SOIL SURVEY OF

Woodson 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 1958-72. Soil names and descriptions were approved in 1972. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1972. 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 Woodson County Conservation District.

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

All of the soils of Woodson 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 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 page for the woodland suitability group and range site in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and information in the text. Translucent material can be laid 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 the mapping units, the range sites, and the woodland suitability groups.

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

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

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

Community planners and others can read about soil properties that affect recreation areas in the section "Recreation." They can find information on soil limitations for community development under "Engineering Uses of the Soils."

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

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

Newcomers in Woodson 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: Round bales of prairie hay in an area of Kenoma soils.

Contents

SOIL SURVEY OF WOODSON COUNTY, KANSAS

BY DEANE W. SWANSON AND RICHARD L. GOOGINS, SOIL CONSERVATION SERVICE

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

WOODSON COUNTY, in the southeastern part of Kansas (fig. 1), covers a total area of 447 square miles, or about 318,080 acres. Yates Center, the county seat, is located in the center of the county. Population of the county is 5,059 (*7*).[1]

Agriculture and related services are the most important enterprises in Woodson County. About 45 percent of the area of the county is in native grass, 40 percent is in cropland, 5 percent is in pasture, 5 percent is in woodland, and 5 percent is in miscellaneous land, such as urban and water areas. Grain sorghum, soybeans, wheat, and alfalfa are the main crops. Beef cattle is the main kind of livestock in the county. There are a few dairy herds and several hog farms. Sheep and poultry are raised on a few farms.

The physiographic features in Woodson County are typified by a succession of east-facing escarpments combined with rolling or hilly landscapes and broad, nearly level and gently sloping areas. The elevation increases with each succession of hills from about 980 feet above sea level in the southeast to about 1,250 feet above sea level in the northwest. The nearly level and gently sloping areas are used mainly for cropland.

Woodson, Kenoma, and Dennis soils are the dominant soils in areas where practices to control water erosion are needed. The hilly areas are in native grasses used mainly as range and hayland. Eram, Ringo, and Summit soils are the dominant soils in areas where proper range use is important to management.

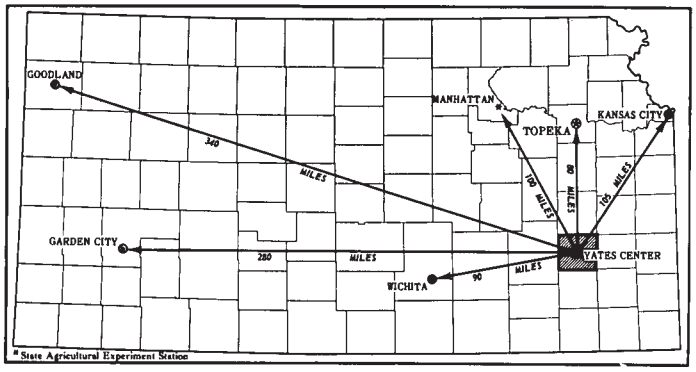

***Figure 1.*—Location of Woodson County in Kansas.**

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Woodson 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 nature of streams; the kinds of native plants or crops; the kinds of rock; and various 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 survey.

Soils that have profiles alike or 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, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of the series was first observed and mapped. Woodson and Dennis, for example, are the names of two soil series. All 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 their use 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, Dennis silt loam, 1 to 3 percent slopes, is one of several phases within the Dennis 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 woodlands, 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

[1] Italic numbers in parentheses refer to Literature Cited, p. 65.

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 Woodson County: soil complexes and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Eram-Collinsville complex, 4 to 25 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. Dennis and Eram soils, 3 to 7 percent slopes, eroded, is an undifferentiated group in Woodson County.

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

Soil scientists observe how soils behave when used as a growing place for native and cultivated plants, and as material, foundation, or covering for structures. They relate this behavior to specific properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this to the slow permeability of the soil or to its high water table. They see that streets, road pavements, and foundations for houses are cracked on a particular 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 suitabilities 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

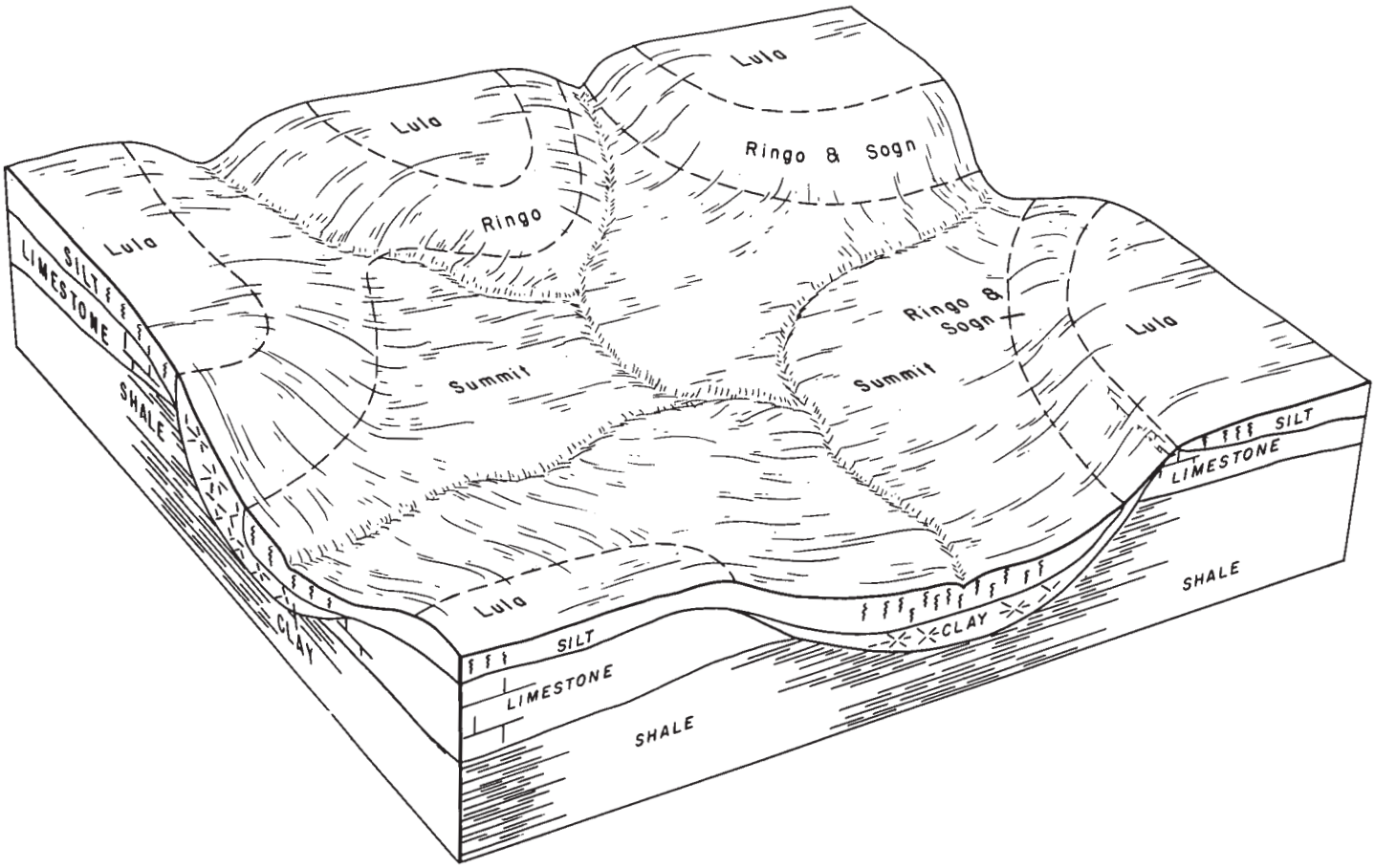

***Figure 2.*—Relationship of soils to the landscape in the Summit-Lula-Ringo association.**

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 Woodson 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 Woodson County are described in the following pages.

1. Summit-Lula-Ringo Association

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

This association consists of soils that formed in material weathered from alkaline and calcareous clay shale and limestone. Limestone ledges form low, elongated escarpments throughout the association. Slopes are gentle above and below the escarpments. The escarpments are strongly sloping and sloping (fig. 2).

The association makes up about 17 percent of the county. It is about 35 percent Summit soils, 25 percent Lula soils, 20 percent Ringo soils, and 20 percent minor soils.

Summit soils are on foot slopes. They are sloping or gently sloping and somewhat poorly drained. In a representative profile the surface layer is black silty clay loam 12 inches thick. The upper 4 inches of the subsoil is black heavy silty clay loam, and the lower 24 inches is very dark grayish-brown and dark grayish-brown silty clay. The underlying material is mixed dark grayish-brown and olive-brown silty clay.

