches thick. The underlying material is very pale brown, grayish-brown, and light-gray calcareous silty clay loam and silt loam.

Surface runoff is slow, and internal drainage is medium. Permeability is moderate. Available water capacity is high.

Representative profile of Roxbury silt loam, in a cultivated field, 1,500 feet east and 500 feet south of the northwest corner of sec. 22, T. 8 S., R. 5 W.:

Ap—0 to 8 inches, gray (10YR 5/1) silt loam, very dark gray (10YR 3/1) moist; weak, fine, granular structure; slightly hard, friable; many fine roots, insect holes, worm casts, and fine pores; strongly effervescent, mildly alkaline; clear boundary.

A1—8 to 20 inches, gray (10YR 5/1) silt loam, very dark gray (10YR 3/1) moist; moderate, medium and fine, granular structure; hard, friable; many fine roots, insect holes, worm casts, and fine pores; strongly effervescent, moderately alkaline; gradual boundary.

B2—20 to 36 inches, dark-gray (10YR 4/1) silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, angular blocky structure; hard, friable; few roots, worm casts, and many fine pores; few, white, soft calcium carbonate accumulations; strongly effervescent, moderately alkaline; gradual boundary.

C1ca—36 to 42 inches, very pale brown and grayish-brown (10YR 7/3 and 5/2) silty clay loam, brown and dark grayish brown (10YR 5/3 and 4/2) moist; moderate, fine, granular structure; hard, friable; few worm casts and many fine pores; common, white, soft calcium carbonate accumulations; violently effervescent, moderately alkaline; gradual boundary.

C2—42 to 60 inches, light-gray (10YR 7/2) silt loam, grayish brown (10YR 5/2) moist; weak, fine, granular structure; slightly hard, very friable; few worm casts and many fine pores; few, white, soft calcium carbonate accumulations; violently effervescent, moderately alkaline.

The combined thickness of the A and B horizons ranges from 30 to 52 inches. In places, the depth to free carbonates is 7 to 10 inches. The thickness of the upper horizons that are gray or darker ranges from 20 to 40 inches.

The A horizon ranges from 16 to 24 inches in thickness and is silty clay loam in places. The B horizon ranges from 18 to 30 inches in thickness and is silt loam in places. In places the C horizon is light silty clay loam or stratified silt loam and silty clay loam.

Roxbury soils are near Detroit, New Cambria, Sutphen, McCook, Bridgeport, and Hord soils. They have less clay throughout the profile than Detroit, New Cambria, and Sutphen soils. They have more clay throughout the profile than McCook soils. Roxbury soils have thicker dark upper layers than McCook and Bridgeport soils. They are shallower to free carbonates than Hord, Detroit, and Sutphen soils. They are less stratified and are at higher elevations than Bridgeport soils.

Roxbury silt loam (0 to 2 percent slopes) (Rx).—This soil is on terraces in the Solomon River Valley. Surface runoff is slow. Included with this soil in mapping are small areas of Detroit, McCook, Hord, New Cambria, and Sutphen soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, silage or forage crops, wheat, and alfalfa. If this soil is cropped, the main limitations are soil blowing and loss of moisture by runoff and evaporation. Good management of crop residue and adequate fertilization improve tilth and moisture intake and reduce soil blowing and evaporation. In large fields, alternate strips of row crops and close-growing crops help to reduce soil blowing and snow drifting. On longer slopes, contour or cross-slope farming reduce runoff. Cropping systems can be changed to meet individual farm needs. This soil is suitable for irrigation if water of good or excellent quality is available. Capability units I-1, dryland, and I-3, irrigated; Loamy Terrace range site; windbreak suitability group 1.

Sarpy Series

The Sarpy series consists of deep, somewhat excessively drained, nearly level, gently sloping, and strongly sloping soils on the flood plain and terraces of the Republican River Valley. These soils formed in sandy alluvium.

In a representative profile the surface layer is grayish-brown and dark grayish-brown loamy sand about 16 inches thick. The underlying material is grayish-brown and light brownish-gray loamy sand and loamy fine sand to a depth of 48 inches and light brownish-gray sand below. It is calcareous below a depth of 20 inches.

Surface runoff is slow, and internal drainage is rapid. Permeability is moderately rapid. Available water capacity is low.

Representative profile of a Sarpy loamy sand, in a cultivated field, 1,000 feet north and 100 feet west of the southeast corner of sec. 29, T. 5 S., R. 2 W.:

Ap—0 to 10 inches, grayish-brown (10YR 5/2) loamy sand, dark grayish brown (10YR 4/2) moist; weak, fine, granular structure; slightly hard, loose; many fine roots and insect holes; neutral; clear boundary.

A1—10 to 16 inches, grayish-brown and dark grayish-brown (10YR 5/2 and 4/2) loamy sand, dark grayish brown (10YR 4/2) moist, streaks of very dark grayish brown (10YR 3/2) moist; weak, fine, granular structure; slightly hard, loose; many fine roots, fine pores, and insect holes; neutral; gradual boundary.

C1—16 to 24 inches, grayish-brown and light brownish-gray (10YR 5/2 and 6/2) loamy sand, dark grayish brown (10YR 4/2) moist; single grained; loose; few roots and insect holes, many fine pores; slightly effervescent below a depth of 20 inches, mildly alkaline; gradual boundary.

C2—24 to 48 inches, light brownish-gray (10YR 6/2) stratified loamy sand and loamy fine sand, grayish brown and dark grayish brown (10YR 5/2 and 4/2) moist; single grained; loose, slightly effervescent, mildly alkaline; gradual boundary.

C3—48 to 60 inches, light brownish-gray (10YR 6/2) sand, grayish brown (10YR 5/2) moist; single grained; slightly effervescent.

The A horizon ranges from 6 to 16 inches in thickness. It is loamy fine sand or fine sand in places. The depth to free carbonates is more than 20 inches. The depth to loose sand ranges from 40 to 60 inches or more. In places, lighter colored, coarser textured, or darker finer textured strata are below the surface layer.

Sarpy soils are near Carr, Eudora, Hobbs, Humbarger, Detroit, and Muir soils. They have more sand and coarser sand than Carr, Eudora, Hobbs, Humbarger, Detroit, and Muir soils. They are deeper to free carbonates than Carr and Humbarger soils. They are shallower to free carbonates than Muir and Hobbs soils. They have thinner, dark upper layers than Eudora, Hobbs, Humbarger, Detroit, and Muir soils. Sarpy soils, except on sand dunes, are at lower elevations than Detroit, Eudora, and Muir soils.

Sarpy loamy sand (0 to 3 percent slopes) (Sa).—This soil is on the flood plain of the Republican River. It has the profile described as representative of the series. Surface runoff is slow. Included with this soil in mapping are small areas of Carr, Eudora, and Humbarger soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, silage or forage, wheat, and alfalfa. If this soil is cropped, the main limitations are soil blowing and loss of moisture by runoff and evaporation. Good management of crop residue and adequate fertilization improve tilth and reduce soil blowing and evaporation. In larger fields, alternate strips of row crops and close-growing crops help to reduce soil blowing and snow drifting. On some slopes, contour farming reduces runoff. Cropping systems can be adjusted to meet individual farm needs. This soil is suitable for irrigation if water of acceptable or better quality is available. Capability units IIIw-1, dryland, and IIIw-3, irrigated; Sandy Lowland range site; windbreak suitability group 2.

Sarpy loamy sand, duned (3 to 12 percent slopes) (Sd).—This soil occurs on irregular sand dunes on the flood plain and terraces of the Republican River Valley. This soil has a profile similar to that described as representative of the series, but the surface layer is darker and is 8 to 12 inches thick, also, the depth to free carbonates is 30 to 36 inches. Surface runoff is slow. Included with this soil in mapping are small areas of Carr and Humbarger soils on the flood plain and Eudora and Muir soils on the terraces.

This soil is suited to native range, wildlife habitat, and recreation. Nearly all of this soil is in native range. Capability unit VIe-2; Sands range site; windbreak suitability group 2.

Sutphen Series

The Sutphen series consists of deep, somewhat poorly drained, nearly level soils on flood plains and low terraces in the Buffalo Creek and Solomon River Valleys. These soils formed in calcareous, clayey alluvium.

In a representative profile the surface layer is dark-gray silty clay about 26 inches thick. The next layer is grayish-brown and dark-gray, calcareous, very firm silty clay about 6 inches thick. The underlying material is light brownish-gray, calcareous heavy silty clay loam.

Surface runoff and internal drainage are slow. Permeability is very slow. Available water capacity is high.

Representative profile of Sutphen silty clay, in a cultivated field, 1,600 feet north and 50 feet west of the southeast corner of sec. 16, T. 5 S., R. 5 W.:

Ap—0 to 8 inches, dark-gray (10YR 4/1) silty clay, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; hard, firm; many fine roots, insect holes, and worm casts; neutral; clear boundary.

A11—8 to 20 inches, dark-gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) moist; strong, fine and medium, angular blocky structure; very hard, firm; many fine roots and worm casts, few fine pores; neutral; gradual boundary.

A12—20 to 26 inches, dark-gray (10YR 4/1) silty clay, very dark grayish brown (10YR 3/2) moist; moderate, fine, angular blocky structure; very hard, very firm;

few roots, worm casts, and fine pores; slightly effervescent at a depth of 24 inches, moderately alkaline; gradual boundary.

AC—26 to 32 inches, grayish-brown and dark-gray (10YR 5/2 and 4/1) silty clay, dark grayish brown and very dark gray (10YR 4/2 and 3/1) moist; few, faint, dark-brown mottles; moderate, fine, angular blocky structure; very hard, very firm; few worm casts; fine hard calcium carbonate concretions; slightly effervescent, moderately alkaline; gradual boundary.

C—32 to 60 inches, light brownish-gray (10YR 6/2) heavy silty clay loam, dark grayish brown (10YR 4/2) moist; few, faint, dark-brown mottles; massive; very hard, very firm; fine hard calcium carbonate concretions; strongly effervescent, moderately alkaline.

The combined thickness of the A and AC horizons ranges from 24 to 44 inches. Depth to free carbonates ranges from 20 to 30 inches. The thickness of the upper horizons that are dark gray or darker ranges from 24 to 44 inches.

The A horizon ranges from 20 to 36 inches in thickness and in places is heavy silty clay loam. In places the C horizon is silty clay.

Sutphen soils are near New Cambria, Detroit, Bridgeport, Roxbury, Hord, and McCook soils. They have more clay throughout the profile and are more poorly drained than New Cambria, Detroit, Bridgeport, Roxbury, Hord, and McCook soils. They have thicker, dark upper layers than McCook and Bridgeport soils. They are deeper to free carbonates than New Cambria, Bridgeport, McCook, and Roxbury soils. They are shallower to free carbonates than Detroit and Hord soils.

Sutphen silty clay (0 to 1 percent slopes) (St).—This soil is on low terraces and flood plains in the Buffalo Creek and Solomon River Valleys. Surface runoff is slow. Included with this soil in mapping are small areas of Bridgeport, Detroit, New Cambria, and Roxbury soils.

Included with this soil in mapping are small areas of a soil that has free carbonates at a depth of 10 to 15 inches. These included areas are in the Solomon River Valley.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, silage or forage crops, wheat, and soybeans. About 25 percent of the acreage of this soil is used for pasture. If this soil is cropped, the main limitations are excess moisture, flooding, and soil blowing in dry periods. Good management of crop residue and adequate fertilization help to maintain or improve tilth and reduce soil blowing. Cropping systems can be adjusted to meet individual farm needs. Drainage ditches and proper direction of plowing improve surface runoff. Drainage of ponded areas improves workability and productivity. Diversion terraces are needed to intercept runoff from higher lying areas, and flowways or ditches are needed to remove excess surface water. Where feasible, flood-control measures reduce crop losses and soil damage. Capability units IIIw-2, dryland, and IIIw-4, irrigated; Clay Lowland range site; windbreak suitability group 1.

Tobin Series

The Tobin series consists of deep, well-drained, nearly level soils on narrow flood plains in and near the limestone hills. These soils formed in calcareous, silty alluvium.

In a representative profile the surface layer is grayish-brown and dark grayish-brown silt loam about 24 inches thick. The next layer is grayish-brown and dark grayish-brown, friable light silty clay loam about 20 inches thick. The underlying material is grayish-brown and gray silty clay loam.

Surface runoff is slow, and internal drainage is medium. Permeability is moderate. Available water capacity is high. The water table generally is below a depth of 5 feet during the growing season. These soils are frequently flooded, but floodwaters usually recede in a short time.

Representative profile of Tobin silt loam, in native range, 2,200 feet east and 400 feet north of the southwest corner of sec. 5, T. 7 S., R. 3 W.:

A11—0 to 10 inches, grayish-brown and dark grayish-brown (10YR 5/2 and 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak, thin, platy structure parting to fine, granular; slightly hard, very friable; many fine roots, insect holes, worm casts; and fine pores; mildly alkaline; gradual boundary.

A12—10 to 24 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist, thin streaks of grayish brown (10YR 5/2) dry; thinly stratified with silty clay loam; moderate, fine, granular structure; hard, friable; many fine roots, insect holes, worm casts, and fine pores; mildly alkaline; gradual boundary.

AC—24 to 44 inches, grayish-brown and dark grayish-brown (10YR 5/2 and 4/2) light silty clay loam, dark grayish brown and very dark grayish brown (10YR 4/2 and 3/2) moist, light brownish-gray (10YR 6/2) streaks dry; few, fine, faint, brown mottles; weak, fine, granular structure; slightly hard, friable; few worm casts, many fine pores; slightly effervescent, moderately alkaline; gradual boundary.

C—44 to 60 inches, grayish-brown and gray (10YR 5/2 and 5/1) silty clay loam, dark grayish brown and grayish brown (10YR 4/2 and 5/2) moist; common, fine, faint, brown mottles; moderate, fine, granular structure; hard, friable; few worm casts, many fine pores; strongly effervescent, moderately alkaline.

The combined thickness of the A and AC horizons ranges from 40 to 50 inches. The depth to free carbonates ranges from 20 to 40 inches. Thickness of the upper layers that are grayish brown or darker ranges from 24 to 50 inches.

The A horizon ranges from 20 to 30 inches in thickness and is silty clay loam in places. Recent deposits of grayish-brown calcareous silt loam or silty clay loam are in places. Thin layers of fine limestone gravel are below a depth of about 40 inches in places.

Tobin soils are near Detroit, Muir, Hobbs, and Hord soils. They have less clay throughout the profile than Detroit soils. They are shallower to free carbonates than Detroit, Muir, and Hobbs soils. They are more stratified and are at lower elevations than Hord soils.

Tobin silt loam (0 to 2 percent slopes) (To).—This soil is on narrow flood plains of creeks and smaller streams. Surface runoff is slow. Included in mapping are small areas of Hobbs, Hord, and Roxbury soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, corn, silage or forage crops, wheat, and alfalfa. If this soil is cropped, the main limitations are flooding, loss of moisture by evaporation, and soil blowing in dry periods. Good management of crop residue and adequate fertilization reduce soil blowing and evaporation. Cropping systems can be adjusted to meet individual farm needs. In low areas waterways, drainage ditches, or diversion terraces help to remove or intercept excess surface water. The use of flood-control measures, where feasible, reduces crop losses and soil damage. This soil is suitable for irrigation if water of good or excellent quality is available. Capability units IIw-2, dryland, and IIw-4, irrigated; Loamy Lowland range site; windbreak suitability group 1.

Wakeen Series

The Wakeen series consists of moderately deep, well-drained, moderately sloping soils on uplands. These soils formed in material weathered from thin-bedded limestone and calcareous shale.

In a representative profile the surface layer is dark grayish-brown, calcareous light silty clay loam about 8 inches thick. The upper 6 inches of the subsoil is grayish-brown and dark grayish-brown, calcareous, friable silty clay loam; and the lower 8 inches of the subsoil is pale-brown, calcareous, friable silty clay loam. The underlying material is very pale brown, calcareous channery light silty clay loam underlain by thin-bedded limestone and calcareous shale at a depth of 28 inches.

Surface runoff and internal drainage are medium. Permeability is moderate. Available water capacity is moderate.

Representative profile of Wakeen silty clay loam, 3 to 6 percent slopes, in a cultivated field, 1,300 feet west and 600 feet south of the northeast corner of sec. 1, T. 6 S., R. 5 W.:

Ap—0 to 8 inches, dark grayish-brown (10YR 4/2) light silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; hard, friable; many fine roots, insect holes, and worm casts; many, small, flat limestone and shale fragments; strongly effervescent, moderately alkaline; clear boundary.

B21—8 to 14 inches, grayish-brown and dark grayish-brown (10YR 5/2 and 4/2) silty clay loam, dark grayish brown and very dark grayish brown (10YR 4/2 and 3/2) moist; moderate, fine, subangular blocky structure; hard, friable; many fine roots, insect holes, worm casts, and fine pores; many, small, flat limestone and shale fragments; strongly effervescent, moderately alkaline; gradual boundary.

B22—14 to 22 inches; pale-brown (10YR 6/3) silty clay loam, brown and dark grayish brown (10YR 5/3 and 4/2) moist; moderate, fine, subangular blocky structure; hard, friable; few worm casts, many fine pores; 15 to 20 percent of soil mass is small, flat limestone and shale fragments; violently effervescent, strongly alkaline; gradual boundary.

C1—22 to 28 inches, very pale brown (10YR 8/3) channery light silty clay loam, very pale brown and yellow (10YR 7/4 and 7/6) moist; weak fine, granular structure; slightly hard, very friable; few worm casts, many fine pores; lower part is thin, platy, weathered shale; violently effervescent, strongly alkaline; gradual boundary.

C2—28 inches, white (10YR 8/2) limestone, yellow (10YR 7/6) shale; medium and coarse, platy structure; thinly bedded limestone and soft shale; fractured.

The combined thickness of the A and B horizons generally is 24 to 30 inches, but it ranges from 20 to 36 inches. All horizons contain free carbonates. Depth to limestone and shale ranges from 24 to 40 inches. The upper horizons that are grayish brown or darker range from 10 to 16 inches in thickness.

The A horizon ranges from 6 to 16 inches in thickness and is silt loam or channery silty clay loam in places. In places the B horizon is strong brown or brown. it ranges from 7 to 20 inches in thickness. The C horizon ranges from 4 to 12 inches in thickness.

Wakeen soils are near Crete, Hastings, Kipson, and Armo soils. They have less clay throughout the profile than Crete and Hastings soils. They have more clay throughout the profile and are deeper to limestone and shale bedrock than Kipson soils. They are shallower to bedrock than Armo soils. They are shallower to free carbonates than Crete and Hastings soils.

Wakeen silty clay loam, 3 to 6 percent slopes (Wa).—This soil is on uplands at lower elevations than Kipson soils. Surface runoff is medium. Included with this soil in mapping are small areas of Crete, Hastings, and Kipson soils.