Lula soils are above the escarpments. They are nearly level and gently sloping and are well drained. In a representative profile the surface layer is very dark grayish-brown silt loam about 9 inches thick. The upper 9 inches of the subsoil is dark-brown silty clay loam, and the lower 39 inches is dark reddish-brown and reddish-brown silty clay loam. Hard limestone bedrock is at a depth of 57 inches.

Ringo soils are strongly sloping on the side slopes of limestone and shale escarpments and sloping on slightly concave foot slopes. They are well drained. In a representative profile the surface layer is black heavy silty clay loam about 8 inches thick. The upper 4 inches of the subsoil is very dark grayish-brown silty clay, and the lower 38 inches is dark grayish-brown and olive, calcareous silty clay. The underlying material, at a depth of 50 inches, is light olive-brown, very soft, calcareous shale.

Minor soils in this association are Clareson, Dwight, Kenoma, Sogn, and Woodson soils. The moderately deep Clareson soils and the shallow Sogn soils are immediately above the escarpments. The very slowly permeable Dwight, Kenoma, and Woodson soils are mostly nearly level and gently sloping.

About two-thirds of the acreage of this association is in native grasses. A small acreage is in woodland, and the rest is cultivated. All locally adapted crops are grown; however, most of the acreage is planted to small grain, grain sorghum, corn, soybeans, and alfalfa. The main enterprise on farms in this association is beef production, but hog production and cash crops are important. The main concerns of range management are using range properly and controlling brush, trees, and weeds. The main concerns of cropland management are controlling water erosion and maintaining good tilth and fertility.

2. Woodson-Kenoma-Dennis Association

Deep, nearly level to sloping, moderately well drained and somewhat poorly drained soils that have a silty clay subsoil; on uplands

This association consists of soils that formed in old alluvium and material weathered from shale and limestone. Most areas are nearly level and gently sloping. A few sloping areas are long and narrow. This association occupies broad areas (fig. 3).

The association makes up about 45 percent of the county. It is about 40 percent Woodson soils, 25 percent Kenoma soils, 25 percent Dennis soils, and 10 percent minor soils.

Woodson soils are mostly nearly level but are gently sloping in places. They are somewhat poorly drained. In a representative profile, the surface layer is very dark gray silt loam about 8 inches thick. The subsoil is silty clay about 39 inches thick. It is very dark gray in the upper part and gray in the lower part. The underlying material is gray light silty clay mottled with yellowish brown.

Kenoma soils are gently sloping. They are moderately well drained. In a representative profile the surface layer is very dark brown and very dark grayish-brown silt loam about 11 inches thick. The silty clay subsoil, about 35 inches thick, is dark brown in the upper part and gray in the lower part. The underlying material is mixed dark grayish-brown, gray, light-gray, and yellowish-brown light silty clay.

Dennis soils are mostly gently sloping but are sloping in a few places. They are moderately well drained. In a representative profile the surface layer

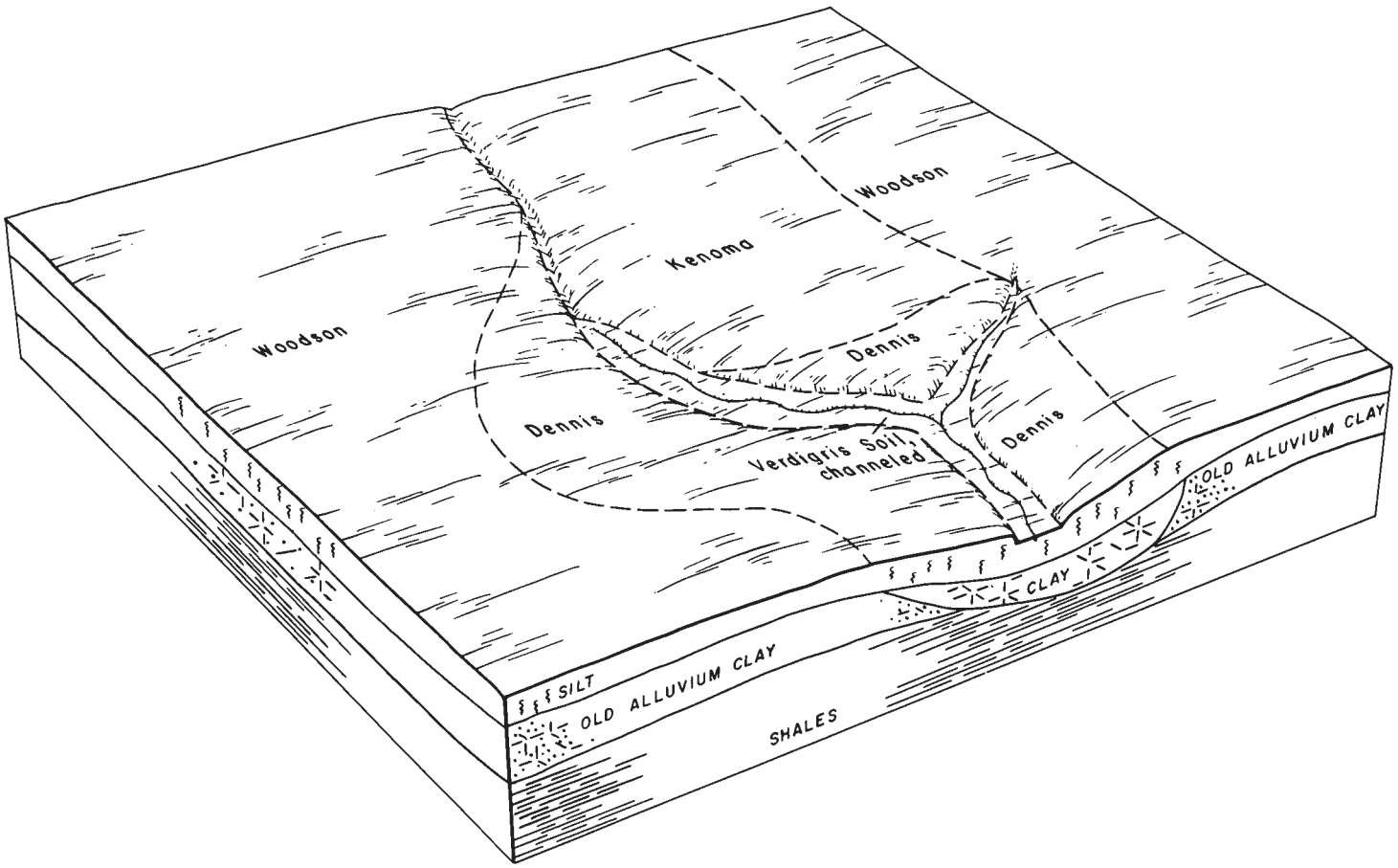

Figure 3.—**Relationship of soils to the landscape in the Woodson-Kenoma-Dennis association.**

is very dark grayish-brown silt loam about 10 inches thick. The upper 5 inches of the subsoil is dark-brown silty clay loam, and the lower 59 inches is brown and yellowish-brown silty clay. The underlying material is yellowish-brown heavy silty clay loam.

Minor soils in this association are Bates, Eram, and Verdigris soils. Bates and Eram soils are underlain by shale or sandstone at a depth of about 30 inches. They are intermingled with gently sloping and sloping Dennis soils. Verdigris soils are loamy alluvial soils that extend along drainageways.

About three-fourths of the acreage of this association is cultivated. The rest is in native grasses and is used as hayland and range. Deciduous trees grow along some of the drainageways. All locally adapted crops are grown; however, the largest acreage is planted to small grain, grain sorghum, and soybeans. The main enterprises on farms in this association are production of cash crops and livestock. The main concerns of mangement are controlling water erosion and maintaining good tilth and fertility.

3. Eram-Dennis-Bates Association

Moderately deep and deep, gently sloping to moderately steep, moderately well drained and well drained soils that have a clay loam or silty clay subsoil; on uplands

This association consists of soils that formed in material weathered from clayey and sandy shale and sandstone. The ridgetops and foot slopes in this association are gently sloping. The sides of the ridges are sloping, strongly sloping, and moderately steep, and some have sandstone rocks scattered on the surface (fig. 4).

The association makes up about 25 percent of the county. It is about 35 percent Eram soils, 30 percent Dennis soils, 20 percent Bates soils, and 15 percent minor soils.

Eram soils are mostly sloping and moderately steep but are gently sloping in a few areas. They are moderately deep and moderately well drained. In a representative profile the surface layer is very dark grayish-brown silty clay loam about 10 inches thick. The subsoil is dark-brown and strong-brown silty clay about 21 inches thick. Soft clayey and sandy shale is at a depth of about 31 inches.

Dennis soils are gently sloping or sloping. They are deep and moderately well drained and are on ridgetops, side slopes, and foot slopes. In a representative profile the surface layer is very dark grayish-brown

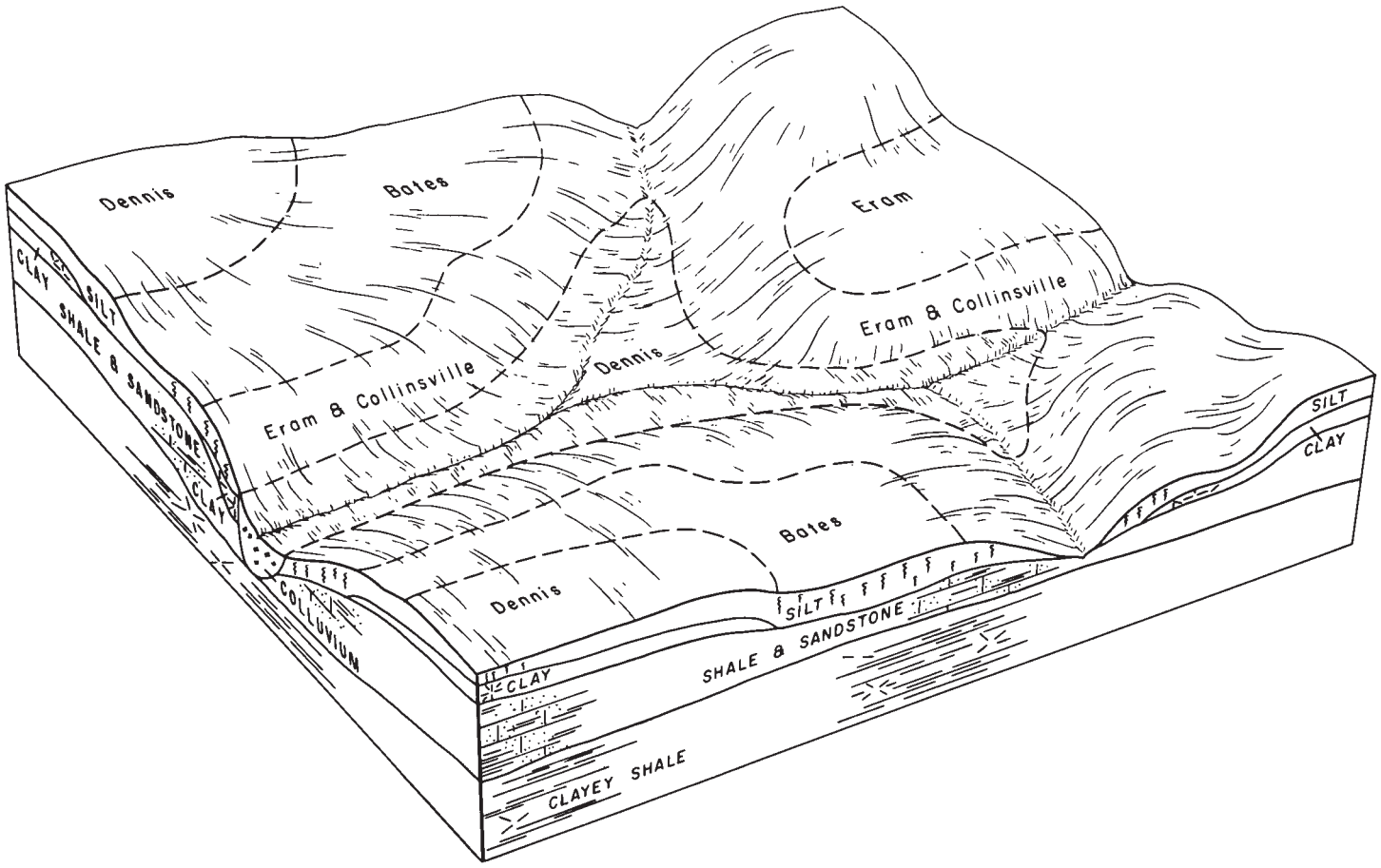

Figure 4.—**Relationship of soils to the landscape in the Eram-Dennis-Bates association.**

silt loam about 10 inches thick. The upper 5 inches of the subsoil is dark-brown silty clay loam. The lower 59 inches is brown and yellowish-brown silty clay. The underlying material is yellowish-brown heavy silty clay loam.

Bates soils are gently sloping on ridgetops and sloping on side slopes. They are moderately deep and well drained. In a representative profile the surface layer is very dark brown loam about 10 inches thick. The upper 6 inches of the subsoil is dark-brown loam. The lower 17 inches is dark yellowish-brown and yellowish-brown clay loam. The underlying material, at a depth of about 33 inches, is sandy shale and sandstone.

Minor soils in this association are Collinsville, Kenoma, Mason, and Woodson soils. Collinsville soils are mainly along the rims of ridgetops. Kenoma and Woodson soils are nearly level and gently sloping and are on ridgetops. Mason soils are on stream terraces and high flood plains along streams.

This association is mostly in native grasses and is used for grazing beef cattle. A few small areas along foot slopes and on ridgetops are cultivated. Sorghum, small grain, and soybeans are commonly grown crops. The main concern of range management is the proper use of range to avoid the invasion of brush, trees, and weedy species. The main concerns of cropland management are controlling water erosion and maintaining good fertility and tilth.

4. Stephenville-Niotaze-Darnell Association

Moderately deep and shallow; gently sloping to steep; well drained, somewhat poorly drained, and somewhat excessively drained soils that have a fine sandy loam, sandy clay loam, or silty clay subsoil; on uplands

This association consists of soils that formed in material weathered from shale and sandstone. The ridgetops are gently sloping and sloping and their sides are strongly sloping and moderately steep. A few steep areas are long and narrow, mostly around drainageways that have cut into the hills (fig. 5).

The association makes up about 4 percent of the county. It is about 45 percent Stephenville soils, 35 percent Niotaze soils, 15 percent Darnell soils, and 5 percent minor soils.

Stephenville soils are mostly gently sloping and sloping and are on ridgetops and side slopes. They are well drained. In a representative profile the surface layer is very dark grayish-brown fine sandy loam about 5 inches thick. The subsurface layer is dark-brown fine sandy loam about 9 inches thick. The subsoil is dark-brown and reddish-brown sandy clay

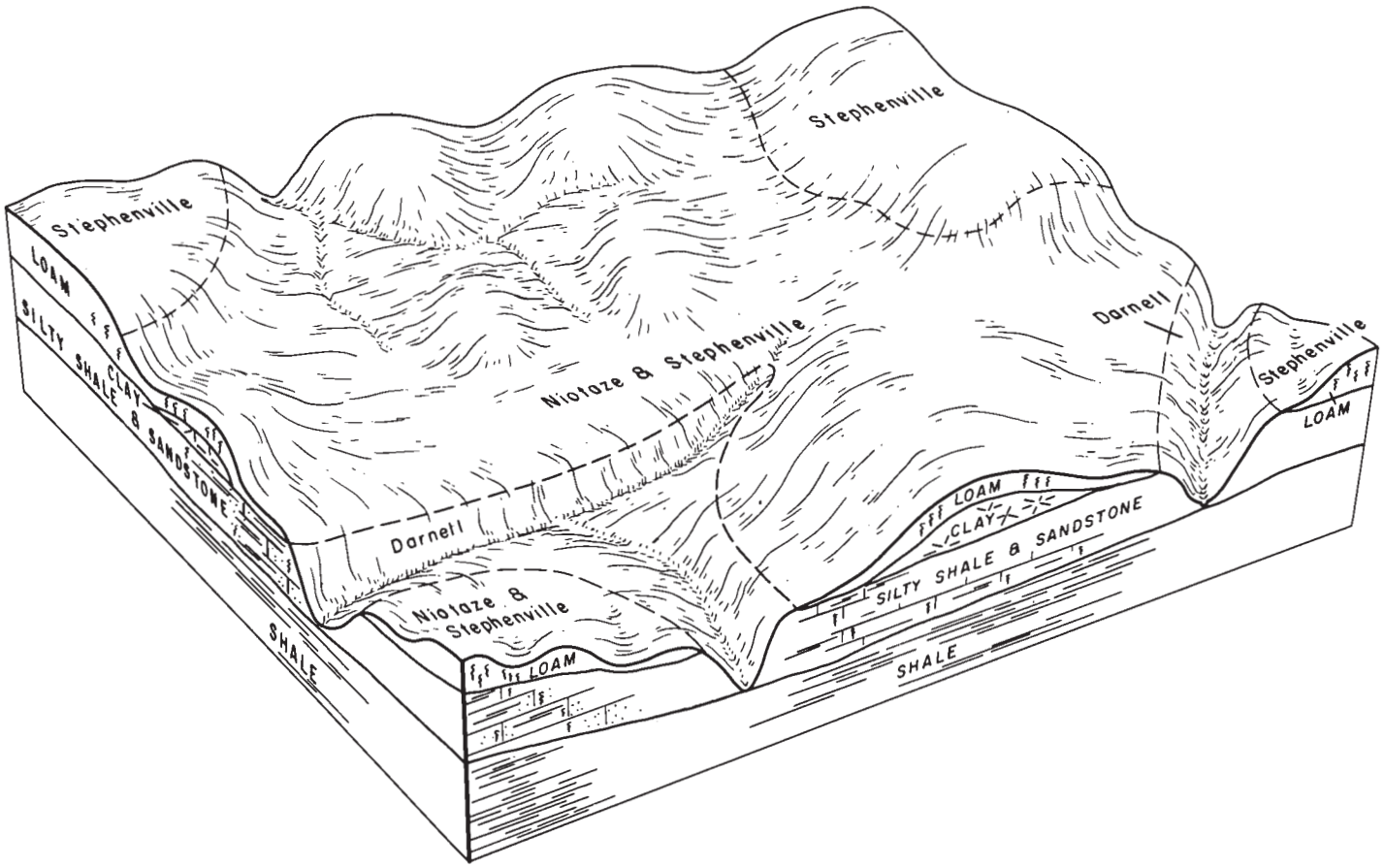

Figure 5.—**Relationship of soils to the landscape in the Stephenville-Niotaze-Darnell association.**

loam about 17 inches thick. The underlying material, at a depth of about 31 inches, is sandstone.