This soil is suited to all crops commonly grown in the county. The main crops are grain sorghum, silage or forage crops, wheat, and alfalfa. If this soil is cropped, the main hazards are erosion and loss of moisture. Use of contour farming, terraces, and grassed waterways reduces loss of moisture and soil. A cropping system that has 1 or 2 years of row crops or silage or forage crops also reduces loss of moisture and soil. If this soil is adequately protected and fertilized, the intensity of row cropping and silage or forage cropping can be increased. Good management of crop residue helps to maintain or improve tilth and reduces moisture loss and soil blowing. Capability unit IVe-2; Limy Upland range site; windbreak suitability group 4.

Use and Management of the Soils

The soils in Cloud County are used mainly for cultivated crops, pasture, and native range. The soils are also used for windbreaks, for wildlife, for recreational sites, and in the building of highways, farm ponds, and other engineering structures. This section discusses how the soils can be used for these various purposes.

Use of the Soils for Crops[2]

Nearly all of the farms in Cloud County have cropland, pasture, and range. Some of the smaller farms are all range or all cropland. Some soils are suitable for all uses, but others are limited to certain uses.

Throughout the county, soils suitable for farming adjoin soils suitable for grassland and other purposes. Soils suitable for farming are in valleys and on uplands and make up about 80 percent of the county. Soils in the valleys are nearly level and gently sloping, and those on uplands commonly are irregular. The kinds of soil and slope in the valleys permit use of cropping systems that are not commonly applicable to soils on uplands. The soils suitable for farming are used to produce the commonly grown crops: grain sorghum, forage sorghum, wheat, corn, soybeans, and alfalfa.

For dryland or irrigated farming in the valleys, management that includes some cropping systems, cultural practices, adequate fertilization, and conservation measures helps to obtain high crop productions.

Good management of crop residue reduces soil puddling by beating raindrops, reduces soil blowing, and helps to maintain or improve tilth (fig. 20). In large areas alternate strips of row crops and close-growing

[2] EARL BONDY, agronomist, Soil Conservation Service, helped to prepare this section.

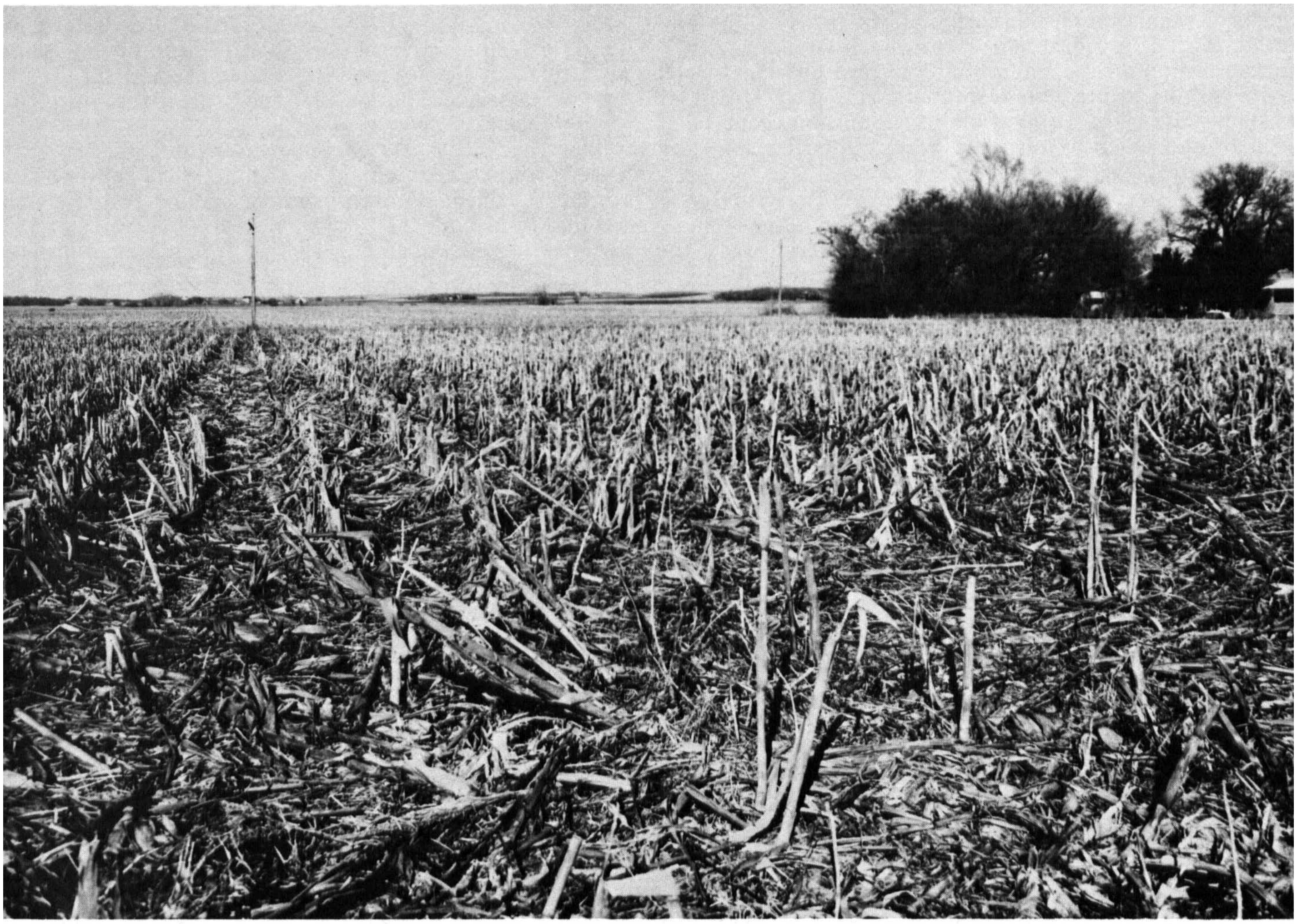

Figure 20.—**Crop residue left on surface of Muir silt loam.**

crops reduce soil blowing and snow drifting. On long slopes contour farming reduces runoff and helps to retain rainwater. Rotating crops helps to control soil-borne insects and disease. Crop rotation, adequate fertilization, and minimum tillage reduces moisture losses and helps to maintain productivity.

In places diversion terraces or improved waterways are needed to control and remove runoff from higher areas. On flood plains flood-control measures reduce crop loss and soil damage. Some of the soils that have a clayey subsoil need drainage ditches to improve workability and productivity. If adequately protected, managed, and fertilized, the soils in the valleys can be row cropped as long as desired without loss of productivity.

All of the soils in the valleys that are suitable for farming are suitable for irrigation if water of good or excellent quality is available. The acreage under irrigation depends on the quantity of water available. The irrigation system and layout are determined by the intake rate of the soil. Proper plant population, control of insects and disease, adequate water, fertilization, and cultural practices are needed.

For dryland or irrigation farming on the soils on uplands, a combination of cropping systems, cultural practices, adequate fertilization, and conservation measures help to obtain moderate to high crop production.

If the common cropping systems are used on these soils, use of contour cultivation, terraces, and grassed waterways are needed to reduce moisture loss, soil loss, and soil blowing. Under these practices row crops can be planted for 2 to 5 consecutive years, depending on slope and degree of erosion. If good crop residue management is added to these practices, the intensity of row cropping can be increased. If good crop residue management, adequate fertilization, and adequate conservation practices are used, the gently sloping soils can be row cropped productively as long as desired. Where wheat is the principal crop and stubble is worked into the soil slowly, some conservation practices are not needed.

All of the upland soils that are suitable for dryland farming, except Nuckolls and Wakeen soils, are suitable for irrigation farming if water of good or excellent quality is available. The acreage under irrigation generally depends on the quantity of water available and on slope. The irrigation system and layout are determined by the intake rate of the soil and by slope. Good crop residue management reduces runoff if sprinkler systems are used. Proper plant population, control of insects and disease, adequate water, fertilization, and cultural practices are needed.

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 horticultural crops or to other crops that require 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 clayey; and *c*, used in some parts of the United States but not in Cloud County, 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-2 or IIIe-3. 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 paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

The capability classes, subclasses, and units used in Cloud County are defined in the list that follows. The unit for each soil in the county can be found in the "Guide to Mapping Units."

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

Units I-1, dryland, and I-3, irrigated. Deep, well drained or moderately well drained, nearly level and gently sloping soils that have a subsoil of silty clay loam.

Units I-2, dryland, and I-3, irrigated. Deep, well-drained, nearly level and gently sloping soils that have a subsoil of silt loam or fine sandy loam.

Class II. Soils that have some limitations that may hinder cropping or that require moderate conservation practices.

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

Units IIe-1, dryland, and IIe-3, irrigated. Deep, moderately well drained, gently sloping soils that have a subsoil of silty clay.

Units IIe-2, dryland, and IIe-3, irrigated. Deep, well-drained, gently sloping soils that have a subsoil of silty clay loam.

Subclass IIw. Soils that are subject to flooding or ponding that hinders normal operations.

Units IIw-1, dryland, and IIw-3, irrigated. Deep, moderately well drained, nearly level soils that have a subsoil of clay loam.

Units IIw-2, dryland, and IIw-4, irrigated. Deep, well-drained, nearly level soils that have a subsoil of silty clay loam, silty clay, or silt loam.

Subclass IIs. Soils that have moderate limitations due to high clay content and slow drainage or to sandy texture and a hazard of soil blowing.

Units IIs-1, dryland, and IIs-2, irrigated. Deep, moderately well drained, nearly level soils that have a subsoil of silty clay or heavy silty clay loam.

Units IIs-3, dryland, and IIs-4, irrigated. Deep, well-drained, nearly level and gently sloping soils that have a subsoil of sandy loam.

Class III. Soils that have severe limitations that may restrict normal operations, reduce intensity of cropping, or require special conservation practices or a combination of practices.

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

Units IIIe-1, dryland, and IIIe-3, irrigated. Deep, well drained or moderately well drained, moderately sloping soils that have a subsoil of silty clay loam or silty clay.

Units IIIe-2, dryland, and IIIe-3, irrigated. Deep, well drained or moderately well drained, moderately sloping, eroded soils that have a subsoil of silty clay loam or silty clay.

Subclass IIIw. Soils that are subject to flooding or ponding that restricts normal operations.

Units IIIw-1, dryland, and IIIw-3, irrigated. Somewhat excessively drained, gently sloping soils that have a subsoil of loamy sand.

Units IIIw-2, dryland, and IIIw-4, irrigated. Deep, somewhat poorly drained, nearly level soils that have a subsoil of silty clay.

Class IV. Soils that have very severe limitations that affect choice of plants, restrict intensity of cropping, or require special conservation practices or a combination of practices.

Subclass IVe. Soils that are subject to very severe erosion if they are not protected.

Unit IVe-1. Deep, well-drained, moderately sloping to strongly sloping soils that have a subsoil of light silty clay loam.

Unit IVe-2. Moderately deep, well-drained, moderately sloping soils that have a subsoil of channery silty clay loam.

Class V. Soils not likely to erode, but that 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 and in which drainage or protection is not feasible.

Unit Vw-1. Deep, poorly drained, nearly level soils that have a subsoil of silty clay loam, silty clay, or clay; on low flood plains.

Class VI. Soils that have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife habitat.

Subclass VIe. Soils that are severely limited by droughtiness, by shallowness, or by risk of flooding and erosion from irregular adjoining side slopes.

Unit VIe-1. Deep to shallow, nearly level soils on flood plains and strongly sloping soils on adjoining irregular side slopes, and shallow moderately sloping to steep soils.

Unit VIe-2. Deep, somewhat excessively drained, moderately sloping to strongly sloping soils that have a subsoil of loamy sand; on sand dunes.

Class VII. Soils that have very severe limitations that make them generally unsuitable for cultivation and limit their use largely to range, woodland, or wildlife habitat.

Subclass VIIe. Soils that are severely limited by shallowness or by risk of frequent flooding and erosion from irregular adjoining side slopes.

Unit VIIe-1. Deep to shallow, frequently flooded, nearly level soils on flood plains and strongly sloping soils on adjoining irregular side slopes, and shallow moderately sloping to steep, stony soils.

Subclass VIIw. Soils that are severely limited by frequent flooding and variable texture.

Unit VIIw. Deep, frequently flooded, nearly level and gently sloping soils that have a subsoil of loamy sand, fine sandy loam, clay loam, or silty clay loam and that occur as irregularly shaped, intermingled areas on the Republican River flood plain.

Class VIII. Soils and landforms that have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, water supply, or esthetic purposes. (None in Cloud County)

Predicted yields

Table 2 gives predicted average yields of the principal crops for the soils in the county suitable for farming. The predicted yields indicate the yields that can be expected over a period of years. These yields do not apply to any field in any particular year. The estimates in table 2 were made on the basis of information obtained from farmers, agricultural technicians, demonstration plots, and research data.

The predicted yields shown in columns A are those to be expected under an intensive management system for dryland farming. Those in columns I are to be expected under irrigation. Yields in columns A are for the principal crops grown on all soils suitable for cultivation. Yields in columns I are for crops commonly irrigated on soils suitable for irrigation.

The intensive management system for dryland farming consists of—

1. Planting high-yielding varieties of crops adapted to the county.
2. Seeding at the proper rates and on the proper dates and using efficient methods of planting and harvesting.
3. Controlling weeds, insects, and disease.
4. Using adequate fertilizer to obtain optimum yields.
5. Using a cropping system that fits the needs of the operator and that keeps the soil in good condition.
6. Managing crop residue to reduce water erosion and soil blowing; to increase moisture intake; to reduce evaporation; and to improve conditions for emergence of seedlings.
7. Establishing terraces and grassed waterways, farming on the contour, and using other practices that conserve moisture and help to control erosion.

Irrigated farming consists of all the measures listed above, in addition to developing the irrigation system and using the water efficiently.

Range[3]

Range is land on which the climax, or potential, plant community is composed principally of native grasses, sedges, forbs, and shrubs that are valuable for grazing by livestock. Some range can be used by wildlife and for recreation.

In Cloud County, about 38 percent of the farm income is from the sale of livestock and of milk and other live-

[3] By HARLAND E. DIETZ, range conservationist, Soil Conservation Service.

TABLE 2.—*Predicted average yields per acre for principal crops grown under intensive dryland management and under irrigation*

[Only the soils suited to cultivation are listed. The absence of a yield figure indicates the soil is not suited to the crop or that the management is not feasible]

Soil	Corn		Grain sorghum		Forage sorghum		Wheat	Alfalfa hay
	A	I	A	I	A	I	A	A
	Bu	*Bu*	*Bu*	*Bu*	*Tons*	*Tons*	*Bu*	*Tons*
Armo silt loam, 2 to 7 percent slopes	50	115	68	112	14	22	30	3.5
Bridgeport silt loam	65	125	70	120	18	24	32	3.5
Carr fine sandy loam	62	95	68	95	16	20	28	3.5
Carr fine sandy loam, high	60	92	65	92	14	18	24	2.5
Crete silt loam, 0 to 1 percent slopes	45	110	70	105	16	22	38	3.0
Crete silt loam, 1 to 3 percent slopes	45	110	70	105	16	22	38	3.5
Crete silt loam, 3 to 6 percent slopes	40	100	65	98	12	20	32	3.5
Crete silty clay loam, 2 to 6 percent slopes, eroded	30	95	55	95	10	18	28	2.5
Detroit silty clay loam	65	120	70	115	16	24	40	3.5
Eudora silt loam, thick surface variant	65	125	75	125	16	20	32	3.5
Geary silt loam, 3 to 7 percent slopes	56	115	75	115	14	20	32	3.5
Geary silty clay loam, 3 to 7 percent slopes, severely eroded	45	100	68	100	12	16	28	3.0
Hastings silt loam, 1 to 3 percent slopes	56	120	75	118	16	24	36	3.5
Hastings silt loam, 3 to 7 percent slopes	52	118	68	115	14	22	32	3.5
Hastings silty clay loam, 2 to 6 percent slopes, eroded	42	115	60	115	12	18	30	3.0
Hobbs silt loam	68	130	74	125	18	24	36	3.5
Hord silt loam	68	150	78	148	18	24	34	4.0
Humbarger loam	70	105	74	100	18	22	42	4.0
Longford silt loam, 1 to 3 percent slopes	52	115	65	115	14	20	32	2.5
Longford silt loam, 3 to 7 percent slopes	48	110	60	110	12	18	32	2.5
Longford silty clay loam, 3 to 7 percent slopes, eroded	40	95	55	95	10	14	28	2.5
McCook silt loam	65	125	72	125	14	20	32	3.5
Muir silt loam	68	150	78	148	18	24	34	3.5
New Cambria silty clay loam	62	120	68	115	16	22	38	4.0
Nuckolls silt loam, 4 to 12 percent slopes	45	—	55	—	12	—	28	3.0
Nuckolls silt loam, 4 to 12 percent slopes, eroded	38	—	45	—	10	—	24	2.5
Roxbury silt loam	70	150	80	148	18	24	42	4.0
Sarpy loamy sand	48	80	52	85	10	16	26	2.0
Sutphen silty clay	—	—	58	—	11	—	30	2.5
Tobin silt loam	65	130	72	125	18	24	36	3.5
Wakeen silty clay loam, 3 to 6 percent slopes	48	—	60	—	12	—	28	4.0

stock products. The number of cattle, including calves, in the county generally ranges from 35,000 to 50,000

The major source of livestock forage is range, but large amounts of crops and crop byproducts are used as supplemental feed. Approximately 30 percent of the county, or 122,500 acres, is in range. An additional 5,200 acres is used for native hay production.

The potential plant cover on range in the county varies considerably in the kind and amount of native plants produced. To properly manage range, operators need to be familiar with the capabilities of different kinds of range and to be able to appraise the present condition of range in relation to its potential.

Range sites and range condition

A range site is a distinctive kind of range that differs from other kinds of range in its potential to produce native plants. Major differences result from differences in soil depth, texture, permeability, and topography.

In the absence of abnormal disturbances, a range site will support the mixture of native plants best adapted to the soil and to the environmental conditions of the site. This plant cover is called the potential, or climax, plant community. Climax vegetation generally is the most productive combination of range plants that a site is capable of growing under natural conditions.

Under proper grazing management, a mixture of plants representative of the climax community can be maintained indefinitely. If a site is subjected to continuous excessive grazing, however, the plant cover is altered. Plants in the climax vegetation are not equally palatable to grazing animals. Livestock graze selectively and continually seek the more palatable plants. Unless grazing is regulated, the preferred plants become overgrazed. All range plants are classed as decreasers, increasers, or invaders, depending on their response to continuous overgrazing.

Decreasers are the most palatable plants in the climax community. They decrease in abundance when the site is subject to continued excessive grazing use. Increasers are less palatable plants in the climax community. They increase in abundance when the site is continually overgrazed. Under prolonged excessive grazing, decreasers are largely eliminated and increasers dominate the site. Invaders are not present in the climax community on the site. They invade as a result of such disturbances on the site as prolonged excessive grazing, drought, fire, or rodent and insect infestations.

The degree of change in the vegetation on each range site can be determined by comparing the present vegetation to the climax vegetation for that site. This change is expressed as range condition. It provides a measure of the alterations that have taken place in the plant cover and provides a basis for predicting the amount of improvement that can be expected in the plant community from proper management. Four range condition classes are recognized: *excellent,* 76 to 100 percent of the climax vegetation is present on the site; *good,* 51 to 75 percent; *fair,* 26 to 50 percent; and *poor,* 0 to 25 percent.