Niotaze soils are mostly strongly sloping and moderately steep on side slopes, but in a few areas on ridgetops, they are sloping. They are somewhat poorly drained. In a representative profile the surface layer is very dark brown loam about 5 inches thick. The subsurface layer is brown loam about 4 inches thick. The subsoil is dark-brown light silty clay about 15 inches thick. The underlying material, at a depth of 24 inches, is gray and yellowish-brown soft clayey shale.

Darnell soils are mostly steep and are on side slopes. They are well drained to somewhat excessively drained. In a representative profile the surface layer is very dark grayish-brown fine sandy loam about 4 inches thick. The subsoil is brown fine sandy loam 12 inches thick. Hard sandstone is at a depth of about 16 inches.

Minor soils in this association are Bates, Cleora, Dennis, and Eram soils. None of these soils has the lighter colored subsurface layer typical of the Stephenville and Niotaze soils. Cleora and Dennis soils are deep to bedrock. Bates soils are gently sloping and sloping and are on ridgetops. Eram soils are mostly sloping and strongly sloping and are on side slopes. Dennis soils are mostly gently sloping and sloping and are on foot slopes. Cleora soils are on flood plains along drainageways.

Nearly all of the acreage of this association is in woodland. Small areas of native grasses are interspersed throughout the area. In a few small areas along drainageways, all locally adapted crops are grown. The main enterprise on farms in this association is beef production. The main concern of management is maintaining vegetative cover for controlling water erosion. Runoff is medium or rapid.

5. Osage-Verdigris Association

Deep, nearly level, poorly drained and moderately well drained soils that have a silty clay loam or silty clay subsoil and underlying material; on flood plains

This association consists of soils that formed in clayey and loamy alluvium. It extends along the larger streams of the county. Areas of this association are nearly level except for abandoned stream channels and low, narrow benches adjacent to the active streams (fig. 6).

The association makes up about 4 percent of the county. It is about 60 percent Osage soils, 30 percent Verdigris soils, and 10 percent minor soils.

Osage soils are nearly level and poorly drained. In most places, they are a few hundred feet from the

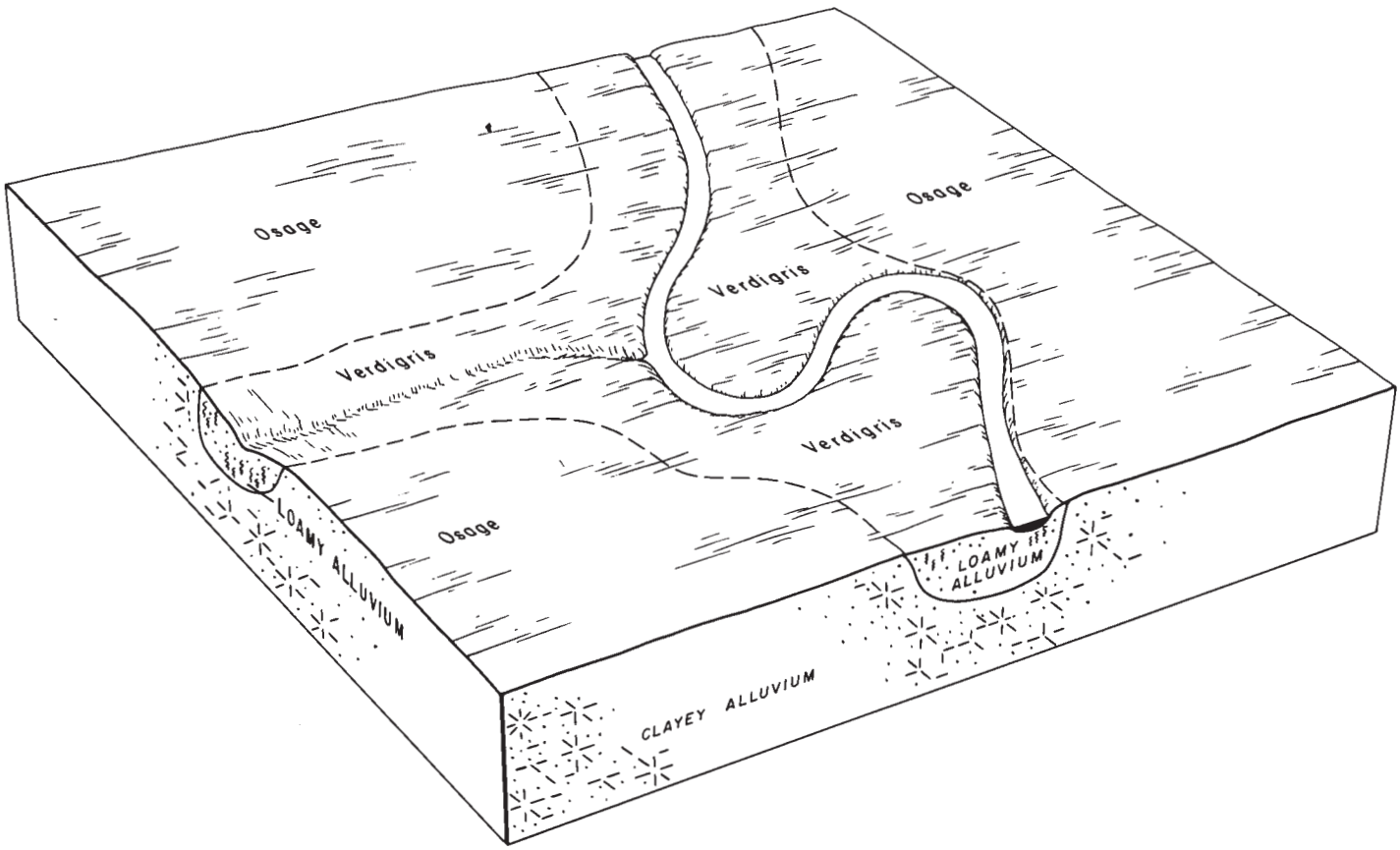

Figure 6.—**Relationship of soils to the landscape in the Osage-Verdigris association.**

stream, extending toward the uplands. In a representative profile the surface layer is very dark gray silty clay or silty clay loam about 18 inches thick. The subsoil is very dark gray and dark-gray silty clay about 52 inches thick. The underlying material, at a depth of about 70 inches, is gray silty clay.

Verdigris soils are mostly nearly level but have short slopes along abandoned stream channels and on low, narrow benches. They are moderately well drained. They extend across an area a few hundred feet wide along both sides of the stream. In a representative profile the surface layer is very dark grayish-brown silt loam and silty clay loam about 25 inches thick. The next layer is dark grayish-brown silty clay loam about 25 inches thick. The underlying material, at a depth of 50 inches, is very dark grayish-brown silty clay loam.

Minor soils in this association are Hepler, Leanna, and Mason soils. Also, soils that are similar to Verdigris soils, except that the surface layer is thinner, are intermingled with Verdigris soils. Hepler and Leanna soils are in a few small areas scattered throughout the association. They have light-colored subsurface layers. Mason soils are mainly on the small tributary streams on high flood plains.

Nearly all of the acreage of this association is cultivated. A few small areas are in woodland and native grasses. All locally adapted crops are grown on Verdigris soils. Corn, grain sorghum, and soybeans are the main crops grown on Osage soils. The main enterprise on farms in this association is growing cash crops and producing a limited amount of lumber and prairie hay. The main concerns of management are controlling occasional flooding and maintaining good tilth and fertility. Poor surface drainage is a concern on Osage soils.

6. Hepler-Leanna Association

Deep, nearly level, poorly drained and somewhat poorly drained soils that have a silty clay loam and silty clay subsoil; on flood plains and low stream terraces

This association consists of soils that formed in clayey and loamy alluvium. It extends mostly along Owl Creek, but scattered areas are along other streams of the county. Areas of this association are nearly level except for a few small swells and swales caused by flood deposition and scouring (fig. 7).

The association makes up about 5 percent of the county. It is about 50 percent Hepler soils, 35 percent Leanna soils, and 15 percent minor soils.

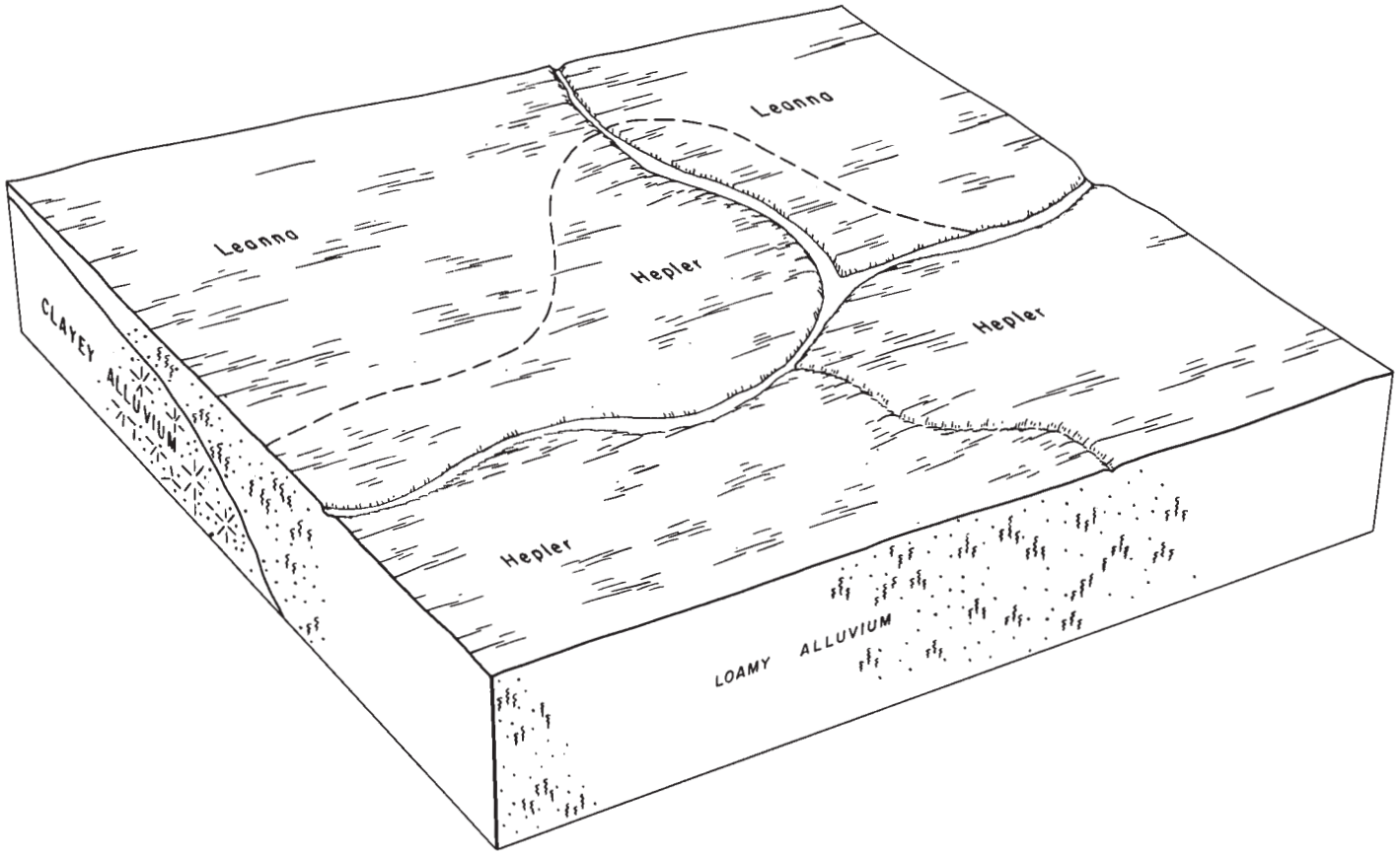

Figure 7.—**Relationship of soils to the landscape in the Hepler-Leanna association.**

Hepler soils are nearly level and somewhat poorly drained. They are on broad flats of the flood plains and low stream terraces. In a representative profile the surface layer is very dark gray silt loam about 7 inches thick. The subsurface layer is dark grayish-brown silt loam about 23 inches thick. The upper 7 inches of the subsoil is dark-gray silt loam. The subsoil below this is dark-gray and very dark gray silty clay loam to a depth of 80 inches.

Leanna soils are nearly level and are poorly drained and somewhat poorly drained. They are on low stream terraces and flood plains. They are usually a few hundred feet from the stream and extend toward the uplands; however, in a few places they extend to the streambanks. In a representative profile the surface layer is very dark gray silt loam about 9 inches thick. The subsurface layer is dark-gray silt loam about 7 inches thick. The silty clay subsoil, about 36 inches thick, is very dark gray in the upper part and dark grayish brown in the lower part. The underlying material is dark grayish-brown silty clay loam.

Minor soils in this association are Cleora, Osage, and Verdigris soils. These soils do not have a light-colored subsurface layer. Also, soils that are similar to Verdigris soils, except that the surface layer is thinner, are adjacent to the streams in some places. Cleora soils are more sandy and are intermingled with Hepler soils. They extend along streambanks, mostly in the upper reaches of Owl Creek. Verdigris soils extend intermittently along streams throughout the association. A few small areas of Osage soils are mostly in the lower reaches of Owl Creek.

About three-fourths of the acreage of this association is cultivated. A small acreage is in woodland, and the rest is in native grasses and used as hayland and range. All locally adapted crops are grown; however, the largest acreage is planted to grain sorghum, soybeans, small grain, and corn. The main enterprise on farms in this association is growing cash crops, livestock, and prairie hay. A limited amount of lumber is produced. The main concerns of management are controlling occasional flooding and maintaining good tilth and fertility. Poor surface drainage is occasionally a concern on Leanna soils.

Descriptions of the Soils

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

and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second, detailed and in technical terms, is for scientists, engineers, and others who need to make thorough and precise studies of soils. Color terms are for moist soil unless otherwise stated.

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

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 at the end of this survey, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*14*).

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

Soil	Area	Extent	Soil	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Bates loam, 1 to 4 percent slopes	13,000	4.1	Lula silt loam, 0 to 2 percent slopes	13,000	4.1
Bates loam, 4 to 7 percent slopes	3,820	1.2	Lula-Dwight complex, 0 to 2 percent slopes	2,240	.7
Clareson-Sogn complex, 1 to 8 percent slopes	2,640	.8	Mason silt loam	4,840	1.5
Cleora fine sandy loam	840	.3	Niotaze-Stephenville complex, 4 to 25 percent slopes	7,620	2.4
Darnell-Niotaze complex, 25 to 45 percent slopes	1,430	.5	Olpe soils, 4 to 15 percent slopes	380	.1
Dennis silt loam, 1 to 3 percent slopes	40,900	12.9	Osage silty clay	4,140	1.3
Dennis silt loam, 3 to 6 percent slopes	3,940	1.2	Osage silty clay loam	2,820	.9
Dennis silty clay loam, 1 to 3 percent slopes, eroded	7,100	2.2	Ringo silty clay loam, 4 to 7 percent slopes	7,590	2.4
Dennis and Eram soils, 3 to 7 percent slopes, eroded	1,180	.4	Ringo-Sogn complex, 4 to 15 percent slopes	9,800	3.0
Dwight silt loam, 0 to 2 percent slopes	3,070	1.0	Stephenville fine sandy loam, 1 to 4 percent slopes	1,250	.4
Eram silty clay loam, 1 to 4 percent slopes	4,280	1.3	Summit silty clay loam, 1 to 4 percent slopes	13,370	4.1
Eram silty clay loam, 4 to 7 percent slopes	3,120	1.0	Summit silty clay loam, 4 to 7 percent slopes	1,940	.6
Eram-Collinsville complex, 4 to 25 percent slopes	34,000	10.7	Verdigris silt loam	3,730	1.2
Hepler silt loam	8,620	2.7	Verdigris soils, channeled	18,750	5.9
Kenoma silt loam, 1 to 2 percent slopes	35,930	11.3	Woodson silt loam, 0 to 2 percent slopes	54,070	17.0
Kenoma-Olpe complex, 2 to 7 percent slopes	1,030	.4	Gravel pits and quarries	200	.1
Kenoma and Woodson soils, 1 to 3 percent slopes, eroded	1,630	.5	Borrow pits	80	(1)
Leanna silt loam	5,730	1.8	Total	318,080	100.0

[1] Less than 0.05 percent.

Bates Series

The Bates series consists of moderately deep, well drained soils on uplands. These soils are gently sloping on ridgetops and sloping on side slopes. They formed in material weathered from soft, fine-grained sandstone and in beds of sand or clayey shale.