Major changes or trends in range vegetation take place so gradually that they are often overlooked unless the operator is familiar with the characteristics of the range sites and the response of different kinds of plants to grazing. Sometimes plant growth is stimulated during periods of favorable rainfall, giving the appearance of range improvement, whereas actually the long-term trend is toward less palatable grasses and lower production. On the other hand, a dry season may result in overgrazing of a healthy range and cause it to appear degraded, whereas actually the setback is only seasonal or temporary.

Descriptions of the range sites

The soils of Cloud County have been grouped into range sites according to the climax vegetation produced. In the following paragraphs, the soils in each site are described and the names of the more important decreaser, increaser, and invader plants common to the site are briefly discussed.

Estimates of production of air-dry herbage given for each site are based on limited field clippings and research. Since rainfall fluctuates widely from year to year, estimates are given for both favorable and unfavorable years.

The range site for each soil is listed in the "Guide to Mapping Units" at the back of this soil survey.

CLAY LOWLAND RANGE SITE

This range site consists only of Sutphen silty clay. This soil is nearly level on lowlands. It has a firm, clayey subsoil. It absorbs water slowly and is somewhat poorly drained. Production is high during years of abundant rainfall, but it drops sharply during droughts.

The climax plant community is mainly a mixture of big bluestem, little bluestem, indiangrass, switchgrass, Canada wildrye, Virginia wildrye, maximilian sunflower, prairie cordgrass, eastern gamagrass, Illinois bundleflower, and other decreaser grasses. Decreasers make up about 90 percent of the vegetation. Increasers account for the rest. Increasers are western wheatgrass, tall dropseed, sedges, blue grama, buffalograss, side-oats grama, tall goldenrod, baldwin ironweed, health aster, and western ragweed. Common invaders are silver bluestem, inland saltgrass, annual bromes, windmillgrass, tumblegrass, common sunflower, snow-on-the-mountain, and little barley.

If this site is in excellent condition, the average annual production of air-dry herbage is 6,000 pounds per acre in years of favorable moisture and 3,500 pounds per acre in years of unfavorable moisture.

CLAY TERRACE RANGE SITE

This range site consists of deep, nearly level alluvial soils on benches or terraces. These soils have a clayey subsoil that is slowly permeable to water and impedes the penetration of plant roots. These soils have high available water capacity. Additional moisture drains from nearby uplands, but flooding is infrequent.

The climax plant community is mainly tall and mid grasses. Common decreasers are big bluestem, little bluestem, indiangrass, switchgrass, prairie cordgrass, Canada wildrye, Virginia wildrye, and Illinois bundleflower. Decreasers make up about 90 percent of the vegetation. Increasers forbs and grasses account for the rest. Principal increasers are western wheatgrass, tall dropseed, meadow dropseed, side-oats grama, sedges, blue grama, buffalograss, tall goldenrod, Missouri goldenrod, slimflower scurf-pea, and baldwin ironweed. Common invaders are silver bluestem, Kentucky bluegrass, windmillgrass, cocklebur, annual bromes, common sunflower, and snow-on-the-mountain.

If this site is in excellent condition, the average annual production of air-dry herbage is 5,000 pounds per acre in years of favorable moisture and 3,000 pounds per acre in years of unfavorable moisture.

CLAY UPLAND RANGE SITE

This range site consists of nearly level to moderately sloping soils on uplands. These soils have a clayey subsoil that absorbs water slowly and restricts the growth of plant roots. In years of below-average rainfall, these soils are droughty.

The climax plant community is mainly a mixture of decreaser grasses. Common decreasers are big bluestem, little bluestem, side-oats grama, switchgrass, Canada wildrye, indiangrass, blacksamson, purple prairie-clover, and white prairie-clover. Decreasers make up at least 70 percent of the vegetation. Increaser grasses and forbs account for the rest. Common increasers are blue grama, buffalograss, western wheatgrass, tall dropseed, prairieconeflower, slimflower scurf-pea, Missouri goldenrod, and western ragweed. Common invaders are silver bluestem, windmillgrass, annual bromes, and common sunflower.

If this site is in excellent condition, the average annual production of air-dry herbage is 4,000 pounds per acre in years of favorable moisture and 2,000 pounds per acre in years of unfavorable moisture.

LIMY UPLAND RANGE SITE

This range site consists of deep, moderately deep, and shallow, moderately sloping to steep soils on uplands. The surface layer typically is calcareous and granular. These soils absorb water well. and the plant-moisture relationship is good.

The climax plant community is mainly a mixture of decreaser grasses and forbs. Common decreasers are big bluestem, little bluestem, indiangrass, switchgrass, Canada wildrye, leadplant, catclaw sensitivebriar, blacksamson, purple prairie-clover, and white prairie-clover. Decreasers make up at least 80 percent of the

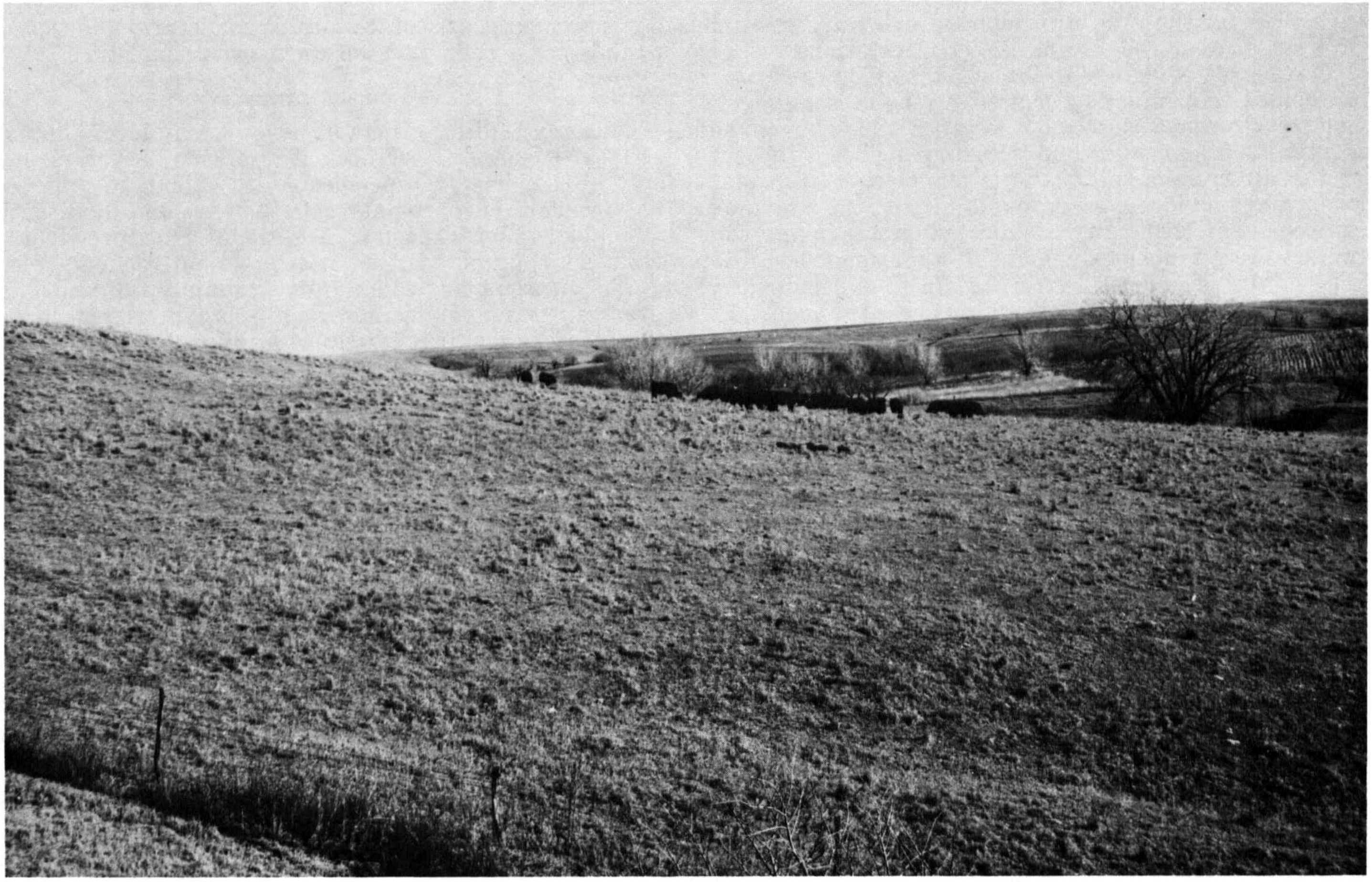

Figure 21.—Limy Upland range site in excellent condition.

vegetation. Increasers account for the rest. Common increasers are blue grama, buffalograss, side-oats grama, hairy grama, western wheatgrass, tall dropseed, Missouri goldenrod, and western ragweed. Common invaders are silver bluestem, windmillgrass, annual bromes, common pricklypear, and common sunflower.

If this site is in excellent condition (fig. 21), the average annual production of air-dry herbage is 5,000 pounds per acre in years of favorable moisture and 2,000 pounds per acre in years of unfavorable moisture.

LOAMY LOWLAND RANGE SITE

This range site consists of nearly level to gently sloping soils on bottom lands along the rivers and major streams. These soils are deep and are loamy throughout the profile. They have a high capacity for root growth and high available water capacity.

The climax plant community is mainly a mixture of warm-season decreaser grasses. Common decreasers are big bluestem, little bluestem, indiangrass, switchgrass, prairie cordgrass, Canada wildrye, Virginia wildrye, maximilian sunflower, Illinois bundleflower, and whole-leaf rosinweed. Decreasers make up about 90 percent of the vegetation. Increasers account for the rest. Common increasers are western wheatgrass, sedges, tall dropseed, meadow dropseed, side-oats grama, blue grama, buffalograss, tall goldenrod, Louisiana sagewort, baldwin ironweed, elm, cottonwood, sycamore, and bur oak. Trees, mainly elm, cottonwood, sycamore, and bur oak, grow naturally along streambanks. Under the canopy of these trees grow shade-tolerant grasses such as Canada wildrye, Virginia wildrye, and green muhly. Common invaders are silver bluestem, Kentucky bluegrass, cocklebur, annual bromes, common sunflower, giant ragweed, poison-hemlock, and snow-on-the-mountain.

If this site is in excellent condition, the average annual production of air-dry herbage is 7,000 pounds per acre in years of favorable moisture and 4,000 pounds per acre in years of unfavorable moisture.

LOAMY TERRACE RANGE SITE

This range site consists of nearly level to gently sloping soils on alluvial benches or terraces. Flooding is infrequent, but additional moisture drains from nearby uplands. The soils in this range site are deep and loamy throughout the profile. They are permeable to water and roots and have high available water capacity.

The climax plant community is mainly tall and mid decreaser grasses. Common decreasers are big blue-

Figure 22.—**Loamy Upland range site in excellent condition.**

stem, little bluestem, indiangrass, switchgrass, Canada wildrye, maximilian sunflower, leadplant, and Illinois bundleflower. Decreasers make up about 90 percent of the vegetation. Increasers account for the rest. Common increasers are western wheatgrass, tall dropseed, blue grama, buffalograss, side-oats grama, vine-mesquite, tall goldenrod, baldwin ironweed, heath aster, and western ragweed. As the site degenerates from continuous overgrazing, annual grasses and weeds invade. Common invaders are silver bluestem, annual bromes, windmillgrass, tumblegrass, common sunflower, snow-on-the-mountain, little barley, elm, and cottonwood.

If this site is in excellent condition, the average annual production of air-dry herbage is 6,000 pounds per acre in years of favorable moisture and 3,000 pounds per acre in years of unfavorable moisture.

LOAMY UPLAND RANGE SITE

This range site consists of deep, gently sloping to strongly sloping soils on uplands (fig. 22). These soils have a surface layer of loam and a subsoil that is loamy to clayey. Permeability is moderate to slow. Available water capacity is high.

The climax plant community is mainly a mixture of decreaser grasses. Common decreasers are big bluestem, little bluestem, indiangrass, switchgrass, Canada wildrye, breadroot scurf-pea, Illinois bundleflower, compassplant, and serrateleaf eveningprimrose. Decreaser plants make up about 65 percent of the vegetation. Increasers account for the rest. Common increasers are blue grama, buffalograss, western wheatgrass, tall dropseed, prairie-coneflower, prairie sagewort, slimflower scurf-pea, and western ragweed. Common invaders are annual bromes, little barley, common sunflower, curlycup gumweed, windmillgrass, and tumblegrass.

If this site is in excellent condition, the average annual production of air-dry herbage is 5,000 pounds per acre in years of favorable moisture and 2,000 pounds per acre in years of unfavorable moisture.

SANDS RANGE SITE

This range site consists only of Sarpy loamy sand, duned. This is a deep, rolling or hummocky soil that is sandy throughout the profile. It is mainly along the Republican River. This soil absorbs moisture rapidly, but the available water capacity is low.

The climax plant community is mainly a mixture of decreaser grasses. Common decreasers are sand bluestem, big bluestem, little bluestem, switchgrass, indiangrass, sand lovegrass, Illinois bundleflower, roundhead lespedeza, and Illinois tickclover. Decreasers make up at least 70 percent of the vegetation. Increasers account for the rest. Common increasers are blue grama, sand paspalum, sand dropseed, western wheatgrass, tall dropseed, small soapweed, prairie sagewort, purple lovegrass, slimflower scurf-pea, and western ragweed. Common invaders are annual bromes, rose-ring gaillardia, common sunflower, annual eriogonum, camphorweed, and false buffalograss.

If this site is in excellent condition, the average annual production of air-dry herbage is 5,000 pounds per acre in years of favorable moisture and 3,000 pounds per acre in years of unfavorable moisture.

SANDY LOWLAND RANGE SITE

This range site consists of nearly level to gently undulating soils on flood plains adjacent to the Republican River. These soils are deep and have a surface layer and subsoil that are sandy or loamy. Permeability is moderate or moderately rapid, and available water capacity is moderate to low. If not protected, these soils are highly susceptible to soil blowing. The water table fluctuates between depths of 4 and 12 feet. If it is within the root zone of the better grasses, growth and production of forage increase.

The climax plant community is mainly decreaser grasses. Common decreasers are sand bluestem, little bluestem, indiangrass, switchgrass, sand lovegrass, Canada wildrye, Virginia wildrye, maximilian sunflower, and Illinois bundleflower. Decreasers make up about 70 to 90 percent of the vegetation. Increasers account for the rest. Common increasers are western wheatgrass, tall dropseed, sand dropseed, side-oats grama, blue grama, sand paspalum, purpletop, and baldwin ironweed. Willow and cottonwood trees are common along streambanks. Common invaders are silver bluestem, windmillgrass, cocklebur, annual bromes, common sunflower, and common ragweed.

If this site is in excellent condition, the average annual production of air-dry herbage is 6,000 pounds per acre in years of favorable moisture and 3,500 pounds in years of unfavorable moisture.

SANDY TERRACE RANGE SITE

This range site consists only of Carr fine sandy loam, high. This soil is nearly level to gently sloping on alluvial benches or terraces where flooding is infrequent. It is deep and has a surface layer and subsoil that are sandy or loamy. Permeability is moderate, and available water capacity is moderate.

The climax plant community is mainly tall and mid grasses. Common decreasers are sand bluestem, big bluestem, little bluestem, indiangrass, switchgrass, Canada wildrye, sand lovegrass, leadplant, roundhead lespedeza, and Illinois bundleflower. Decreasers make up about 90 percent of the vegetation. Increasers account for the rest. Common increasers are western wheatgrass, sand dropseed, tall dropseed, blue grama, sand paspalum, side-oats grama, purple lovegrass, tall goldenrod, baldwin ironweed, heath aster, and western ragweed. Common invaders are silver bluestem, annual bromes, windmillgrass, common sunflower, rose-ring gaillardia, and annual eriogonum.

If this site is in excellent condition, the average annual production of air-dry herbage is 5,500 pounds per acre in years of favorable moisture and 3,500 pounds per acre in years of unfavorable moisture.

SHALLOW OVER SANDSTONE RANGE SITE

This range site consists of moderately sloping to steep soils on uplands. The soils are less than 20 inches thick over sandstone and sandy shale. They have a loamy surface layer that contains fragments of sandstone. Permeability is moderate. Shallow depth limits available water capacity.

The climax plant community is mainly a mixture of decreaser grasses. Common decreasers are big bluestem, little bluestem, indiangrass, switchgrass, Canada wildrye, leadplant, catclaw sensitivebrier, blacksamson, stiff sunflower, purple prairie-clover, and white prairie-clover. Decreasers make up at least 75 percent of the vegetation. Increasers account for the rest. Common increasers are blue grama, buffalograss, side-oats grama, hairy grama, western wheatgrass, tall dropseed, Scribner panicum, noble goldenrod, and western ragweed. Common invaders are windmillgrass, curlycup gumweed, annual bromes, and annual three-awn.

If this site is in excellent condition, the average annual production of air-dry herbage is 3,500 pounds per acre in years of favorable moisture and 2,000 pounds per acre in years of unfavorable moisture.

SUBIRRIGATED RANGE SITE

This range site consists only of Alluvial land, wet. This nearly level soil is frequently flooded and is on bottom lands. It has a water table that is within reach of plant roots most of the growing season, which significantly benefits plant growth and forage production. The water table generally fluctuates between depths of 2 and 5 feet.

The climax plant community is mainly a mixture of decreaser grasses. Common decreasers are big bluestem, little bluestem, switchgrass, indiangrass, prairie cordgrass, eastern gamagrass, Illinois bundleflower, and serrateleaf eveningprimrose. Decreasers make up at least 80 percent of the vegetation. Increasers account for the rest. Common increasers are western wheatgrass, knotroot bristlegrass, meadow dropseed, and sedges. Other increasers are alkali sacaton, tall dropseed, American licorice, grassleaf goldenrod, and cottonwood. Woody increasers include willow, buttonbush, and indigobush. Common invaders are annual bromes, baldwin ironweed, foxtail barley, seacoast sumpweed, elm, russian-olive, saltcedar, inland saltgrass, and dogwood.

If this site is in excellent condition, the average annual production of air-dry herbage is 9,000 pounds per acre in years of favorable moisture and 7,000 pounds per acre in years of unfavorable moisture.

Windbreaks

Cloud County has no native forests or large wooded areas. Woodlots border many of the streams, but few of these areas have trees of high commercial value. The woodlots are used mainly for fuel, fenceposts, pasture, and wildlife habitat. Occasionally, certain kinds of trees are sold for commercial use.

The greatest use of trees and shrubs is in windbreaks near the farmstead. A combination of native trees and shrubs can be used in adequate windbreaks. This includes such trees and shrubs as bur oak, hackberry, cottonwood, wild plum, and others. Other tree and shrub species, not native to Cloud County, are also well suited to this purpose.

Windbreaks are shaped to give maximum protection for each site. The trees and shrubs can be selected to fit suitability groups of the different kinds of soil. The trees and shrubs are planted in an area cleared of vegetation. The windbreak is cultivated or sprayed to keep out weeds. The trees and shrubs need protection from fire, livestock, rabbits, rodents, insects, and disease. More information on windbreaks can be obtained from the Soil Conservation Service office or the office of the County Agent.

Windbreak suitability groups

The soils of Cloud County have been placed in four windbreak suitability groups. Each group is made up of soils that are suitable for about the same kinds of trees and shrubs. Each group requires similar management and provides about the same chance of survival and the same rate of growth for the adapted trees and shrubs (*9*).

Following is a list of the windbreak suitability groups and a brief description of the soils in each group.

Windbreak suitability group 1.—Loamy and clayey soils on lowlands. This group consists of soils that have a surface layer of silt loam and a subsoil of silt loam or silty clay loam, and of soils that have a surface layer of silty clay loam and a subsoil of silty clay loam or silty clay.

Windbreak suitability group 2.—Sandy and loamy soils on lowlands. This group consists of soils that have a surface layer and subsoil of fine sandy loam or loamy sand.

Windbreak suitability group 3.—Deep, loamy and clayey soils on uplands. This group consists of soils that have a surface layer and subsoil of silt loam or silty clay loam and of soils that have a surface layer of silt loam or silty clay loam and a subsoil of silty clay.

Windbreak suitability group 4.—Shallow, loamy soils on uplands. This group consists of soils that have a surface layer of loam over sandstone and shale, and of soils that have a surface layer and subsoil of silt loam to light silty clay loam over limestone and shale.

In table 3, ratings are given for the vigor of the best adapted species on the soils of each windbreak suitability group. A rating of *excellent* indicates that trees grow well, leaves have good color, no dead branches are in the upper part of the crown, and there is no indication of damage by fungi or disease. A rating of *good* indicates that trees grow moderately well, there are a few dead branches and some die-back in the upper part of the crown, and slight damage has been done by fungi or insects. 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, growth is slow, and moderate damage by fungi or insects can be expected. A rating of *poor* indicates that surviving trees will have severe dieback, less than three-fourths of the trees planted will sur-

TABLE 3.—*Vigor ratings of trees and shrubs as windbreak plantings*

Trees and shrubs	Windbreak suitability groups			
	Group 1	Group 2	Group 3	Group 4
Shrubs:				
Fragrant sumac	Excellent	Excellent	Excellent	Good.
Tamarisk	Excellent	Excellent	Excellent	Good.
Common lilac	Excellent	Excellent	Good	Fair.
Wild plum	Excellent	Excellent	Good	Fair.
Intermediate Trees:				
Osage-orange	Not suitable	Excellent	Excellent	Good.
Russian mulberry	Excellent	Excellent	Excellent	Not suitable.
Russian-olive	Excellent	Excellent	Excellent	Good.
Tall Trees:				
Siberian elm	Excellent	Excellent	Excellent	Good.
Bur oak	Excellent	Excellent	Good	Fair.
Green ash	Excellent	Excellent	Good	Not suitable.
Hackberry	Excellent	Excellent	Good	Fair.
Honey locust	Excellent	Excellent	Excellent	Good.
Cottonwood	Good	Excellent	Fair	Not suitable.
Black walnut	Good	Fair	Fair	Not suitable.
Conifers:				
Eastern redcedar	Excellent	Excellent	Excellent	Good.
Rocky Mountain juniper	Good	Excellent	Excellent	Good.
Austrian pine	Excellent	Excellent	Excellent	Good.
Ponderosa pine	Good	Good	Excellent	Good.

vive, and severe damage by fungi and insects can be expected.

The windbreak suitability group for each soil is given in the "Guide to Mapping Units" at the back of this survey.

Wildlife Management[4]

Soils influence wildlife primarily through the vegetation they produce. The carrying capacity of wildlife of an area is largely determined by the kind, amount, and distribution of this vegetation. Farming has many effects on wildlife because it changes or removes the cover of vegetation. When grassland is converted to cropland, some kinds of wildlife lose their protective cover, but an improved supply of food and new kinds of cover are made available to other species.

Soils suitable for farming differ in their capacity to produce food and cover for wildlife. Where slopes are gentle, the assortment of crops and the area of cropland are large. The food supply is more than adequate, but cover is limited, except for certain kinds of wildlife. Where slopes are moderate or steeper, the area of cropland is smaller. The native grassland maintains the food supply, and wildlife cover is more plentiful. In areas where the soils are hilly, the area of cropland is small and the wildlife cover is plentiful but the food supply is more limited in variety.

Cloud County has diverse wildlife habitat and consequently a diverse wildlife population. The interspersion of food, cover, and water provides an index to the kinds and quantities of adapted wildlife species in a particular locality.

A part of the Jamestown State Waterfowl Management Area is in the Detroit-Sutphen-Bridgeport soil association. Salt Creek and St. John's Creek flow through the area and provide the water source for the management area. Large concentrations of waterfowl—geese and ducks—as well as shore birds and songbirds and insectivorous birds find their basic needs in this area. Waterfowl use the area principally for resting during their spring and fall migrations, although some nesting does occur here. Plans are being made to improve the management capabilities of the area, so that additional alternatives can be considered.

A convenient way to discuss wildlife in the county is by soil associations, although interpretations of wildlife use by soils is available from each District Office of the Soil Conservation Service.

The soil characteristics and related topographic conditions were considered in grouping the soils in the county into soil associations. The potential of each soil association for producing food and cover for the various kinds of wildlife is rated in table 4. The general soil map at the back of this survey shows the location of each association.

The following paragraphs discuss important animal species according to the associations in which they most generally occur.

Bobwhite quail is the most popular upland game bird in the county. Many nonhunters also enjoy the presence

[4] By JACK W. WALSTROM, biologist, Soil Conservation Service.

TABLE 4.—*Potential of the soil associations for producing habitat required by various kinds of wildlife*

Soil associations	Kinds of wildlife	Habitat			
		Woody cover	Herbaceous cover	Aquatic habitat	Food
1. Crete-Hastings-Hobbs.	Upland	Fair	Good	Poor	Good.
	Woodland	Fair	Good	Poor	Fair.
	Wetland	Fair	Fair	Poor	Poor.
2. Kipson-Hastings-Armo.	Upland	Fair	Good	Poor	Good.
	Woodland	Fair	Good	Poor	Fair.
	Wetland	Fair	Fair	Poor	Poor.
3. Crete-Longford-Hedville.	Upland	Fair	Good	Poor	Good.
	Woodland	Fair	Good	Poor	Fair.
	Wetland	Poor	Fair	Poor	Poor.
4. Hastings-Crete-Hord.	Upland	Fair	Good	Fair	Good.
	Woodland	Fair	Good	Fair	Fair.
	Wetland	Poor	Fair	Poor	Fair.
5. Lancaster-Hedville.	Upland	Fair	Good	Poor	Good.
	Woodland	Poor	Good	Poor	Poor.
	Wetland	Very poor	Poor	Very poor	Very poor.
6. Muir-Carr-Humbarger.	Upland	Good	Good	Fair	Good.
	Woodland	Good	Good	Fair	Good.
	Wetland	Good	Good	Fair	Fair.
7. Detroit-Sutphen-Bridgeport.	Upland	Good	Good	Good	Good.
	Woodland	Good	Good	Good	Good.
	Wetland	Good	Good	Good	Good.
8. Roxbury-New Cambria-McCook.	Upland	Good	Good	Good	Good.
	Woodland	Good	Good	Good	Good.
	Wetland	Good	Good	Good	Good.

and characteristic call of this native bird. The highest populations are in the Roxbury-New Cambria-McCook, Crete-Hastings-Hobbs, Muir-Carr-Humbarger, and Hastings-Crete-Hord associations, although bobwhite are found throughout the county. Wooded areas near cropland provide ideal bobwhite habitat. These soil associations also support fair populations of pheasant, which are also found throughout the county.

A few remnant populations of prairie chicken exist in the Crete-Longford-Hedville and Lancaster-Hedville associations in the southeastern part of the county.

Wetland wildlife are most common in the Detroit-Sutphen-Bridgeport, Muir-Carr-Humbarger, and Roxbury-New Cambria-McCook associations, which include Buffalo Creek, Republican River, and Solomon River drainages. Wetland wildlife includes beaver, muskrat, mink, raccoon, kingfishers, and various waterfowl and shore birds.

Both mule deer and white-tailed deer are increasing in the county. White-tailed deer predominate. Deer generally are along the streams and rivers as described for wetland wildlife. The associations described for wetland wildlife also provide desirable habitat for cottontail rabbits and for such song and insectivorous birds as thrashers, cardinals, woodpeckers, flycatchers, warblers, orioles, and robins.

Fishing varies from good to excellent in the many farm ponds, reservoirs, streams, and rivers throughout the county. Bass, bluegill, channel catfish, flathead catfish, bullhead catfish, and crappie are the common game species.

The general kinds of wildlife found in the county, and rated in table 4, are described in the following paragraphs.

Upland, or open-land, wildlife includes birds and mammals that normally frequent croplands, pastures, meadows, lawns, and areas overgrown with grasses, herbs, and shrubby growth. Examples of this kind of wildlife are quail, pheasant, meadowlark, field sparrow, redwing blackbird, cottontail rabbit, red fox, and marmot.

Woodland wildlife includes birds and mammals that normally frequent areas of hardwood trees and shrubs, coniferous trees and shrubs, or mixtures of such plants. Examples of this kind of wildlife are thrush, vireo, fox squirrel, red fox, white-tailed and mule deer, raccoon, and turkey.

Wetland wildlife includes birds and mammals that normally frequent such wet areas as ponds, streams, ditches, marshes, and swamps. Examples of this kind of wildlife include wood duck, rail, heron, shore birds, mink, muskrat, beaver, mallards, and pintails.

Further information and assistance in planning and developing wildlife habitat can be obtained at the local offices of the Soil Conservation Service; the Forestry, Fish, and Game Commission; the Fish and Wildlife Service; or the County Extension Service.

Recreation[5]

Cloud County has good potential for the development of several types of recreational enterprise. It is crossed from north to south by U.S. Highway No. 81, which passes through Concordia. The volume of traffic should increase when this highway is widened to four lanes. The county is crossed from east to west by U.S. Highway No. 24, which crosses the southern part of the county. Two east-to-west Kansas State highways in the northern part of the county also pass through Concordia. These highways allow traffic to flow in all directions.

The increasing need for campgrounds offers opportunities for businesses to be established near trafficways. Fee fishing and hunting opportunities also offer promise. In establishing scenic trails and historic sites, the public sector can best assist.

The soil and topographic conditions that affect the suitability of the soils for use as recreational sites are evaluated in table 5. The ratings for uses are slight, moderate, and severe. They indicate the degree of

[5] By JACK W. WALSTROM, biologist, Soil Conservation Service.

TABLE 5.—*Degree of limitation and soil features affecting the use of the soils for recreation*

Soil series and map symbols	Camp areas	Picnic areas	Playgrounds	Paths and trails
Alluvial land:				
Aa	Severe: flood hazard; slope.	Severe: flood hazard; slope.	Severe: flood hazard; slope.	Moderate: flood hazard; slope.
Ah	Severe: flood hazard; poorly drained.	Severe: flood hazard; poorly drained.	Severe: flood hazard; poorly drained.	Severe: poorly drained; flood hazard.
Armo: Ar	Slight	Slight	Moderate: slope	Slight.
Breaks-Alluvial land complex: Ba.	Severe: slope; flood hazard.	Severe: slope; flood hazard.	Severe: slope; flood hazard.	Moderate where slope is less than 25 percent.
Bridgeport: Br	Severe: flood hazard	Severe: flood hazard	Severe: flood hazard	None to slight.
Carr:				
Ca	Severe: flood hazard; hazard of soil blowing.	Moderate: flood hazard; hazard of soil blowing.	Moderate: flood hazard; hazard of soil blowing.	None to slight.
Cb	None to slight: hazard of soil blowing.	None to slight: hazard of soil blowing.	None to slight: hazard of soil blowing.	None to slight.
Cf	Severe: flood hazard; fine sandy loam and loamy sand texture.	Severe: flood hazard; fine sandy loam and loamy sand texture.	Severe: flood hazard; fine sandy loam and loamy sand texture.	Moderate: flood hazard.

TABLE 5.—*Degree of limitation and soil features affecting the use of the soils for recreation*—Continued

Soil series and map symbols	Camp areas	Picnic areas	Playgrounds	Paths and trails
Crete:				
Cr, Cs, Ct	Moderate: moderately slow permeability; moderately well drained; silt loam texture.	Slight where slope is 1 to 6 percent. Moderate where slope is 0 to 1 percent: moderately well drained; ponding hazard.	Moderate: moderately slow permeability; moderately well drained; slope.	None to slight.
Cu	Moderate: moderately slow permeability; silty clay loam texture; moderately well drained.	Moderate: silty clay loam texture; moderately well drained.	Moderate: moderately slow permeability; silty clay loam texture; moderately well drained; slope.	Moderate: silty clay loam texture.
Detroit: De	Severe: slow permeability; silty clay loam texture; moderately well drained; ponding hazard.	Moderate: silty clay loam texture; moderately well drained; ponding hazard.	Moderate: slow permeability; silty clay loam texture; moderately well drained; ponding hazard.	Moderate: silty clay loam texture; ponding hazard.
Eudora, thick surface variant: Eu.	None to slight: slightly dusty.	None to slight: slightly dusty.	Slight: slightly dusty	None to slight.
Geary:				
Ge	None to slight	None to slight	Moderate: slope	None to slight.
Gs	Moderate: silty clay loam texture.	Moderate: silty clay loam texture.	Moderate: silty clay loam texture.	Moderate: silty clay loam texture.
Hastings:				
Hb, Hc	None to slight	None to slight	Moderate: slope; moderately slow permeability.	None to slight.
Hd	Moderate: silty clay loam texture, moderately slow permeability.	Moderate: silty clay loam texture.	Moderate: slope; silty clay loam texture, moderately slow permeability.	Moderate: silty clay loam texture.
Hedville: He	Severe: stony; shallow; slope.	Severe: stony; shallow; slope.	Severe: stony; shallow; slope.	Moderate: stony; slope.
Hobbs: Ho	Severe: flood hazard; ponding hazard.	Severe: flood hazard; ponding hazard.	Severe: flood hazard; ponding hazard.	Moderate: flood hazard; ponding hazard.
Hord: Hr	None to slight	None to slight	None to slight	None to slight.
Humbarger: Hu	Severe: flood hazard; ponding hazard.	Moderate: flood hazard; ponding hazard.	Moderate: flood hazard; ponding hazard.	None to slight.
Kipson: Kp	Severe: slope; shallow	Severe: slope; shallow	Severe: slope; shallow	Moderate: slope.
Lancaster: Lh	Severe: moderately deep and shallow; slope.	Severe: moderately deep and shallow; slope.	Severe: moderately deep and shallow; slope.	Moderate: stony; slope.
Longford:				
Lm, Ln	Moderate: moderately slow permeability; slope.	None to slight	Moderate: slope; moderately slow permeability.	None to slight.
Lo	Moderate: silty clay loam texture; moderately slow permeability.	Moderate: silty clay loam texture.	Moderate: silty clay loam texture; slope; moderately slow permeability.	Moderate: silty clay loam texture.
McCook: Mc	None to slight: slightly dusty.	None to slight: slightly dusty.	Slight: slightly dusty	None to slight.
Muir: Mr	None to slight	None to slight	None to slight	None to slight.
New Cambria: Nc	Severe: moderately well drained; slow permeability; silty clay loam texture; ponding.	Moderate: moderately well drained; silty clay loam texture; ponding.	Severe: moderately well drained; slow permeability; silty clay loam texture; ponding.	Moderate: moderately well drained; silty clay loam texture; ponding.
Nuckolls: Nu, Nx	Moderate: average slope is more than 8 percent.	Moderate: average slope is more than 8 percent.	Severe: average slope is more than 8 percent.	None to slight.
Roxbury: Rx	None to slight	None to slight	None to slight	None to slight.
Sarpy:				
Sa	Severe: flood hazard; hazard of soil blowing; loamy sand texture.	Moderate: flood hazard; loamy sand texture; hazard of soil blowing.	Severe: flood hazard; loamy sand texture; hazard of soil blowing.	None to slight.

TABLE 5.—*Degree of limitation and soil features affecting the use of the soils for recreation*—Continued

Soil series and map symbols	Camp areas	Picnic areas	Playgrounds	Paths and trails
Sarpy—Continued				
Sd	Severe: loamy sand texture; slope; hazard of soil blowing.	Severe: loamy sand texture; slope; hazard of soil blowing.	Severe: loamy sand texture; slope; hazard of soil blowing.	Moderate where slopes are less than 25 percent: loamy sand texture. Severe where slopes are more than 25 percent.
Sutphen: St	Severe: silty clay texture; somewhat poorly drained; very slow permeability; ponding hazard.	Severe: silty clay texture; ponding hazard; drainage.	Severe: silty clay texture; somewhat poorly drained; very slow permeability; ponding hazard.	Severe: silty clay texture; somewhat poorly drained; flood hazard; ponding hazard.
Tobin: To	Severe: flood hazard	Severe: flood hazard	Severe: flood hazard	Moderate: flood hazard.
Wakeen: Wa	Moderate: silty clay loam texture; moderately deep.	Moderate: silty clay loam texture; moderately deep.	Severe: silty clay loam texture; slope; moderately deep.	Moderate: silty clay loam texture.

limitation or the preparation necessary to develop the site for the intended use.

A rating of *slight* indicates that the soil has few limitations or that little preparation is necessary to overcome the limitations for the use specified. A rating of *moderate* indicates that the soil has some limitations, or specific limitations, that require definite planning and preparation to overcome. A rating of *severe* indicates that the soil is poorly suited to the use intended and that detailed planning, preparations, and large investments are needed to overcome the limitations. The ratings are very broad and do not mean that the same amount of planning and work is needed for each specified use. The planning and work necessary to develop a playground is much greater than that needed to develop a picnic area even though the rating is slight for each.

The ratings give general information regarding suitability, but a specific site generally requires detailed onsite investigation. The properties considered in giving the ratings are noted in table 5.

The kind of recreational uses considered and a general statement of their requirements follow.

Camp areas to be used for tents and 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 areas.

The ratings for picnic areas are based on the features of the soil only. Such other considerations as lakes, trees, or beauty may affect the desirability of the site.

Playgrounds are for such activities as baseball, football, and badminton. Areas should have a nearly level surface, good drainage, and no rock. It is assumed that good plant cover can be established and maintained where needed.

Paths and trails include foot trails, cross-country hiking routes, bridle paths, and other nonintensive uses. It is not anticipated that soils will have to be graded and shaped to any great extent. Ratings are based on soil features only and do not include other items that are important in the selection of a site for this use.

The following soils, listed in table 5, have characteristics that may result in annoying conditions. Carr soils have a surface layer and subsoil of fine sandy loam and have moderate available water capacity. Sarpy soils have a surface layer and subsoil of loamy sand and have low available water capacity. During dry periods, heavy traffic on these soils can develop bare areas that are subject to soil blowing on windy days. Heavy traffic during dry periods can develop dusty conditions on McCook and Eudora soils. The notation "ponding hazard" as a limitation indicates the presence of depressions that retain water after rains.