In a representative profile the surface layer is very dark brown loam about 10 inches thick. The upper 6 inches of the subsoil is dark-brown, friable loam, and the lower 17 inches is dark yellowish-brown and yellowish-brown clay loam. The underlying material is sandy shale and sandstone at a depth of about 33 inches (fig. 8).

Permeability is moderate; available water capacity is low. The content of organic matter and natural fertility are medium.

About three-fourths of the acreage is in native grasses and used as range and hayland. A small acreage is wooded, and the rest is cultivated.

Representative profile of Bates loam, 1 to 4 percent slopes, in an area of native grasses, 600 feet north and 110 feet west of the southeast corner of sec. 16, T. 26 S.; R. 16 E.:

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

B1—10 to 16 inches, dark-brown (10YR 3/3) heavy loam, brown (10YR 5/3) dry; moderate, medium, granular structure; slightly hard, friable; common roots; many fine sandstone chips; medium acid; gradual, smooth boundary.

B2t—16 to 27 inches, dark yellowish-brown (10YR 4/4) light clay loam, yellowish brown (10YR 5/4) dry; few, fine, faint mottles of yellowish brown (10YR 5/8); moderate, fine and medium, subangular blocky structure; hard, firm; few roots; few black concretions; 5 percent sandstone fragments; medium acid; gradual boundary.

B3—27 to 33 inches, yellowish-brown (10YR 5/6), very gravelly clay loam, yellow (10YR 7/6) dry; few, fine, faint mottles of yellowish brown (10YR 5/8); weak, medium, subangular blocky structure; hard, firm; few roots; few black concretions; 60 percent sandstone fragments, 10 percent larger than 3 inches; medium acid; clear, wavy boundary.

C—33 inches, sandy and clayey shale and interbedded sandstone.

The solum ranges from 20 to 40 inches in thickness. It is slightly acid to strongly acid. The A horizon is very dark brown or very dark grayish-brown silt loam or loam 7 to 14

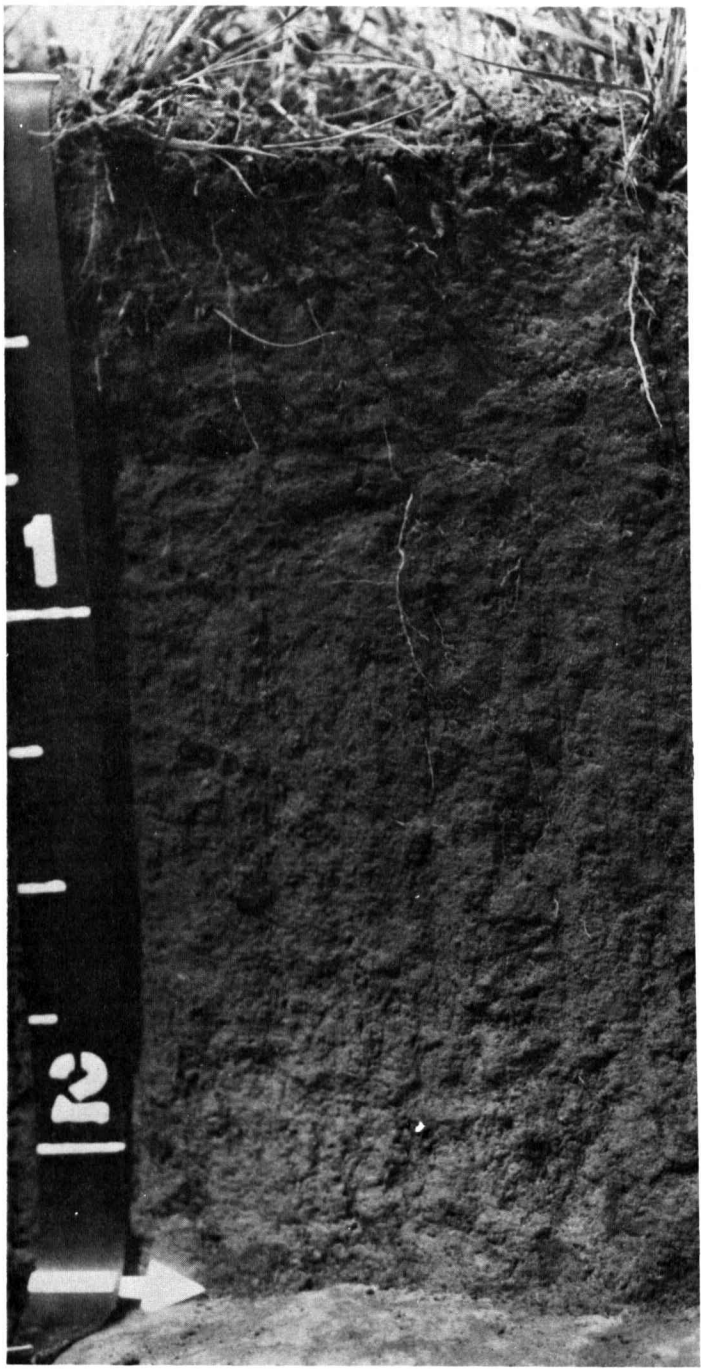

Figure 8.—**Representative profile of Bates loam. Sandstone bedrock is indicated by the marker on the tape.**

inches thick. The B2t horizon is dark yellowish-brown or brown heavy loam or light clay loam. The C horizon is sandy shale, clayey shale, or sandstone.

Bates soils are near Collinsville, Dennis, and Eram soils. They have a less clayey B horizon than the one in Eram and Dennis soils, and the solum is thinner than in Dennis soils. The solum is thicker than in Collinsville soils.

Bates loam, 1 to 4 percent slopes (Bb).—This gently sloping soil is mainly on ridgetops. It has the profile described as representative of the series. Included in mapping were a few small areas of Dennis and Eram soils. Also included were a few small areas of soils similar to Bates soils, but having a thicker combined surface layer and subsoil.

Runoff is medium, and the hazard of water erosion is moderate.

This soil is suited to all locally grown crops, to trees, and to native grasses. Areas in native grasses are used as range and hayland. Grain sorghum, soybeans, and small grain are the crops most commonly grown. Dry periods have an adverse effect on crops, especially corn.

The main concerns of cropland management are controlling water erosion and maintaining good soil tilth and fertility. Such practices as terracing, contour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss to a minimum. Using range properly and controlling undesirable plants that compete with native grasses are good management practices. Capability unit IIe–2; Loamy Upland range site; not placed in a woodland suitability group.

Bates loam, 4 to 7 percent slopes (Bc).—This sloping soil is on narrow, elongated side slopes. It has a profile similar to the one described as representative of the series, but it contains a few more sandstone fragments in the subsoil. Included in mapping were small areas of Collinsville, Dennis, and Eram soils. Also included were small areas of soils similar to Bates soils, but having a thicker combined surface layer and subsoil.

Runoff is rapid, and the hazard of water erosion is moderate to severe.

This soil is suited to all locally grown crops. Small grains and grain sorghum are the crops most commonly grown. Dry periods have an adverse effect on crops, especially corn. This soil is well suited to trees and to native grasses. Areas in native grasses are used as range and hayland.

The main concerns of cropland management are controlling water erosion and maintaining good soil tilth and fertility. Such practices as terracing, contour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss to a minimum. Using range properly and controlling brush and trees are good range management practices. Capability unit IIIe–2; Loamy Upland range site; not placed in woodland suitability group.

Clareson Series

The Clareson series consists of moderately deep, gently sloping and sloping, well-drained soils that form the caps of limestone escarpments or that are on smooth side slopes. These soils formed in material weathered from limestone.

In a representative profile the surface layer is very dark brown silty clay loam about 9 inches thick. The subsoil, about 16 inches thick, is dark reddish-brown, firm, flaggy silty clay loam in the upper part and red, very firm, flaggy, light silty clay in the lower part. Hard limestone bedrock is at a depth of about 25 inches.

Permeability is moderately slow; available water capacity is low. The content of organic matter and natural fertility are medium.

Nearly all of this acreage is in native grasses and is used mostly as range. A small acreage is used as hayland.

Representative profile of Clareson silty clay loam, in an area of Clareson-Sogn complex, 1 to 8 percent slopes, in an area of native grasses, 330 feet north and 250 feet west of the southeast corner of the SW 1/4 sec. 15, T. 25 S., R. 17 E.:

A—0 to 9 inches, very dark brown (7.5YR 2/2) silty clay loam, brown (7.5YR 4/2) dry; moderate, medium, granular structure; slightly hard, friable; common roots; few small limestone fragments; slightly acid; gradual, smooth boundary.

B1—9 to 16 inches, dark reddish-brown (5YR 3/3) flaggy silty clay loam, reddish brown (5YR 4/3) dry; strong, fine and medium, granular structure; hard, firm; few roots; few black concretions; 30 percent flaggy limestone; slightly acid; gradual, smooth boundary.

B2t—16 to 25 inches, red (2.5YR 4/6) flaggy light silty clay; moderate, medium, subangular blocky structure; very hard, very firm; few roots; few black concretions; 60 percent flaggy limestone; slightly acid; abrupt, wavy boundary.

R—25 inches, hard limestone bedrock.

The solum ranges from 20 to 40 inches in thickness and coincides with depth of limestone bedrock. The A horizon is very dark brown or dark-brown silt loam or silty clay loam 6 to 12 inches thick. The B1 horizon is similar to the A horizon except that the color is more red and the texture is silty clay loam. The content of flaggy limestone ranges from 0 to 50 percent. The Bt horizon is red to dark reddish-brown heavy silty clay loam or silty clay. The content of flaggy limestone ranges from 35 to 65 percent. A B3 horizon is present in some places. It is similar to the Bt horizon, except that it is mottled with colors of higher value.

Clareson soils are near Lula and Sogn soils. They contain flaggy limestone in the solum and Lula soils do not. Clareson soils are not so deep as Lula soils and are deeper than Sogn soils.

Clareson-Sogn complex, 1 to 8 percent slopes (Ca).—This complex consists of gently sloping and sloping soils above limestone escarpments and on smooth side slopes (fig. 9). About 50 percent of the mapping unit is Clareson silty clay loam, 35 percent is Sogn silty clay loam, and 15 percent is Lula silt loam and soils similar to Clareson silty clay loam except that they do not contain limestone fragments.

The Clareson and Sogn soils are intermingled in irregular patterns. The Sogn soil has the profile described as representative for the series. Exposed rock makes up about 10 to 25 percent of the surface.

Runoff is medium, and the hazard of water erosion is slight unless the soils are bare.

These soils are suited to native grasses and used mainly as range. A small acreage is used as hayland.

The main conerns of management are proper range use and controlling brush and trees. Capability unit VIe–2; Clareson soils in Shallow Flats range site,

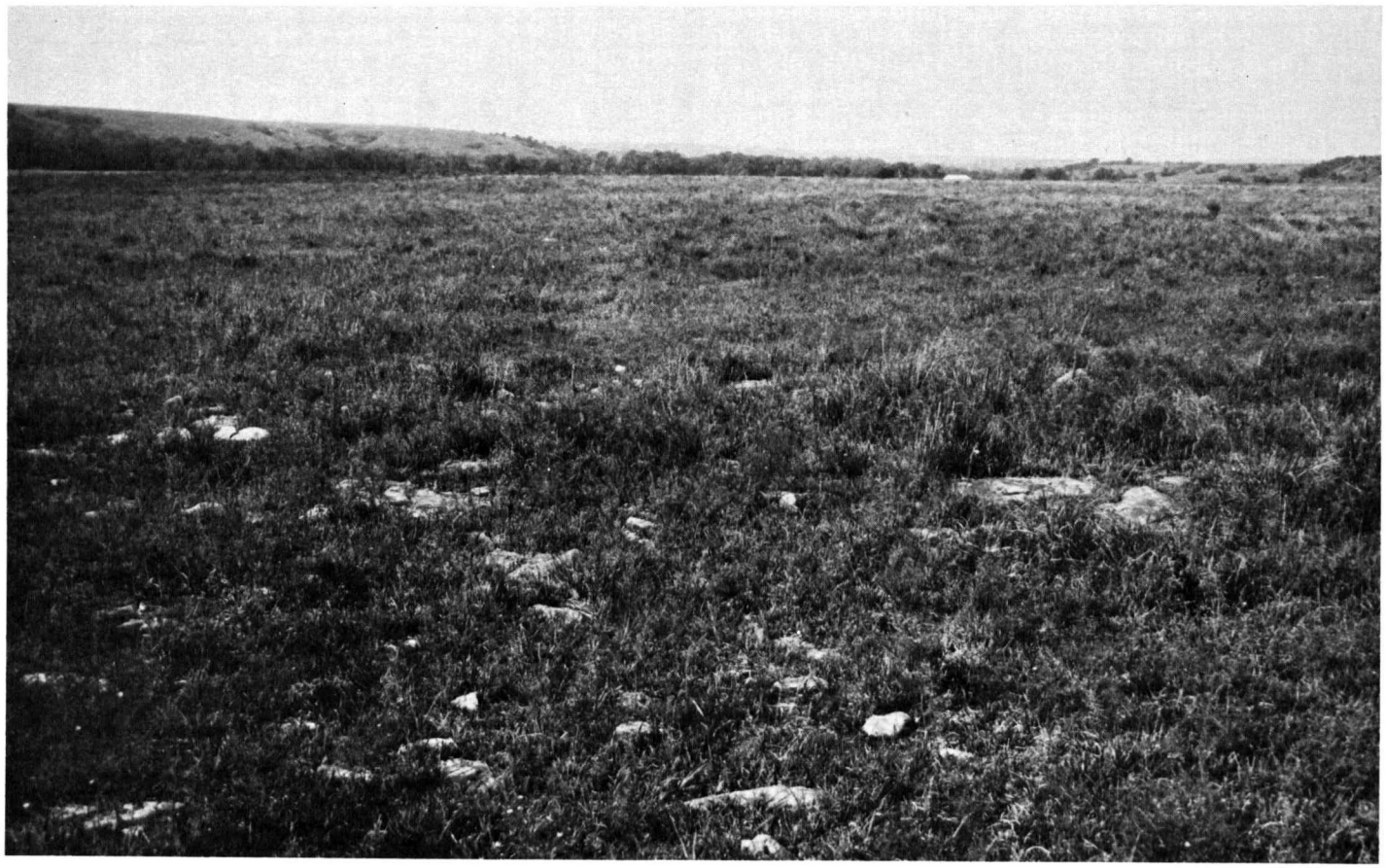

Figure 9.—**Area of Clareson-Sogn complex. Limestone rocks are on the surface.**

Sogn soils in Shallow Limy range site; not placed in a woodland suitability group.

Cleora Series

The Cleora series consists of deep, nearly level, well-drained soils on flood plains that are occasionally flooded. These soils formed in moderately coarse textured alluvium derived mostly from sandstone.

In a representative profile the surface layer is dark-brown fine sandy loam about 18 inches thick. The next layer is brown and dark-brown, very friable fine sandy loam 15 inches thick. The underlying material, to a depth of more than 90 inches, is dark grayish-brown and brown fine sandy loam.

Permeability is moderately rapid; available water capacity is high. The content of organic matter and natural fertility are medium.

About two-thirds of this acreage is cultivated. The rest is wooded, except for a small acreage in native grasses.

Representative profile of Cleora fine sandy loam, in a cultivated field, 900 feet west and 160 feet north of the southeast corner of sec. 34., T. 26 S., R. 14 E.:

A11—0 to 11 inches, dark-brown (10YR 3/3) fine sandy loam, brown (10YR 5/3) dry; weak, fine, granular structure; very friable, slightly hard; few roots; many open pores; medium acid; clear boundary.

A12—11 to 18 inches, dark-brown (10YR 3/3) fine sandy loam, brown (10YR 5/3) dry; weak, fine, granular structure; very friable, slightly hard; few roots; few organic stains; medium acid; clear boundary.

AC—18 to 33 inches, stratified brown and dark-brown (10YR 4/3 and 3/3) fine sandy loam, pale brown and brown (10YR 6/3 and 5/3) dry; massive; very friable, slightly hard; few organic stains; medium acid; clear boundary.

C1—33 to 55 inches, dark grayish-brown (10YR 4/2) fine sandy loam, grayish brown (10YR 5/2) dry; massive; very friable, soft; medium acid; clear boundary.

C2—55 to 90 inches, brown (10YR 4/3) fine sandy loam; brown (10YR 5/3) dry; massive; very friable, soft; medium acid.

The solum ranges from 25 to 50 inches in thickness. The solum and the underlying material are medium acid or slightly acid fine sandy loam or loam. The A horizon is dark brown or very dark grayish brown and is 10 to 24 inches thick. The AC horizon is stratified and is brown and dark brown. The C horizon is brown or dark grayish brown.

Cleora soils are near Mason and Verdigris soils. They are more sandy than those soils.

Cleora fine sandy loam (0 to 1 percent slopes) (Cd).—This soil is on narrow flood plains mostly along Big Sandy Creek. Small areas are scattered along other creeks in the county. Included in mapping were small areas of Mason and Verdigris soils.

Runoff is slow. This soil is occasionally flooded for short periods. Water velocity is rapid enough to cause scouring.

This soil is suited to all locally adapted crops, to trees, and to native grasses. Sorghum, small grain, and alfalfa are the crops most commonly grown, and areas in native grasses are used mainly as range. Deciduous trees are used for lumber. Nuts are harvested from walnut trees.

The main concerns of cropland management are maintaining good soil tilth and fertility. Using range properly and controlling brush and trees are good management practices. Improving timber stands is important in woodland management. Capability unit IIw-1; Loamy Lowland range site, woodland suitability group 2o2.