Engineering Uses of the Soils[6]

This section 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. Listed in this section are those properties of the soils that affect construction and maintenance of roads and airports, pipelines, building foundations, water storage facilities, erosion control structures, drainage systems, 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 are furnished in tables 6, 7, and 8. 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, and other structures for controlling water and conserving soil.
2. Selecting potential locations for highways, airports, pipelines, underground cables, and waste disposal areas.
3. Locating probable sources of sand, gravel, and rock suitable for use as construction material.

[6] GLENN CREAGER, JR., civil engineer. Soil Conservation Service, assisted in the preparation of this section.

TABLE 6.—*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 to— Seasonal high water table	Depth from surface of typical profile	Classification: USDA texture	Classification: Unified
	In	*Ft*	*In*		
Alluvial land: Aa, Ah. Too variable to estimate.					
Armo: Ar	>60	>6	0–10	Silt loam	CL
			10–40	Light silty clay loam	CL
			40–60	Silt loam	CL
Breaks-Alluvial land complex: Ba. Too variable to estimate.					
Bridgeport: Br	>60	4–8	0–14	Silt loam	ML or CL
			14–22	Light silty clay loam	CL
			22–40	Silt loam	ML or CL
			40–60	Light silty clay loam	CL
Carr:					
Ca, Cb	>60	4–12	0–18	Fine sandy loam	SM
Cf. No estimates given for Carr and Sarpy soils in Cf. Material too variable to estimate.			18–48	Fine sandy loam and stratified fine sandy loam, loam, and fine sand.	SM
			48–60	Stratified fine sandy loam and loamy fine sand.	SM
Crete: Cr, Cs, Ct, Cu	>60	>6	0–14	Silt loam and silty clay loam	ML–CL or CL
			14–34	Silty clay	CH
			34–60	Silty clay loam	ML–CL or CL
Detroit: De	>60	4–8	0–12	Light silty clay loam	ML–CL or CL
			12–36	Heavy silty clay loam	CH or CL
			36–60	Silty clay loam	CL
Eudora: Eu	>60	>10	0–20	Light silt loam	ML
			20–60	Loam	ML
Geary: Ge, Gs	>60	>6	0–18	Silt loam and silty clay loam	ML or CL
			18–42	Silty clay loam	CL
			42–60	Light silty clay loam and clay loam	CL
Hastings: Hb, Hc, Hd	>60	>6	0–12	Silt loam	ML–CL or CL
			12–44	Silty clay loam	CL
			44–60	Silt loam	ML–CL or CL
Hedville: He	12–18	>6	0–16	Stony loam	SM, ML
			16	Sandstone.	
Hobbs: Ho	>60	>6	0–20	Silt loam	ML or CL
			20–40	Light silty clay loam	CL
			40–60	Silty clay loam	CL
Hord: Hr	>60	>10	0–22	Silt loam	ML or CL
			22–42	Silty clay loam	CL
			42–60	Light silty clay loam	CL
Humbarger: Hu. Depth to sand is 40 inches to more than 60 inches.	>60	4–12	0–10	Loam	ML or CL
			10–22	Heavy silt loam	ML or CL
			22–48	Clay loam	CL
			48–60	Loamy fine sand	SM
Kipson: Kp	10–20	>6	0–10	Stony silt loam	SM, ML
			10–20	Channery light silty clay loam	SM–SC, ML
			20	Limestone and shale.	
*Lancaster: Lh. For Hedville part of Lh, see Hedville series.	24–40	>6	0–20	Loam	ML
			20–28	Light clay loam	CL or ML
			28–36	Loam	ML
			36	Shale and sandstone.	

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 more than; the symbol < means less than]

Classification—Con.	Percentage less than 3 inches passing sieve—				Permea-bility	Available water capacity	Reaction	Shrink-swell potential
AASHO	No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)				
					In per hr	*In per in of soil*	*pH*	
A-6	100	100	90-95	85-90	0.6-2.0	0.16-0.18	7.4-7.8	Low.
A-6	100	100	95-100	90-95	0.6-2.0	0.16-0.18	7.9-8.4	Moderate.
A-6	100	100	90-95	80-85	0.6-2.0	0.16-0.18	7.9-8.4	Low.
A-4 or A-6	100	100	95-100	85-95	0.6-2.0	0.16-0.18	7.4-7.8	Low.
A-6	100	100	95-100	90-100	0.6-2.0	0.16-0.18	7.9-8.4	Low.
A-4 or A-6	100	100	90-95	80-95	0.6-2.0	0.16-0.18	7.9-8.4	Low.
A-6	100	100	95-100	90-100	0.6-2.0	0.16-0.18	7.9-8.4	Low.
A-4	100	100	75-85	40-50	0.6-2.0	0.12-0.14	7.4-7.8	Low.
A-2 or A-4	100	100	65-75	30-45	0.6-2.0	0.10-0.12	7.8-8.4	Low.
A-2 or A-4	100	100	60-70	25-40	0.6-2.0	0.06-0.10	7.8-8.4	Low.
A-4 or A-6	100	100	90-100	85-100	0.2-0.6	0.16-0.18	6.1-6.5	Moderate.
A-7	100	100	95-100	90-100	0.2-0.6	0.18-0.20	6.6-7.3	High.
A-4 or A-6	100	100	95-100	85-100	0.2-0.6	0.18-0.20	7.4-7.8	Moderate.
A-4 or A-6	100	100	90-100	85-100	0.06-0.2	0.17-0.19	6.1-6.5	Moderate.
A-7	100	100	95-100	90-100	0.06-0.2	0.18-0.20	6.6-7.3	High.
A-6 or A-7	100	100	90-100	85-100	0.06-0.2	0.18-0.20	7.4-7.8	Moderate.
A-4	100	100	90-95	80-90	0.6-2.0	0.17-0.19	6.1-6.5	Low.
A-4	100	100	90-95	70-80	0.6-2.0	0.16-0.18	6.6-7.3	Low.
A-4, A-6 or A-7	100	100	95-100	85-100	0.6-2.0	0.17-0.19	6.1-6.5	Moderate.
A-6 or A-7	100	100	95-100	90-100	0.6-2.0	0.18-0.20	6.1-6.5	Moderate.
A-6 or A-7	100	100	95-100	85-100	0.6-2.0	0.17-0.19	6.6-7.3	Moderate.
A-4 or A-6	100	100	90-100	85-100	0.2-0.6	0.17-0.19	6.1-6.5	Moderate.
A-7	100	100	95-100	90-100	0.2-0.6	0.18-0.20	6.1-6.5	Moderate.
A-6	100	100	90-100	85-100	0.2-0.6	0.17-0.19	6.6-7.3	Moderate.
A-4	70-85	70-85	50-70	40-60	0.6-2.0	0.11-0.13	6.1-6.5	Low.
A-4 or A-6	100	100	90-100	85-95	0.6-2.0	0.17-0.19	6.1-6.5	Low.
A-6 or A-7	100	100	95-100	85-95	0.6-2.0	0.18-0.20	6.1-6.5	Low.
A-6 or A-7	100	100	95-100	85-95	0.6-2.0	0.18-0.20	6.6-7.3	Moderate.
A-4 or A-6	100	100	90-100	80-90	0.6-2.0	0.17-0.19	6.6-7.3	Low.
A-7	100	100	95-100	90-95	0.6-2.0	0.18-0.20	7.4-7.8	Moderate.
A-7	100	100	90-100	80-85	0.6-2.0	0.17-0.19	7.8-8.8	Low.
A-4 or A-6	100	100	85-90	65-75	0.6-2.0	0.16-0.18	7.4-7.8	Low.
A-6	100	100	90-100	85-90	0.6-2.0	0.17-0.19	7.4-7.8	Low.
A-6 or A-7	100	100	90-100	70-75	0.6-2.0	0.18-0.20	7.8-8.4	Moderate.
A-3	100	100	70-75	20-25	0.6-2.0	0.10-0.12	7.8-8.4	Low.
A-2 or A-4	70-80	60-75	50-65	35-55	0.6-2.0	0.14-0.16	7.9-8.4	Low.
A-2 or A-4	70-85	65-80	60-70	40-60	0.6-2.0	0.14-0.16	7.9-8.4	Low.
A-4	100	100	60-75	50-70	0.6-2.0	0.11-0.13	6.1-6.5	Low.
A-6 or A-7	100	100	90-95	70-80	0.6-2.0	0.16-0.18	6.1-6.5	Low.
A-4	100	100	60-70	50-65	0.6-2.0	0.10-0.12	6.1-6.5	Low.

TABLE 6.—*Estimates of soil*

Soil series and map symbols	Depth to— Bedrock	Seasonal high water table	Depth from surface of typical profile	Classification: USDA texture	Unified
	In	*Ft*	*In*		
Longford: Lm, Ln, Lo	>60	>6	0–16	Silt loam and silty clay loam	ML–CL or ML
			16–46	Heavy silty clay loam	CL
			46–60	Light clay loam	CL
McCook: Mc	>60	>10	0–15	Light silt loam	ML–CL or ML
			15–40	Loam	ML–CL or ML
			40–60	Stratified loam, very fine sand, and fine sandy loam.	ML
Muir: Mr	>60	>10	0–18	Silt loam	ML or CL
			18–42	Silty clay loam	CL
			42–60	Silt loam	ML or CL
New Cambria: Nc	>60	>10	0–12	Silty clay loam	CL
			12–40	Silty clay	CH
			40–60	Heavy silty clay loam	CH
Nuckolls: Nu, Nx	>60	>10	0–18	Silt loam	ML or ML–CL
			18–46	Light silty clay loam	CL
			46–60	Silt loam	ML or ML–CL
Roxbury: Rx	>60	>10	0–20	Silt loam	ML–CL or CL
			20–42	Silty clay loam	CL
			42–60	Silt loam	ML–CL or CL
Sarpy: Sa, Sd Depth to sand is 40 inches to more than 60 inches.	>60	4–12	0–48	Loamy sand	SM
			48–60	Sand	SP–SM
Sutphen: St	>60	4–8	0–32	Silty clay	CH
			32–60	Heavy silty clay loam	CH
Tobin: To	>60	>6	0–24	Silt loam	ML or CL
			24–60	Silty clay loam	CL
Wakeen: Wa	30–40	>6	0–8	Light silty clay loam	CL
			8–22	Silty clay loam	CL
			22–28	Channery silty clay loam	CL
			28	Limestone and shale.	

properties significant in engineering—Continued

Classification—Con.	Percentage less than 3 inches passing sieve—				Permea-bility	Available water capacity	Reaction	Shrink-swell potential
AASHO	No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)				
					In per hr	*In per in of soil*	*pH*	
A–6 or A–7	100	100	90–100	80–90	0.2–0.6	0.17–0.19	5.6–6.0	Moderate.
A–6 or A–7	100	100	95–100	80–95	0.2–0.6	0.18–0.20	6.1–6.5	Moderate.
A–6	100	100	90–100	60–80	0.2–0.6	0.17–0.19	6.6–7.3	Moderate.
A–4	100	100	95–100	90–95	0.6–2.0	0.12–0.16	7.4–7.8	Low.
A–4	100	100	90–100	65–95	0.6–2.0	0.12–0.14	7.9–8.4	Low.
A–4	100	100	80–90	55–95	0.6–2.0	0.12–0.14	7.9–8.4	Low.
A–4 or A–6	100	100	90–100	70–95	0.6–2.0	0.17–0.19	6.1–6.5	Low.
A–6	100	100	90–100	80–100	0.6–2.0	0.18–0.20	6.1–6.5	Moderate.
A–4 or A–6	100	100	90–100	70–95	0.6–2.0	0.17–0.19	7.4–7.8	Low.
A–7	100	100	90–100	85–100	0.06–0.2	0.18–0.20	7.4–7.8	Moderate.
A–7	100	100	95–100	90–100	0.06–0.2	0.18–0.20	7.9–8.4	High.
A–7	100	100	95–100	85–100	0.06–0.2	0.18–0.20	7.9–8.4	High.
A–4	100	100	90–100	70–100	0.6–2.0	0.17–0.19	6.1–6.5	Low.
A–6	100	100	95–100	85–100	0.6–2.0	0.18–0.19	6.6–7.3	Low.
A–4	100	100	90–100	70–100	0.6–2.0	0.17–0.19	7.4–7.8	Low.
A–6	100	100	90–100	85–95	0.6–2.0	0.17–0.19	7.4–7.8	Low.
A–6 or A–7	100	100	95–100	85–95	0.6–2.0	0.18–0.20	7.9–8.4	Low to moderate.
A–6	100	100	90–100	85–95	0.6–2.0	0.17–0.19	7.9–8.4	Low.
A–2–4	100	100	50–75	15–30	2.0–6.3	0.07–0.09	6.1–6.5	Low.
A–2 or A–3	100	100	50–70	5–15	2.0–6.3	0.05–0.07	6.6–7.3	Low.
A–7	100	100	95–100	90–95	<0.06	0.18–0.20	7.4–7.8	High.
A–7	100	100	95–100	85–95	<0.06	0.18–0.20	7.9–8.4	High.
A–4 or A–6	100	100	90–100	75–95	0.6–2.0	0.18–0.19	6.6–7.3	Low.
A–6	100	100	95–100	85–95	0.6–2.0	0.18–0.19	7.9–8.4	Moderate.
A–6	90–95	90–95	85–90	70–80	0.6–2.0	0.18–0.19	7.4–7.8	Low.
A–7	95–100	95–100	85–95	75–85	0.6–2.0	0.18–0.20	7.9–8.4	Moderate.
A–6	70–80	65–75	55–65	45–60	0.6–2.0	0.17–0.19	7.9–8.4	Low.

TABLE 7.—*Interpretations of engineering*

[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

Soil series and map symbols	Degree and kind of limitation for—						Suitability as source of—	
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings	Sanitary land fill[1] Trench type	Sanitary land fill[1] Area type	Sanitary land fill cover material	Topsoil
Alluvial land: Aa, Ah. No interpretations made, because material is variable.								
Armo: Ar	Moderate: moderate permeability.	Moderate to severe: moderate permeability; slope; gravelly substratum.[3]	Slight	Moderate: gravelly substratum.[3]	Slight to moderate: silty clay loam and silt loam texture; gravelly substra-. tum.	Slight	Good to fair: silty clay loam and silt loam texture.	Good[4]
Breaks-Alluvial land complex: Ba. No interpretations made, because material is variable.								
Bridgeport: Br	Severe: flooding.[5]	Severe: flooding.[5]	Severe: flooding.	Severe: flooding.	Severe: flooding.[5]	Severe: flooding.[5]	Good	Good[4]
Carr: Ca	Severe: flooding.[5]	Severe: flooding.[5]	Severe: flooding.	Severe: flooding.	Severe: flooding.[5]	Severe: flooding.[5]	Good	Good[4]
Cb	Slight: moderate permeability.[5]	Severe: pervious substratum.	Slight	Slight	Slight[5]	Slight[5]	Good	Good[4]
Cf. No interpretations made, because material is variable.								

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 care-
that appear in the first column of this table]

Suitability as source of—Continued			Soil features affecting—					
Sand and gravel	Road subgrade [2]	Road fill [2]	Highway location [2]	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation	Drainage of cropland and pasture
Poor: pockets of gravel in places.	Poor: low soil support.	Fair: medium to low shear strength.	Moderate erodibility; slope of 2 to 7 percent.	Moderate permeability: gravelly substratum; slope of 2 to 7 percent.	Good to fair stability and compaction.	Moderately erodible; slope of 2 to 7 percent.	Moderate permeability; high available water capacity; slope of 2 to 7 percent.	Well drained.
Unsuited	Fair: medium soil support.	Good	Flooding	Moderate permeability.	Fair to good stability.	Nearly level; fair stability; flooding.	Moderate permeability; high available water capacity; flooding.	Well drained; flooding.
Fair: sand below a depth of 40 inches and gravel below a depth of 6 feet; suitable as road surfacing material.	Good	Good to a depth of 2 feet. Good below a depth of 2 feet if confined.	Moderate erodibility; flooding.	Moderate permeability; seepage in substratum.	Erodible slopes; subject to piping.	Nearly level; hazard of soil blowing; flooding; erodible slopes.	Moderate permeability; moderate available water capacity; depth to sand; flooding; hazard of soil blowing.	Well drained; flooding.
Fair: sand and fines below a depth of 40 inches. Poor for gravel.	Good	Good	Moderate erodibility.	Moderate permeability; pervious substratum.	Erodible slopes; subject to piping.	Nearly level; hazard of soil blowing; erodible slopes.	Moderate permeability; moderate available water capacity; hazard of soil blowing.	Well drained.

TABLE 7.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—						Suitability as source of—	
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings	Sanitary land fill [1] Trench type	Sanitary land fill [1] Area type	Sanitary land fill cover material	Topsoil
Crete: Cr, Cs, Ct, Cu.	Severe to a depth of 36 inches. Moderate below a depth of 36 inches: moderately slow permeability.	Slight where slope is less than 2 percent. Moderate where slope is more than 2 percent.	Moderate: moderately well drained.	Severe: high shrink-swell potential.	Moderate to severe: silty clay subsoil.	Slight	Fair in surface layer: limited thicknes of material. Poor in subsoil: silty clay.	Fair: thickness of surface layer; silty clay subsoil.
Detroit: De	Severe: slow permeability; flooding.[5]	Moderate to severe: flooding.[5]	Moderate to severe: flooding.	Severe: flooding; high shrink-swell potential.	Severe: flooding.[5]	Severe: flooding.[5]	Fair: silty clay loam texture.	Fair: thickness of surface layer; silty clay loam subsoil.
Eudora, thick surface variant: Eu.	Moderate: flooding in places; pervious substratum.[5]	Moderate to severe: flooding in places; moderate permeability.[5]	Slight to moderate: flooding in places.	Moderate: flooding in places.	Moderate: flooding in places.[5]	Moderate: flooding in places.[5]	Good	Good
Geary: Ge, Gs	Moderate: moderate permeability.	Moderate: moderate permeability; slopes of 3 to 7 percent; pervious substratum.	Slight	Slight	Slight to moderate: silty clay loam texture.	Slight	Good to fair: silty clay loam texture.	Fair:[4] thickness of surface layer.
Hastings: Hb, Hc, Hd.	Severe: moderately slow permeability.	Slight where slope is less than 2 percent. Moderate where slope is 2 to 7 percent.	Slight	Moderate to severe: moderate shrink-swell potential.	Moderate: silty clay loam texture.	Slight	Fair: silty clay loam texture.	Fair:[4] thickness of surface layer; silty clay loam subsoil.
Hedville: He	Severe: less than 20 inches deep to bedrock; slope of 5 to 30 percent.	Severe: less than 20 inches deep to bedrock; slope of 5 to 30 percent.	Severe: less than 20 inches deep to bedrock; slope of 5 to 30 percent.	Severe: less than 20 inches deep to bedrock; slope of 5 to 30 percent.	Severe: less than 20 inches deep to bedrock.	Moderate to severe: slope of 5 to 30 percent.	Poor: less than 20 inches deep to bedrock.	Poor: thickness of material; slope of 5 to 30 percent.
Hobbs: Ho	Severe: flooding.[5]	Severe: flooding.[5]	Severe: flooding.	Severe: flooding.	Severe: flooding.[5]	Severe: flooding.[5]	Good	Good

properties of the soils—Continued

Suitability as source of—Continued			Soil features affecting—					
Sand and gravel	Road subgrade [2]	Road fill [2]	Highway location [2]	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation	Drainage of cropland and pasture
Unsuited	Poor to a depth of 36 inches; high plasticity. Fair at a depth of 36 to 60 inches; medium plasticity.	Fair: medium to low shear strength.	Moderately slow permeability.	Moderately slow permeability; slope of 0 to 7 percent.	Moderately slow permeability; high shrink-swell potential.	Erodible; high shrink-swell potential; slope of 0 to 6 percent; clayey subsoil.	Moderately slow permeability; high available water capacity; moderately well drained; slope of 0 to 6 percent.	Moderately well drained.
Unsuited	Poor: high plasticity.	Fair: medium to low shear strength.	Slow permeability; flooding.	Slow permeability; high shrink-swell potential.	Medium to low shear strength; high shrink-swell potential.	Nearly level: high shrink-swell potential; flooding.	Slow permeability; high available water capacity; moderately well drained.	Moderately well drained; nearly level; flooding.
Unsuited	Good	Good	Moderate erodibility.	Moderate permeability; moderate seepage.	Medium to low shear strength; subject to piping.	Nearly level; hazard of soil blowing.	Moderate permeability; high available water capacity; hazard of soil blowing.	Well drained.
Unsuited	Fair: medium soil support.	Good	Slope of 3 to 7 percent.	Moderate permeability.	Medium to low shear strength; fair stability and compaction.	Erodible slopes; moderate shrink-swell potential; fair stability and compaction.	Moderate permeability; high available water capacity; slope of 3 to 7 percent.	Well drained.
Unsuited	Poor to a depth of 36 inches; high plasticity. Fair at a depth of 36 to 60 inches; moderate plasticity.	Fair: medium to low shear strength.	Slope of 1 to 7 percent.	Moderately slow permeability.	Medium to low shear strength; fair stability and compaction.	Erodible slopes; moderate shrink-swell potential.	Moderately slow permeability; high available water capacity; slope of 1 to 7 percent.	Well drained.
Unsuited	Poor: stony.	Good	Less than 20 inches deep to bedrock; slope of 5 to 30 percent.	Less than 20 inches deep to bedrock; slope of 5 to 30 percent.	Less than 20 inches deep to bedrock; slope of 5 to 30 percent.	Less than 20 inches deep to bedrock; slope of 5 to 30 percent.	Less than 20 inches deep to bedrock; slope of 5 to 30 percent.	Somewhat excessively drained.
Unsuited	Fair: medium soil support.	Good	Flooding	Moderate permeability.	High compressibility; fair stability and compaction.	Nearly level; flooding; fair stability.	Moderate permeability; flooding; high available water capacity.	Moderately well drained; flooding.

TABLE 7.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—						Suitability as source of—	
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings	Sanitary land fill [1]		Sanitary land fill cover material	Topsoil
					Trench type	Area type		
Hord: Hr	Moderate: moderate permeability.[5]	Moderate: moderate permeability.[5]	Slight	Moderate: moderate shrink-swell potential.	Slight [5]	Slight [5]	Good to fair: silty clay loam texture in places.	Good [4]
Humbarger: Hu	Severe: flooding.[5]	Severe: flooding.[5]	Severe: flooding.	Severe: flooding.	Severe: flooding.[5]	Severe: flooding.[5]	Good	Good [4]
Kipson: Kp	Severe: less than 20 inches deep to bedrock; slope of 5 to 30 percent.	Severe: less than 20 inches deep to bedrock; slope of 5 to 30 percent.	Moderate to severe: less than 20 inches deep to rippable bedrock; slope of 5 to 30 percent.	Moderate to severe: less than 20 inches deep to rippable bedrock; slope of 5 to 30 percent.	Severe: less than 20 inches deep to bedrock.	Moderate to severe: slope of 5 to 30 percent.	Fair to poor: slope; stony.	Fair to poor: slope; stony.
*Lancaster: Lh. For Hedville part, see Hedville series.	Severe: less than 40 inches deep to bedrock; slope of 5 to 30 percent.	Severe: less than 40 inches deep to bedrock; slope of 5 to 30 percent.	Severe: less than 40 inches deep to bedrock; slope of 5 to 30 percent.	Moderate to severe: less than 40 inches deep to bedrock; slope of 5 to 30 percent.	Severe: less than 40 inches deep to bedrock.	Slight to severe: slope of 5 to 30 percent.	Fair: thickness of material.	Fair: slope.
Longford: Lm, Ln, Lo.	Severe to a depth of 36 inches: moderately slow permeability. Moderate below a depth of 36 inches.	Slight where slope is less than 2 percent. Moderate where slope is 2 to 7 percent.[3]	Slight	Moderate to severe: moderate shrink-swell potential.	Moderate: silty clay loam texture.[3]	Slight [3]	Fair: silty clay loam texture.	Fair: [4] thickness of surface layer; silty clay loam subsoil.
McCook: Mc	Slight: moderate permeability.[5]	Moderate: moderate permeability.[5]	Slight	Slight	Slight [5]	Slight [5]	Good	Good [4]

properties of the soils—Continued

Suitability as source of—Continued			Soil features affecting—					
Sand and gravel	Road subgrade [2]	Road fill [2]	Highway location [2]	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation	Drainage of cropland and pasture
Unsuited	Fair: medium soil support.	Good	No detrimental features.	Moderate permeability.	Low to medium shear strength; fair stability and compaction.	Nearly level; fair stability.	Moderate permeability; high available water capacity; hazard of soil blowing.	Well drained.
Fair: sand below a depth of 40 inches and gravel below a depth of 6 feet; suitable as road surfacing material.	Fair to a depth of 48 inches; medium soil support. Good at a depth of 48 to 60 inches.	Good	Flooding	Moderate permeability; pervious substratum.	Low to medium shear strength; fair stability and compaction.	Nearly level; flooding; fair stability; depth to sand.	Moderate permeability; depth to sand; flooding; high available water capacity.	Moderately well drained; flooding.
Unsuited	Fair: medium soil support.	Fair: medium to low shear strength.	Less than 20 inches deep to rippable bedrock; slope of 5 to 30 percent.	Less than 20 inches deep to rippable bedrock; slope of 5 to 30 percent.	Less than 20 inches deep to rippable bedrock; slope of 5 to 30 percent.	Less than 20 inches deep to rippable bedrock; slope of 5 to 30 percent.	Less than 20 inches deep to rippable bedrock; slope of 5 to 30 percent.	Somewhat excessively drained.
Unsuited	Fair: medium soil support.	Good	Less than 40 inches deep to bedrock.	Less than 40 inches deep to bedrock; slope of 5 to 30 percent; possible seepage.	Less than 40 inches deep to bedrock; low to medium shear strength; fair stability and compaction; slope of 5 to 30 percent.	Less than 40 inches deep to bedrock; erodible; slope of 5 to 30 percent.	Less than 40 inches deep to bedrock; moderate available water capacity; slope of 5 to 30 percent.	Well drained.
Unsuited	Poor to a depth of 40 inches; high plasticity. Fair below a depth of 40 to 60 inches; moderate plasticity.	Fair: medium to low shear strength.	Slope of 1 to 7 percent; moderately slow permeability.	Moderately slow permeability; slope of 1 to 7 percent.	Medium to low shear strength; moderate shrink-swell potential.	Erodible; moderate shrink-swell potential; slope of 1 to 7 percent; clayey subsoil.	Moderately slow permeability; high available water capacity; slope of 1 to 7 percent.	Well drained.
Unsuited	Good	Good	Moderate erodibility.	Moderate permeability.	Subject to piping; erodible slopes.	Nearly level; hazard of soil blowing; erodible slopes.	Moderate permeability; high available water capacity; hazard of soil blowing.	Well drained.

TABLE 7.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—						Suitability as source of—	
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings	Sanitary land fill [1] Trench type	Sanitary land fill [1] Area type	Sanitary land fill cover material	Topsoil
Muir: Mr	Slight [5]	Moderate: moderate permeability.[5]	Slight	Slight	Slight to moderate: silty clay loam texture.	Slight [5]	Good to fair: silty clay loam texture.	Good [4]
New Cambria: Nc	Severe: slow permeability; occasional flooding.[5]	Moderate: occasional flooding.[5]	Moderate to severe: occasional flooding; silty clay loam and silty clay texture.	Severe: high shrink-swell potential; occasional flooding.	Severe: silty clay loam and silty clay texture; occasional flooding.	Severe: occasional flooding.	Fair: silty clay loam and silty clay texture.	Fair: silty clay loam and silty clay texture.
Nuckolls: Nu, Nx	Slight to moderate: moderate permeability; slope of 4 to 12 percent.	Moderate to severe: moderate permeability; slope of 4 to 12 percent.	Slight to moderate: slope of 4 to 12 percent.	Slight to moderate: low shrink-swell potential; slope of 4 to 12 percent.	Slight to moderate: silty clay loam texture.	Slight where slope is less than 8 percent. Moderate where slope is more than 8 percent.	Good to fair: slope; silty clay loam texture.	Good to fair: slope; silty clay loam texture.
Roxbury: Rx	Moderate: flooding in places; pervious substratum.[5]	Moderate to severe: flooding in places; moderate permeability.[5]	Slight to moderate; flooding in places.	Moderate: flooding in places.	Moderate: flooding in places.[5]	Moderate: flooding in places.[5]	Good	Good
Sarpy: Sa, Sd	Severe: flooding.[5]	Severe: moderately rapid permeability; flooding.[5]	Severe: flooding; loamy sand texture.	Severe: flooding.	Severe: moderately rapid permeability; flooding.[5]	Severe: moderately rapid permeability; flooding.[5]	Fair: loamy sand texture.	Poor: loamy sand texture.
Sutphen: St	Severe: very slow permeability; flooding in places.[5]	Slight to moderate: flooding in places.[5]	Severe: high shrink-swell potential; flooding in places.[5]	Severe: high shrink-swell potential; flooding in places.[5]	Severe: silty clay texture; flooding in places.[5]	Moderate: flooding in places.[5]	Poor: silty clay texture.	Poor: silty clay texture.
Tobin: To	Severe: flooding.[5]	Severe: flooding.[5]	Severe: flooding.	Severe: flooding.	Severe: flooding.[5]	Severe: flooding.[5]	Good	Good [4]

properties of the soils—Continued

Suitability as source of—Continued			Soil features affecting—					
Sand and gravel	Road subgrade [2]	Road fill [2]	Highway location [2]	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation	Drainage of cropland and pasture
Unsuited	Fair: medium soil support.	Good	No detrimental features.	Moderate permeability.	Low to medium shear strength; fair stability and compaction; susceptible to piping.	Nearly level; fair stability.	Moderate permeability; high available water capacity; hazard of soil blowing.	Well drained.
Unsuited	Poor: high plasticity.	Poor: low shear strength.	Slow permeability; occasional flooding.	Slow permeability; high shrink-swell potential.	High shrink-swell potential; low shear strength.	Nearly level; occasional flooding; high shrink-swell potential.	Slow permeability; high available water capacity; moderately well drained; hazard of soil blowing.	Moderately well drained; nearly level; flooding.
Unsuited	Fair: medium soil support.	Fair: medium to low shear strength.	Slope of 4 to 12 percent.	Moderate permeability; subject to piping; slope of 4 to 12 percent; seepage.	Fair stability; erodible slopes; subject to piping.	Fair stability; erodible; slope of 4 to 12 percent.	Moderate permeability; high available water capacity; slope of 4 to 12 percent.	Well drained to somewhat excessively drained.
Unsuited	Poor: low soil support.	Fair: medium to low shear strength.	Flooding in places.	Moderate permeability.	Fair stability and compaction; medium to low shear strength.	Nearly level; fair stability.	Moderate permeability; high available water capacity; hazard of soil blowing.	Well drained.
Fair: sand below a depth of 30 inches; gravel below a depth of 6 feet; suitable as road surfacing material.	Good	Good if confined.	Erodibility; flooding.	Moderately rapid permeability; high seepage rate.	Subject to piping; porous; erodible slopes.	Nearly level; flooding; hazard of soil blowing; erodible slopes.	Moderately rapid permeability; low available water capacity; somewhat excessively drained; hazard of soil blowing.	Somewhat excessively drained.
Unsuited	Poor: high plasticity.	Fair: medium to low shear strength.	Very slow permeability; flooding in places.	Very slow permeability; high shrink-swell potential.	High shrink-swell potential; low shear strength.	Nearly level; flooding in places; high shrink-swell potential.	Very slow permeability; high available water capacity; flooding in places; somewhat poorly drained.	Flooding in places; somewhat poorly drained; nearly level.
Unsuited	Fair: medium soil support.	Fair: medium to low shear strength.	Flooding	Moderate permeability.	Fair stability and compaction.	Nearly level; flooding; fair stability.	Moderate permeability; flooding; high available water capacity.	Well drained.

TABLE 7.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—						Suitability as source of—	
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings	Sanitary land fill [1]		Sanitary land fill cover material	Topsoil
					Trench type	Area type		
Wakeen: Wa	Severe: less than 40 inches deep to rippable bedrock; slope of 3 to 6 percent.	Severe: less than 40 inches deep to bedrock; slope of 3 to 6 percent.	Moderate: less than 40 inches deep to rippable bedrock.	Slight to moderate: less than 40 inches deep to rippable bedrock.	Moderate: less than 40 inches deep to rippable bedrock.	Slight	Fair: thickness of material; silty clay loam texture.	Fair: [4] thickness of suitable material.

[1] Onsite studies of the underlying strata, water table, and hazards of aquifer pollution and drainage into ground water should be made for land fill deeper than 5 or 6 feet.

[2] Norman Clark, engineer of soils, and Herbert Worley, soils research engineer, Kansas State Highway Commission, in cooperation with the Bureau of Public Roads assisted in rating the soils for road subgrade, road fill, and highway location.

properties of the soils—Continued

Suitability as source of—Continued			Soil features affecting—					
Sand and gravel	Road subgrade [2]	Road fill [2]	Highway location [2]	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation	Drainage of cropland and pasture
Unsuited	Poor: low soil support.	Fair: medium to low shear strength.	Less than 40 inches deep to rippable bedrock.	Less than 40 inches deep to bedrock; slope of 3 to 6 percent; seepage in places.	Less than 40 inches deep to bedrock; medium to low shear strength; fair stability and compaction; slope of 3 to 6 percent.	Less than 40 inches deep to bedrock; erodible; slope of 3 to 6 percent.	Moderate permeability; slope of 3 to 6 percent; moderate available water capacity; less than 40 inches deep to bedrock.	Well drained.

[3] In places bedrock is at a depth of less than 6 feet.
[4] Rating refers to surface layer and upper part of subsoil.
[5] Pollution is a hazard because of flooding or because of pervious substratum.

TABLE 8.—*Engineering*

[Tests were performed by the

Soil name and location	Parent material	SCS report No. S71 Kans–	Depth	Moisture density[1]	
				Maximum dry density	Optimum moisture content
			In	*Lb per cu ft*	*Pct*
Crete silt loam:					
1,300 feet E. and 75 feet N. of SW. corner of sec. 33, T. 6 S., R. 5 W.	Loess.	15–1–1	0–10	99	19
		15–1–2	24–34	94	25
		15–1–3	40–60	99	20
Detroit silty clay loam:					
1,000 feet W. and 200 feet N. of E. quarter corner of sec. 30, T. 5 S., R. 4 W.	Silty and clayey alluvium.	15–2–1	0–12	101	17
		15–2–2	24–36	96	22
		15–2–3	40–60	105	19
Geary silt loam:					
2,500 feet S. and 800 feet E. of NW. corner of sec. 27, T. 6 S., R. 2 W.	Old silty loess and sediment.	15–4–1	0–12	95	21
		15–4–2	24–42	99	21
		15–4–3	50–60	105	18
Hastings silt loam:					
1,480 feet S. and 400 feet W. of NE. corner of sec. 1, T. 6 S., R. 2 W.	Loess.	15–5–1	0–12	102	18
		15–5–2	26–38	99	20
		15–5–3	44–60	104	18
Longford silt loam:					
2,100 feet W. and 300 feet S. of NE. corner of sec. 31, T. 8 S., R. 1 W.	Old silty loess and sediment.	15–3–1	0–10	98	19
		15–3–2	22–40	102	20
		15–3–3	46–60	115	15
Nuckolls silt loam:					
1,600 feet W. and 100 feet S. of NE. corner of sec. 6, T. 6 S., R. 3 W.	Loess.	15–6–1	0–12	94	22
		15–6–2	18–38	99	20
		15–6–3	38–60	105	17

[1] Based on AASHO Designation T 99–61, Method A (*1*), with the following variations: (1) all material is ovendried at 230° F; (2) all material is crushed in a laboratory crusher after drying; and (3) no time is allowed for dispersion of moisture after mixing with the soil material.

[2] Mechanical analyses according to the AASHO Designation T 88–57 (*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 in 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

test data

Kansas State Highway Department]

Mechanical analysis [2]							Liquid limit	Plasticity index	Classification	
Percentage less than 3 inches passing sieve—			Percentage smaller than—						AASHO [3]	Unified [4]
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				
							Pct			
100	100	97	89	48	26	20	31	8	A-4(8)	ML-CL
100	100	98	94	76	54	48	65	39	A-7-6(20)	CH
100	100	99	95	67	35	26	40	16	A-6(10)	ML-CL
100	100	97	87	49	22	16	31	8	A-4(8)	ML-CL
100	100	98	93	70	43	37	51	28	A-7-6(15)	CH
100	100	97	90	55	27	23	39	20	A-6(12)	CL
100	100	95	83	46	23	18	41	12	A-7-6(9)	ML
100	100	96	87	60	39	34	48	27	A-7-6(16)	CL
100	100	93	83	51	31	28	38	18	A-6(11)	CL
100	100	96	86	49	25	21	32	10	A-4(8)	ML-CL
100	100	98	90	57	36	32	46	24	A-7-6(15)	CL
100	100	98	88	54	24	19	34	11	A-6(8)	ML-CL
100	99	83	70	45	22	18	42	15	A-7-6(10)	ML-CL
100	98	83	75	54	34	30	38	18	A-6(11)	CL
99	92	61	53	37	24	21	31	14	A-6(7)	CL
100	100	98	86	41	17	13	36	9	A-4(8)	ML
100	100	93	82	49	26	24	37	12	A-6(9)	ML-CL
100	100	98	90	44	13	11	29	6	A-4(8)	ML-CL

obtained by the soil survey procedure of the Soil Conservation Service. 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 calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

[3] Based on AASHO Designation M 145-49 (*1*).

[4] Based on the Unified Soil Classification System (*10*).

4. Selecting potential industrial, commercial, residential, and recreational sites.

The engineering interpretations reported here do not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and excavations deeper than the layers here reported. Even in these situations, however, the soil map is useful in planning more detailed field investigations and for indicating the kinds of problems that may be expected.

Some terms used by soil scientists may be unfamiliar to engineers, and some words have different meanings in soil science than in engineering. Among the terms that have special meaning in soil science are gravel, sand, silt, clay, loam, subsoil, bedrock, and horizon. These and other terms are defined in the Glossary at the back of this survey.

Engineering classification systems

The two systems most commonly used in classifying soil material for engineering (*5*) 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, the best soils for subgrade. 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. 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 example, 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 for the poorest. The AASHO classification for tested soils, with index numbers in parentheses, is shown in table 8; the estimated classification for all soils mapped in the survey area is given in table 6.

In the Unified system, soils are classified according to particle-size distribution, plasticity, liquid limit, and organic-matter content (*10*). Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. If there is doubt as to the single classification of a soil horizon, a range of classification is used, such as ML or CL.

Estimated properties of the soils

Table 6 provides estimates of soil properties significant in engineering. The estimates are based on field classification and descriptions, 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 between locations in the county. In addition, some mapping units contain small inclusions of contrasting soils.

The soil profile described as representative for each soil series in the section "Descriptions of the Soils" is the source of the soil layers on which the estimates of properties were made. In some soils, some layers were grouped together because of similarities in properties and only slight differences in texture. Each layer is classified according to textural terms of the United States Department of Agriculture and according to the Unified and AASHO systems. The percentage of material that passes sieves of various sizes is also estimated for each layer.

USDA texture is determined by the relative proportions of sand, silt, and clay in soil material that is less than 2.0 millimeters in diameter. "Sand," "silt," "clay," and some of the other terms used in the USDA textural classification are defined in the Glossary.

Permeability 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 soils are not considered.

Available water capacity is that amount of capillary water in the soil available for plant growth after all free water has drained away.

Reaction is the degree of acidity or 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 the maintenance of structures built in, on, or with such material.

Engineering interpretations

Table 7 contains selected information useful to engineers and others who plan to use soil material in constructing highways, farm facilities, buildings, and sewage disposal systems. Detrimental or undesirable features are emphasized, but very important desirable features also may be listed. The ratings and other interpretations in this table are based on estimated engineering properties of the soils in table 6; on available test data, including those in table 8; and on field experience.

Septic tank absorption fields are affected mainly by permeability, location of water table, and susceptibility to flooding of the undisturbed soil. The degree of limitations and principal reasons for assigning moderate or severe limitations are given.

Sewage lagoons are influenced chiefly by soil features such as permeability, location of water table, and slope.

The degree of limitation and principal reasons for assigning moderate or severe limitations are given.

Shallow excavations require excavating or trenching to a depth of 6 feet or less. Desirable soil characteristics are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops and big stones, and no flooding.

Dwellings 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.

Trench-type sanitary landfill and area-type sanitary landfill are two methods of handling refuse. The trench-type operation consists of a dug trench in which refuse is buried. In the area-type operation the refuse is placed in successive layers on the surface of the soil and covered with a final layer of soil material. Ratings are based on soil qualities and characteristics affecting those types of use.

Sanitary landfill cover material is rated on soil properties which reflect workability: the ease of digging, moving, and spreading the soil material over the refuse daily.

Topsoil is fertile soil or soil material, ordinarily rich in organic matter, used as topdressing for lawns, gardens, roadbanks, and the like. The ratings indicate suitability for such use. Unless otherwise noted, only the surface layer is rated. Suitability of a soil used as topsoil is important, because topsoil is needed for growing vegetation that controls erosion on embankments, road shoulders, ditches, and cut slopes. The ratings for topsoil are based on thickness of the soil material, texture, fertility, and tilth. A soil may be rated fair or poor if revegetation and erosion control are major problems in areas from which the topsoil is taken.

Sand and gravel ratings are based on the probability that delineated areas of the soil contain deposits of sand and gravel. The ratings do not indicate quality or size of the deposits. In Cloud County, only the soils in the Republican River and the Solomon River Valleys are sources of sand or gravel. Only the Carr and Sarpy soils are a potential source of sand above a depth of 5 feet. This sand commonly contains silty material; but it can be used for road fill if confined or in concrete if screened. On the flood plain sand and gravel are below a depth of 5 feet. This sand and gravel is being pumped from several "sand pits" along the Republican River. In the Solomon River Valley, sand and gravel beds are at a depth of 10 to 15 feet in some areas of Geary soils.

Road subgrade is the uppermost material used in a roadway. It supports the subbase, base course, and surface course. Ratings are based on the performance of the soil material when excavated and used for this purpose.

Road fill is material used to build the embankment that supports the subgrade of a roadway. Ratings are based on the performance of the soil material when excavated and used for this purpose.

Highway location considers those features of the undisturbed soil that affect location, construction, and maintenance of highways. The soil features, favorable as well as unfavorable, are the principal ones that affect geographic location of highways. It is assumed that the surface layer, because of its organic-matter content, will be removed in construction.

Pond reservoir areas are affected by characteristics and qualities of undisturbed soils that affect their suitability for water impoundments. Of primary concern are those properties that influence the seepage rate.

Embankments, dikes, and levees are low structures designed to impound or divert water. The soil features considered are those that affect use of the soil as material for earth fill. Both the subsoil and substratum are evaluated where they have significant thickness for use as borrow.

Terraces, diversions, and waterways are rated on soil properties that affect stability or hinder layout and construction and also on hazards of sedimentation in channels and difficulty of establishing and maintaining cover.

Irrigation uses of soils are rated on those factors affecting suitability for irrigation. The major factors are available water capacity, depth, water intake rate, drainage, and flooding.

Drainage of cropland and pasture is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock, or other layers that influence rate of water movement; depth to the water table; slope; stability in ditchbanks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage.

Engineering test data

Table 8 contains engineering test data for six soil series in Cloud County. These tests were made by the Kansas State Highway Department to help evaluate the soils for engineering purposes. The engineering classifications given are based on data obtained by mechanical analysis and by tests to determine liquid limits and plastic limits. The mechanical analyses were made by a combination of sieve and hydrometer methods.

Compaction, or moisture-density, data are important in earthwork. If a soil material is compacted at successively higher moisture contents, assuming that the compactive force remains constant, the density of the compacted material increases until the *optimum moisture content* is reached. After that, density decreases with increase in moisture content. The highest dry density obtained in the compactive test is termed *maximum dry density*. As a rule, the earthwork is strongest if the soil is compacted to the maximum dry density.

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, the material changes from a semisolid state to a plastic state. If the moisture content is further increased, the material changes from a plastic state to a liquid state. The plastic limit is the moisture content at which the soil material changes from semisolid to plastic, and the liquid limit from plastic to liquid. 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.

Formation and Classification of the Soils

This section explains how soils form and discusses the factors that affected the formation of soils in Cloud County. It briefly describes the current system of soil classification and places each soil series in the county in some classes of that system.

Factors of Soil Formation

Soil is formed by the interaction of soil-forming processes on material deposited or altered by geologic forces. 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 under which the soil material accumulated and has 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 are active factors in soil formation. They act on the parent material that has accumulated and slowly change it into a natural body that has genetically related horizons. The effects of climate and plant and animal life are modified 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. It may be much or little, but some time is always required for the development of horizons. Usually, a long time is required for the development of distinct horizons. In Cloud County, the climate and plant and animal life factors tend to develop similarities in the soils, whereas relief, time, and parent material develop differences in the soils.

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 unless conditions are specified for the other four. Many of the processes of soil formation are not well known.

Parent material

Weathering of the material accumulated by geologic forces produces the parent material in which soils develop. In Cloud County the parent materials have accumulated through the weathering of bedrock or the deposition of loose material by water and wind.

Soil material that weathered from the oldest rock formation outcropping in the county has formed four soils. The shallow Hedville soils formed over sandstone. The moderately deep Lancaster soils formed in material weathered from sandstone and sandy shale. The Longford and Geary soils formed in deep material weathered from shale and sandstone and mixed with some loess.

Soil material that weathered from limestone and shale formed the shallow Kipson soils, the moderately deep Wakeen soils, and the deep Armo soils.

Soil material that weathered from the latest loess deposit, which is present in all parts of the county, formed Crete, Hastings, and Nuckolls soils.

Various mixtures of silt, clay, and sand have been deposited in the valleys as the drainage pattern has developed. On the terraces, or second bottoms, Roxbury, Hord, Muir, and other soils formed in these deposits. Bridgeport, Carr, Hobbs, and other soils formed in the recent alluvial deposits on the bottom land.

The present soils in the county are the result of the interrelated soil-forming factors that slowly change the different parent materials into soil. The soil that forms generally inherits some characteristics from its parent material. These characteristics may be shown by the physical, mineralogical, and chemical nature of the soil. For example, the reddish color of Longford soils and the lack of sand in Crete soils are inherited characteristics. The different kinds of parent material are mainly responsible for the development of different groups of soils.

Climate

Climate is one of the active factors in soil formation; it has both direct and indirect influences. The amount and distribution of precipitation directly influence the formation of soil by causing the parent material slowly to weather and change into soil. An indirect influence is through the effect of climate on the plant and animal life on and in the soil. In Cloud County precipitation has been sufficient to maintain enough plant and animal life to develop a dark surface layer in nearly all of the soils.

The continental climate of Cloud County fluctuates from dry to moist subhumid. This fluctuation can be from year to year or in cycles over several years. During dry periods, precipitation and humidity can be well below normal and temperature can be above normal. In wet periods, precipitation and humidity are considerably above normal and the temperature is normal or below.

As the wet period develops, the soil is slowly moistened. The depth of moistening depends upon the amount of precipitation. As lumps or clods of soil are moistened, they crumble or swell and rupture into smaller pieces. The moisture causes chemical changes that result in leaching of some chemical elements and the formation of new or different chemical compounds. Minute particles of clay minerals or organic matter are carried downward or developed in place as minerals dissolve and precipitate. The presence of different kinds of concretions in the lower part of the subsoil and the substratum indicates the chemical activity and penetration of the moisture.

As the dry period develops, the soil shrinks and large pieces are broken into different sized pieces. This helps to improve structure. New or altered chemical compounds in solution or suspension stick together or onto other surfaces as the soil dries. This concentrates elements and compounds in different places and slowly builds up the horizons.

The alternate wetting and drying has been effective in the development of the profile. The degree of development is related to the length of time the soil-forming factors have been operating. Chemical elements have been, and are being, leached downward to be deposited in lower layers or carried away in drainage waters. Chemical compounds also dissolve, and they reform in the B horizon. In some soils leaching has left the surface layer slightly acid and the lower part of the B horizon about neutral. In other soils leaching has been slight and the soils are calcareous throughout or at a shallow depth. Organic matter has accumulated in the upper part of the profile. Gently sloping soils are more developed than soils that are steep, because more moisture generally penetrates the gently sloping soils. These chemical and physical changes are more active during periods of optimum temperature.

Weather records in Cloud County show that winter is short and cold and summer is long and hot. Average annual precipitation is about 26 inches and 75 percent of this falls as rain during the growing season. The average temperature in January is 27° F and that in July is 79°. The tall-grass vegetation has reduced erosion, retarded the removal of chemical elements, and added organic matter to the upper part of the profile.

Plants and animals

In Cloud County, the fluctuating dry to moist, subhumid climate favors the growth of tall grasses. The original plant cover consisted mainly of big bluestem, little bluestem, indiangrass, switchgrass, Canada wildrye, prairie cordgrass, native legumes, and some sandyland grasses. Scattered trees grew along most of the streams. Some valleys had a somewhat open stand of oak, ash, hickory, black walnut, hackberry, cottonwood, elm, and willows.

As the cover of grass and other plants spread, it reduced geologic erosion and stabilized the soils. Under the grass cover, bacteria and fungi began to decay dead vegetation. Burrowing insects, earthworms, and other animals began mixing the organic matter into the soil. They also added organic matter through excrement and their decayed bodies. Some organic matter was carried downward by percolating moisture. Decayed roots near the surface also added organic matter. In this way the present thick, dark surface layer developed. The addition of organic matter strengthened the soil solution and increased its power of weathering.

Insects and other animals dug holes that aerated the soil and allowed deep penetration of moisture. They also brought fresh material to the surface layer.

The fibrous roots of the grasses helped to develop structure in the soil and draw nutrients from the lower horizons, which helps the thick cover of vegetation to grow. As the vegetation decayed, plant nutrients were released and were carried into the soil by permeating moisture. Moderately leached, dark, fertile soils formed as a result of this growth-decay cycle operating in the fluctuating, subhumid climate.

Relief

Although climate and vegetation are the most active factors in changing soil material into soil, the relief, or lay of the land, modifies these changes. Relief influences soil development mainly by controlling the movement of water on the surface and into the soil. Partly because they are steep or very steep, Kipson and other soils that formed in some of the oldest parent material in the county are shallow. Runoff is rapid on steep slopes, and much of the soil material is removed as fast as it forms. On the other hand, the terraces have broad, nearly level to gently sloping areas from which runoff is very slow. In these areas most of the precipitation penetrates the soil, and moderately well developed soils have formed on some of the most recent material.

The effect of relief and slope is best expressed in the soils that formed in the most recent loess deposits. The strongly developed, gently sloping Crete soils formed in loess and have nearly level to moderate slopes. The weakly developed, strongly sloping Nuckolls soils formed in loess on rolling relief. The moderately sloping Hastings soils, which have less distinct horizons than Crete soils, have slopes between these extremes.

Time

The soil-forming factors require varying amounts of time to change the parent material into soil. On flood plains, continuing deposition and removal of soil interferes with these processes. Some soils on the flood plains have accumulated organic matter in the surface layer or in part of the surface layer. On the terraces above the flood plains, the soils are weakly developed or moderately well developed. This is expressed by organic-matter accumulation, structure development, horizon distinctness, and leaching. Most of the deep soils on the uplands have well-developed profiles. The shallow soils, developed in the oldest geologic material, have little profile development and are immature, or young, 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.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and range; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in such large areas as states, countries, and continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Because this system is under continual study, readers interested in developments of the current system should search the latest literature available (*6, 8*).

The current 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 soils of similar genesis, or mode of origin, are grouped together. The same property or subdivisions of this property may be used in several different categories. In table 9, the soil series of Cloud County are

TABLE 9.—*Classification of soil series*

Series	Family	Subgroup	Order
Armo	Fine-loamy, mixed, mesic	Typic Haplustolls	Mollisols.
Bridgeport [1]	Fine-silty, mixed, mesic	Fluventic Haplustolls	Mollisols.
Carr	Coarse-loamy, mixed, calcareous, mesic	Typic Udifluvents	Entisols.
Crete	Fine, montmorillonitic, mesic	Pachic Argiustolls	Mollisols.
Detroit	Fine, montmorillonitic, mesic	Pachic Argiustolls	Mollisols.
Eudora, thick surface variant [2]	Coarse-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Geary	Fine-silty, mixed, mesic	Udic Argiustolls	Mollisols.
Hastings	Fine, montmorillonitic, mesic	Udic Argiustolls	Mollisols.
Hedville	Loamy, mixed, mesic	Lithic Haplustolls	Mollisols.
Hobbs	Fine-silty, mixed, mesic	Cumulic Haplustolls	Mollisols.
Hord	Fine-silty, mixed, mesic	Pachic Haplustolls	Mollisols.
Humbarger	Fine-loamy, mixed, mesic	Cumulic Haplustolls	Mollisols.
Kipson	Loamy, mixed, mesic, shallow	Udorthentic Haplustolls	Mollisols.
Lancaster	Fine-loamy, mixed, mesic	Udic Argiustolls	Mollisols.
Longford	Fine, montmorillonitic, mesic	Udic Argiustolls	Mollisols.
McCook	Coarse-silty, mixed, mesic	Fluventic Haplustolls	Mollisols.
Muir	Fine-silty, mixed, mesic	Pachic Haplustolls	Mollisols.
New Cambria	Fine, montmorillonitic, mesic	Cumulic Haplustolls	Mollisols.
Nuckolls	Fine-silty, mixed, mesic	Typic Haplustolls	Mollisols.
Roxbury	Fine-silty, mixed, mesic	Cumulic Haplustolls	Mollisols.
Sarpy	Mixed, mesic	Typic Udipsamments	Entisols.
Sutphen	Fine, montmorillonitic, mesic	Udertic Haplustolls	Mollisols.
Tobin	Fine-silty, mixed, mesic	Cumulic Haplustolls	Mollisols.
Wakeen	Fine-silty, carbonatic, mesic	Typic Haplustolls	Mollisols.

[1] These Bridgeport soils are taxadjuncts to the Bridgeport series because their Ap and A12 horizons, have thin, light-colored strata.

[2] These Eudora soils are taxadjuncts to the Eudora series because their mollic epipedon is generally thicker than 20 inches.

placed in four categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

ORDER: Ten soil orders are recognized. The properties used to differentiate among the orders tend to give broad climatic groups of soils. Three exceptions to this are the Entisols, Histosols, and Vertisols, which occur in many different climates. Each order is named with a three or four syllable word ending in *sol* (Moll-i-sol).

The soil series in Cloud County are in two orders—Mollisols and Entisols.

Mollisols are mineral soils that have a thick, dark-colored surface horizon that contains colloids dominated by bivalent cations. They do not have features that reflect soil mixing caused by shrinking and swelling.

Entisols are recently formed mineral soils. They have little or no evidence of genetic horizons and have no features that reflect soil mixing caused by shrinking and swelling

SUBORDER: Each order is subdivided into suborders. The suborders are more narrowly defined than the orders by the soil characteristics that seem to produce classes with the greatest genetic similarity. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of a water table at a shallow depth; soil climate; the accumulation of clay, iron, or organic carbon in the upper part of the profile, cracking of soils caused by a decrease in soil moisture; and fine stratification. The names of the suborders always have two syllables. The first syllable indicates a soil property influencing soil development, and the second syllable indicates the order. An example is Ustoll (*Ust* indicates dryness, and *oll* is from Mollisol).

The soil series in Cloud County are placed in the suborders Ustoll, Udoll, Fluvent, and Psamment.

GREAT GROUP: Each suborder is divided into great groups on the basis of uniformity in the kinds and sequence of soil horizons and features. The horizons used to make separations are those in which clay, carbonates, and other chemical constituents have accumulated or from which they have been removed and horizons that have pans that interfere with growth of roots, movement of water, or both. Some features used are reaction, soil climate, soil composition, and color. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder. An example is Haplustolls (*Hapl* means simple horizons, and *ustoll* is the suborder.

The soil series in Cloud County are placed in the following great groups: Haplustolls, Hapludolls, Argiustolls, Ustifluvents, Udifluvents, and Udipsamments. Only the soils classified as Argiustolls have a well-developed B horizon. The other soils have a weakly developed B horizon or are stratified to a depth of 30 inches or more.

SUBGROUP: Each great group is divided into subgroups. One subgroup represents the central (typic) segment of the group, and others, called intergrades, have properties of the group and also one or more properties of another great group, suborder, or order. Other subgroups may have soil properties unlike those of any other great group, suborder, or order. The names of the subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Haplustolls (a typical Haplustoll).

FAMILY: Each subgroup is separated into families, primarily on the basis of properties important to the growth of plants or to the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, depth, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, and so on, that are used as family differentia. An example in table 9 is the fine-loamy, mixed, mesic family of Typic Haplustolls.

The soil series in Cloud County are grouped into 10 families. Most of the families are separated on the basis of texture. Others are separated on the basis of texture and reaction or depth to bedrock.

Additional Facts About the County

This section should be useful to those who are not familiar with the county. Discussed are history, farming, transportation and markets, industry and natural resources, community facilities, and climate.

History

The first settlers in Cloud County came up the Republican River Valley from Fort Riley. They settled in the vicinity of the present town of Clyde in the summer of 1858. Another settlement, near Ames, was established in 1860. The Solomon River Valley was settled in 1865. Immigration into the county was slow in the early 1860's because of Indian raids, the Civil War, and the drought of 1860.

In 1866 the settlers petitioned for the formation of a county. The legislature organized the county and named it in honor of Col. W. F. Cloud. Elk Creek was designated county seat. In 1869 the people in the county voted to move the county seat to Concordia.

After 1870 the population grew steadily and reached a peak of 18,520 in 1890. Since then, the population has decreased steadily to 13,640 in 1970.

Since 1900 about 95 percent of the land in the county has been in farms. At present, between 50 and 60 percent of the farmland is cultivated and 25 percent is in range and pasture. In 1950, 1,725 farms were in the county and the average size was 260 acres. In 1970 the number of farms had decreased to 1,002 and the average size had increased to about 450 acres.

Farming

The early settlers brought with them the crops they had grown on the farms they left. Corn, spring wheat, oats, and barley were the principal crops. Corn was the main cash crop. Most of the wheat was ground for home use, but some was sold as a cash crop. After the introduction of winter wheat, it slowly surpassed corn as the main cash crop. Since 1955 the main cash crops have been wheat and grain sorghum. At present, most of the corn is produced on irrigated land in the Republican River Valley.

In the last 50 years the acreage of oats and barley has steadily decreased to less than 3,000 acres in 1970. The acreage of corn has decreased since 1950 and was about 15,000 acres in 1970. Grain sorghum has steadily increased as a cash crop since 1950. In 1970 grain sorghum was grown on 45,000 acres, and forage sorghum on about 2,600 acres, somewhat less than the usual 4,000 acres. In 1970, wheat was grown on about 110,000 acres and alfalfa on about 20,000 acres. The acreage of soybeans slowly increased to 2,500 acres in 1970.

Many changes and improvements in farming practices have been made during the last 20 years, and yields have steadily increased during this period. In 1970 the average yield per acre of the major crops was as follows: wheat, 33 bushels (a 19-bushel increase); grain sorghum, 43 bushels (a 17-bushel increase); and corn, 63 bushels (a 26-bushel increase). Irrigation of corn in the Republican River Valley probably accounts for some of the increase in corn yield. Yields of silage crops, alfalfa, and soybeans have not shown a consistant increase over the years.

The increase in average yield per acre is the result of a combination of many things. Some of the major reasons for the increase are the use of improved varieties, the increased use of fertilizer, improvement in farm machinery and cultural practices, and increased application of conservation practices. Part of the increase from 1950 to 1970 was due to the favorable distribution of precipitation.

As the available grain and the acreage of pasture and range increased, beef cattle increased in number. At present, some beef cattle are kept on almost all farms. Dairy cows have steadily decreased in total number and in number of herds. In 1970 beef cattle numbered about 45,000, and milk cows numbered less than 1,000. There are a few commercial producers of swine, but the number of hogs varies from year to year. Most farms have some hogs for home use and sale. Swine, including pigs, numbered 19,000 in 1970, and sheep and lambs decreased to about 4,000.

Transportation and Markets

The Central Railroad was the first railroad built in Cloud County. It reached Concordia in 1879. Five railroads now furnish freight service to the county. The Atchison, Topeka, and Santa Fe and the Union Pacific furnish outlets to Salina and points east. The Missouri Pacific traverses the Republican River Valley and extends to Kansas City. The Chicago Rock Island, and Pacific crosses the northeastern corner of the county and goes to Kansas City. The Chicago, Burlington, and Quincy goes northeast from Concordia to Omaha and Chicago.

The first road outlet was the military road from Fort Riley to Fort Kearney in Nebraska. Supplies and grain were transported over this road. The county is crossed from south to north by U.S. Highway No. 81, which passes through Concordia; and U.S. Highway No. 24 runs east and west across the southern part of the county, connecting Miltonvale and Glasco. State Route No. 9 traverses the Republican River Valley from Clyde to Concordia and then runs southwest to Beloit in Mitchell County. State Route No. 28 runs from Concordia to Jamestown and points west. Hard-surface roads or good gravel roads connect all towns to the main highways and to Concordia. Nearly all points in the county are accessible by road during most of the year. A private airport, accommodating medium and small planes, is on the southeastern edge of Concordia.

All towns in the county have one or more grain elevators. In most towns dealers in seed, fertilizer, farm machinery, and other products supply the farmers' needs.

Industry and Natural Resources

Farming is the major industry in Cloud County. Most other industries are in Concordia. A plant near Concordia makes bricks and ceramic products from material quarried in the county. This material is from the shale layers of the Dakota Formation, which is part of the underlying bedrock. Other enterprises include the manufacture of canoes, farm machinery parts, and pipe and trash racks used in developing farm ponds. A dehydrating plant produces alfalfa products used in livestock feeds. Several shops in Concordia and other towns maintain and repair farm machinery.

Several sand pits have been developed along the Republican River and supply sand and gravel for construction and road surfacing. Sand and gravel are also available near Glasco in the Solomon River Valley. Limestone and shale quarries on hilltops supply material for surfacing dirt roads. Thin, irregular veins of soft coal are along the north county line east of U.S. Highway No. 81. This coal occasionally is mined for local use.

Community Facilities

All parts of Cloud County are included in unified elementary and high school districts. There are five high schools in the county. Cloud County Community Junior College, in Concordia, offers two-year courses in certain fields.

All towns have medical services and some have rest homes. Concordia, no more than 25 miles from any town, has a large hospital and clinic. All towns have parks, playgrounds, swimming pools, and other areas for recreation. Telephone and electric service is available in all parts of the county.

All towns have a system of wells as a source of water. Farm homes use wells to tap the ground water for domestic use and for some livestock. Except in an area southwest of Jamestown, quality of the water is good. The depth to ground water is variable, and so is the quantity. Ponds have been developed to water livestock.

Climate[7]

Cloud County has a typical continental climate characterized by changeable weather. The outstanding features of the climate are cold winters, warm to hot summers, a considerable amount of sunshine in all seasons, large daily and annual variations in temperature, moderate winds, low to moderate humidity, and a pronounced rainfall maximum during the growing season. The Gulf of Mexico is the source of moisture for most of the precipitation in Kansas (*3*). When warm, moist air from the Gulf flows northward and collides over Kansas with cooler air from the north, widespread cloudiness and precipitation result. The eastern half of Kansas, including Cloud County, is frequently under the influence of moist Gulf air, and precipitation in the area is moderate to heavy.

Annual rainfall in Cloud County averages about 26 inches. Winters are very dry, and monthly precipitation in December through February is less than 0.90 inch. Precipitation increases in spring and early in summer. The monthly maximum is 4.41 inches in June. Average monthly precipitation from May through August is more than 3 inches. After the peak in June, monthly rainfall gradually declines to a minimum of 0.60 inch during January.

As in most land-controlled climates, precipitation in Cloud County is unreliable. There is a wide variation in rainfall from month to month and from year to year. Monthly totals have varied as much as 11 inches from May to June in a given year; annual totals in consecutive years have differed more than 19 inches. Between 1885 and 1971, annual precipitation ranged from 12.83 inches in 1956 to 41.88 inches in 1908. Some months during the period of record had no measurable precipitation; a few spring and summer months had more than 10 inches. Greatest monthly rainfall was 14.14 inches in June 1967. Dry weather for several months is not common, and longer droughts occur at irregular intervals. Devastating droughts occurred in the thirties and from 1952 to 1956. Probably the worst drought was in 1955–56, when annual precipitation averaged more than 11½ inches per year below normal.

Annual snowfall is light in most years. It averages about 21 inches, but ranges from 59 inches to 7.6 inches. March, which has a monthly average of 5½ inches, usually has the heaviest snowfall. Only about 8 days per year have a snowfall of 1 inch or more. Ordinarily, snow remains on the ground for only a few days.

Intense solar heating during long summer days and occasional surges of cold, arctic air in winter contribute to the large annual temperature variation (table 10). The monthly average temperature ranges from 27.1°F in January to 79.0° in July. The transition from the cold to the warm season is rapid. The average monthly temperature in March is 40.8°, and this increases to 53.6° in April and to 63.3° in May. In most years, the lowest temperature observed is below 0° and the highest is above 100°. The number of days per year that have a high of 100° or above averages about 9. In the unusually hot years of 1934 and 1936, 45 days had temperatures of 100° or above, but a few years have had no temperatures of 100° or above. The number of days per winter that have a low of 0° or below averages about 6. Weather record extremes at Concordia are −25° and 116°.

The probabilities of the last freeze in spring and the first in fall for central Cloud County are given for five thresholds in table 11. The average freeze-free

[7] By MERLE J. BROWN, climatologist for Kansas, National Weather Service, U.S. Department of Commerce.

TABLE 10.—*Temperature and precipitation*

[From records kept at Concordia, Kans.]

Month	Temperature				Precipitation				
	Average daily maximum[1]	Average daily minimum[1]	Two years in 10 will have about 4 days with— Maximum temperature equal to or higher than—	Two years in 10 will have about 4 days with— Minimum temperature equal to or lower than—	Average total[1]	One year in 10 will have— Less than—	One year in 10 will have— More than—	Days with snow cover of 1 inch or more	Average depth of snow on days that have snow cover
	°F	*°F*	*°F*	*°F*	*In*	*In*	*In*	*No*	*In*
January	36.7	17.4	60	−4	0.60	0.09	1.24	12	2.8
February	41.2	21.0	65	4	.89	.14	1.98	7	4.0
March	51.7	29.8	77	10	1.33	.23	2.56	5	5.0
April	65.0	42.2	85	26	2.23	.73	4.02	(²)	1.7
May	74.0	52.5	92	37	4.06	1.67	7.33	0	0
June	84.3	62.5	101	50	4.41	1.28	8.48	0	0
July	90.4	67.6	106	57	3.30	.87	6.38	0	0
August	88.9	66.0	104	55	3.12	.71	5.78	0	0
September	80.3	57.2	98	39	2.74	.83	4.68	0	0
October	68.6	45.1	88	29	1.83	.32	3.40	(²)	2.0
November	52.6	31.4	73	14	.96	.06	2.29	2	2.9
December	40.8	22.0	61	3	.64	.05	1.33	6	2.8
Year	64.5	42.9	[3] 104	[4] −9	26.11	17.63	35.12	32	3.4

[1] Based on period 1885–70.
[2] Less than one-half day.
[3] Average annual highest temperature.
[4] Average annual lowest temperature.

period is nearly 6 months, extending from April 23 to October 16 (*2*). There is little freeze damage to crops in most years.

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Glossary

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

TABLE 11.—*Probability of last freezing temperature in spring and first in fall*

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 1	April 9	April 14	April 25	May 8
2 years in 10 later than	March 26	April 3	April 9	April 20	May 3
5 years in 10 later than	March 14	March 24	March 31	April 10	April 23
Fall:					
1 year in 10 earlier than	November 8	October 29	October 20	October 10	October 2
2 years in 10 earlier than	November 14	November 3	October 24	October 15	October 6
5 years in 10 earlier than	November 26	November 14	November 3	October 24	October 16

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.

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.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

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 toegther 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 through their profile.

Wel-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 nearly 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.

Flood plain. Nearly level land, consisting of stream sediments. that borders a stream and is subject to flooding unless protected artificially.

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) by 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.

Loam. Soil material that is 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.

Miscellaneous land type. A mapping unit for areas of land that have little or no natural soil; or that are too nearly inaccessible for orderly examination; or that occur where, for other reasons, it is not feasible to classify the soil.

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.

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.*

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.

Road metal. Road suitable for surfacing macadamized roads and for foundations for asphalt and concrete roadways.

Runoff (hydraulics). That part of the precipitation upon a drainage area that is discharged from the area in stream channels. The water that flows off the land surface without sinking in is called surface runoff; that which enters the ground before reaching surface streams is called ground-water runoff or seepage flow from ground water.

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.

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 very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

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 sand) 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.

Substratum. Technically, the part of the soil below the solum.

Surface layer. A term used in nontechnical soil descriptions for one or more layers above the subsoil. Generally, the A horizon.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportions 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.

Variant, soil. A soil having properties sufficiently different from those of other known soils to suggest establishing a new soil series, but a soil of such limited known area that creation of a new series is not believed to be justified.

Wilting point (or permanent wilting point). The moisture content of soil, on an oven-dry basis, at which plants (specifically sunflower) wilt so much that they do not recover when placed in a dark, humid atmosphere.

GUIDE TO MAPPING UNITS

For a complete description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. The suitability of the soils for use as cropland is discussed under "Use of the Soils for Crops" and in the description of each mapping unit. The capability classification system is described on pages 36 and 37. For information on managing the soils for range, see pages 37 to 42; for windbreaks, see pages 43 and 44; for wildlife, see pages 44 and 45; for recreation, see pages 45 to 47. Other information is given in tables as follows:

Acreage and extent, table 1, page 12.
Predicted yields, table 2, page 38.
Engineering uses of the soils, tables 6, 7, and 8, pages 48 through 63.

Map symbol	Mapping unit	Page	Capability unit Dryland Symbol	Capability unit Irrigated Symbol	Range site Name	Range site Page	Windbreak suitability group Number
Aa	Alluvial land, loamy--------------	11	VIIe-1	-----	Loamy Lowland	40	1
Ah	Alluvial land, wet----------------	12	Vw-1	-----	Subirrigated	42	1
Ar	Armo silt loam, 2 to 7 percent slopes-------------------------	13	IIIe-1	IIIe-3	Limy Upland	39	3
Ba	Breaks-Alluvial land complex------	13	VIe-1	-----	----------	--	--
	Breaks------------------------	--	-----	-----	Loamy Upland	41	3
	Alluvial land-----------------	--	-----	-----	Loamy Lowland	40	1
Br	Bridgeport silt loam--------------	14	IIw-2	IIw-4	Loamy Lowland	40	1
Ca	Carr fine sandy loam--------------	15	IIs-3	IIs-4	Sandy Lowland	42	2
Cb	Carr fine sandy loam, high--------	15	I-2	I-3	Sandy Terrace	42	2
Cf	Carr and Sarpy soils--------------	15	VIIw-1	-----	Sandy Lowland	42	1
Cr	Crete silt loam, 0 to 1 percent slopes-------------------------	16	IIs-1	IIs-2	Clay Upland	39	3
Cs	Crete silt loam, 1 to 3 percent slopes-------------------------	17	IIe-1	IIe-3	Clay Upland	39	3
Ct	Crete silt loam, 3 to 6 percent slopes-------------------------	17	IIIe-1	IIIe-3	Clay Upland	39	3
Cu	Crete silty clay loam, 2 to 6 percent slopes, eroded----------	17	IIIe-2	IIIe-3	Clay Upland	39	3
De	Detroit silty clay loam-----------	18	I-1	I-3	Loamy Terrace	40	1
Eu	Eudora silt loam, thick surface variant------------------------	18	I-2	I-3	Loamy Terrace	40	1
Ge	Geary silt loam, 3 to 7 percent slopes-------------------------	19	IIIe-1	IIIe-3	Loamy Upland	41	3
Gs	Geary silty clay loam, 3 to 7 percent slopes, severely eroded-	19	IIIe-2	IIIe-3	Loamy Upland	41	3
Hb	Hastings silt loam, 1 to 3 percent slopes------------------	20	IIe-2	IIe-3	Loamy Upland	41	3
Hc	Hastings silt loam, 3 to 7 percent slopes------------------	21	IIIe-1	IIIe-3	Loamy Upland	41	3
Hd	Hastings silty clay loam, 2 to 6 percent slopes, eroded----------	21	IIIe-2	IIIe-3	Loamy Upland	41	3
He	Hedville stony loam, 5 to 30 percent slopes------------------	22	VIIe-1	-----	Shallow Over Sandstone	42	4
Ho	Hobbs silt loam-------------------	22	IIw-2	IIw-4	Loamy Lowland	40	1
Hr	Hord silt loam--------------------	23	I-1	I-3	Loamy Terrace	40	1
Hu	Humbarger loam--------------------	23	IIw-I	IIw-3	Loamy Lowland	40	1
Kp	Kipson soils, 5 to 30 percent slopes-------------------------	24	VIe-1	-----	Limy Upland	39	4
Lh	Lancaster-Hedville complex, 5 to 30 percent slopes---------------	25	VIe-1	-----	----------	--	--
	Lancaster---------------------	--	-----	-----	Loamy Upland	41	3
	Hedville----------------------	--	-----	-----	Shallow Over Sandstone	42	4
Lm	Longford silt loam, 1 to 3 percent slopes------------------	26	IIe-2	IIe-3	Loamy Upland	41	3
Ln	Longford silt loam, 3 to 7 percent slopes------------------	27	IIIe-1	IIIe-3	Loamy Upland	41	3

Map symbol	Mapping unit	Page	Capability unit: Dryland Symbol	Capability unit: Irrigated Symbol	Range site Name	Range site Page	Windbreak suitability group Number
Lo	Longford silty clay loam, 3 to 7 percent slopes, eroded----------	27	IIIe-2	IIIe-3	Loamy Upland	41	3
Mc	McCook silt loam------------------	27	I-2	I-3	Loamy Terrace	40	1
Mr	Muir silt loam--------------------	28	I-1	I-3	Loamy Terrace	40	1
Nc	New Cambria silty clay loam-------	30	IIs-1	IIs-2	Clay Terrace	39	1
Nu	Nuckolls silt loam, 4 to 12 percent slopes------------------	30	IVe-1	-----	Loamy Upland	41	3
Nx	Nuckolls silt loam, 4 to 12 percent slopes, eroded----------	31	IVe-1	-----	Loamy Upland	41	3
Rx	Roxbury silt loam-----------------	31	I-1	I-3	Loamy Terrace	40	1
Sa	Sarpy loamy sand------------------	32	IIIw-1	IIIw-3	Sandy Lowland	42	2
Sd	Sarpy loamy sand, duned-----------	32	VIe-2	-----	Sands	41	2
St	Sutphen silty clay----------------	33	IIIw-2	IIIw-4	Clay Lowland	39	1
To	Tobin silt loam-------------------	33	IIw-2	IIw-4	Loamy Lowland	40	1
Wa	Wakeen silty clay loam, 3 to 6 percent slopes------------------	34	IVe-2	-----	Limy Upland	39	4

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