Collinsville Series

The Collinsville series consists of very shallow and shallow, gently sloping to moderately steep, well-drained and somewhat excessively drained upland soils on ridgetops above sandstone escarpments and on side slopes. These soils formed in material weathered from sandstone.

In a representative profile the surface layer is very dark grayish-brown loam about 8 inches thick. The subsoil, about 4 inches thick, is dark-brown, friable loam. Sandstone is at a depth of about 12 inches.

Permeability is moderately rapid; available water capacity is very low. The content of organic matter and natural fertility are low.

Nearly all of the acreage is in native grasses. A very small acreage is wooded.

In Woodson County, Collinsville soils are mapped only in complex with Eram soils.

Representative profile of Collinsville loam, in an area of Eram-Collinsville complex, 4 to 25 percent slopes, in an area of native grasses, 1,220 feet south and 200 feet east of the northwest corner of sec. 11, T. 25 S., R. 14 E.:

A—0 to 8 inches, very dark grayish-brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; moderate, very fine, granular structure; slightly hard, friable; many roots; few fine sandstone fragments; slightly acid; gradual, smooth boundary.

B—8 to 12 inches, dark-brown (10YR 3/3) heavy loam, brown (10YR 5/3) dry, moderate, medium, granular structure; slightly hard, friable; common roots; 25 percent fine sandstone fragments; medium acid; abrupt boundary.

R—12 inches, sandstone.

The solum ranges from 4 to 20 inches in thickness. It is slightly acid to strongly acid. The A horizon is very dark grayish-brown or very dark brown loam or fine sandy loam 4 to 14 inches thick. The B horizon is dark-brown or dark yellowish-brown loam or fine sandy loam 0 to 6 inches thick.

Collinsville soils are near Bates and Eram soils. They are less deep and less clayey than those soils.

Darnell Series

The Darnell series consists of shallow, steep, well-drained and somewhat excessively drained upland soils on side slopes. These soils formed in material weathered from sandstone.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam about 4 inches thick. The subsoil is brown, very friable fine sandy loam about 12 inches thick. Sandstone is at a depth of about 16 inches (fig. 10).

Permeability is moderately rapid; available water capacity is very low. The content of organic matter and natural fertility are low.

Nearly all of this acreage is wooded. Small areas of native grasses are interspersed with the trees.

Representative profile of Darnell fine sandy loam, in an area of Darnell-Niotaze complex, 25 to 45 percent slopes, in a wooded area, 400 feet west of the center of sec. 14, T. 26 S., R. 14 E.:

Figure 10.—**Profile of Darnell fine sandy loam on the left grades to a profile of Niotaze fine sandy loam on the right.**

A—0 to 4 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) dry; moderate, very fine, granular structure; soft, very friable; few roots; slightly acid; gradual, smooth boundary.

B—4 to 16 inches, brown (10YR 5/3) fine sandy loam, very pale brown (10YR 7/3) dry; moderate, fine, granular structure; soft, very friable; few roots; 10 percent sandstone fragments; strongly acid; abrupt, broken boundary.

R—16 inches, strong-brown (7.5YR 5/6) hard sandstone.

The solum ranges from 10 to 20 inches in thickness and coincides with depth to sandstone bedrock. It is strongly acid to neutral. The A horizon, 4 to 10 inches thick, is very dark grayish brown or dark brown. Where the A horizon is very dark grayish brown and more than 6 inches thick, the content of organic matter is less than one percent. The B horizon is brown or dark yellowish-brown fine sandy loam or loam 4 to 12 inches thick.

Darnell soils are near Niotaze and Stephenville soils. They are not so deep as those soils. In addition, they have a less clayey B horizon than Niotaze soils.

Darnell-Niotaze complex, 25 to 45 percent slopes (Da).—This complex consists of steep soils on the rough and broken side slopes associated with sandstone escarpments (fig. 11). About 50 percent of the mapping unit is Darnell fine sandy loam, 40 percent is Niotaze loam, and about 10 percent is Stephenville fine sandy loam and soils that are similar to Darnell fine sandy loam, except that the surface layer is thicker. Exposed rock covers 10 to 25 percent of the surface.

Runoff is rapid, and the hazard of water erosion is severe where the soils are bare.

This soil complex is suited to trees and to native grasses. It is used mainly for livestock grazing, recreation, and wildlife habitat.

Controlling water erosion by maintaining good soil cover and controlling grazing are good management practices. Capability unit VIIs–1; Darnell soils in Shallow Savannah range site, Niotaze soils in Savannah range site; Darnell soils in woodland suitability group 5d2, Niotaze soils in woodland suitability group 5r2.

Dennis Series

The Dennis series consists of deep, gently sloping and sloping, moderately well drained soils on uplands. These soils formed in shaly clay material.

In a representative profile the surface layer is very dark grayish-brown silt loam 10 inches thick. The upper 5 inches of the subsoil is dark-brown, firm silty clay loam, and the lower 59 inches is dark-brown and yellowish-brown, very firm silty clay. The underlying material to a depth of 90 inches is yellowish-brown heavy silty clay loam (fig. 12).

Permeability is slow; available water capacity is high. The content of organic matter and natural fertility are medium.

About two-thirds of the acreage is cultivated. A small acreage is wooded, and the rest is in native grasses.

Representative profile of Dennis silt loam, 1 to 3 percent slopes, in an area of native grasses, 600 feet south and 1,220 feet west of the center of sec. 5, T. 26 S., R. 16 E.:

A—0 to 10 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate, very fine, granular structure; slightly hard, friable; few roots; medium acid; gradual, smooth boundary.

B1—10 to 15 inches, dark-brown (10YR 3/3) silty clay loam, brown (10YR 4/3) dry; few fine mottles of strong brown (7.5YR 5/6); few very dark brown (10YR 2/2) stains; moderate, very fine, subangular blocky structure; hard, firm; few roots; medium acid; gradual, smooth boundary.

B21t—15 to 28 inches, dark-brown (10YR 4/3) silty clay, brown (10YR 5/3) dry; many fine to coarse mottles of reddish brown (5YR 4/4) and few very faint mottles of dark grayish brown (10YR 4/2); moderate, fine and medium, angular and subangular blocky structure;

Figure 11.—**Area of Darnell-Niotaze complex.**

very hard, very firm; few roots; few brown concretions; medium acid; gradual, smooth boundary.

B22t—28 to 62 inches, yellowish-brown (10YR 5/6) silty clay, brownish yellow (10YR 6/6) dry; few medium mottles of gray (10YR 5/1) and strong brown (7.5YR 5/6); few very dark brown (10YR 2/2) stains; weak, medium, blocky structure; very hard, very firm; few roots; few fine shale chips; slightly acid; gradual boundary.

B3—62 to 74 inches, yellowish-brown (10YR 5/6) light silty clay, brownish yellow (10YR 6/6) dry; few medium mottles of grayish brown (10YR 5/2); few very dark brown (10YR 2/2) stains; weak, coarse, blocky structure to massive; very hard, firm; few brown shot concretions; mildly alkaline; diffuse boundary.

C—74 to 90 inches, yellowish-brown (10YR 5/8) heavy silty clay loam, brownish yellow (10YR 6/8) dry; few medium mottles of light brownish gray (10YR 6/2); very few very dark brown (10YR 2/2) stains; massive; hard, firm; few brown shot concretions; mildly alkaline.

The solum is more than 60 inches thick. It is medium acid, strongly acid, or very strongly acid in the upper part and medium acid to mildly alkaline in the lower part. The A horizon is very dark grayish-brown or dark-brown silt loam or loam 10 to 15 inches thick. The B1 horizon is dark-brown or brown silty clay loam or clay loam 5 to 10 inches thick. The B2t horizon is brown or yellowish-brown silty clay or heavy silty clay loam. The C horizon is yellowish-brown or brownish-yellow silty clay loam or silty clay. In many places shaly clay is at a depth of 60 inches or more.

In mapping units Df and Dg, the surface layer is thinner and slightly browner than defined in the range for the series, but this difference does not alter the usefulness or behavior of the soils.

Dennis soils are near Bates, Eram, Kenoma, and Woodson soils. The solum is thicker than in Bates and Eram soils. Dennis soils do not have the abrupt textural change between the A and B horizons that is characteristic of Kenoma and Woodson soils.

Dennis silt loam, 1 to 3 percent slopes (Dd).—This gently sloping soil is on moderately broad areas of the uplands. It has the profile described as representative of the series. Included in mapping were small areas of Eram and Kenoma soils. Also included were slickspots, mainly on foot slopes.

Runoff is medium, and the hazard of water erosion is moderate.

This soil is suited to all locally grown crops. Grain sorghum, soybeans, and small grain are the crops most commonly grown. The soil is well suited to trees and to native grasses. Areas in native grasses are used as range and hayland.

The main concerns of cropland management are controlling water erosion and maintaining good soil tilth and fertility. Such practices as terracing, con-

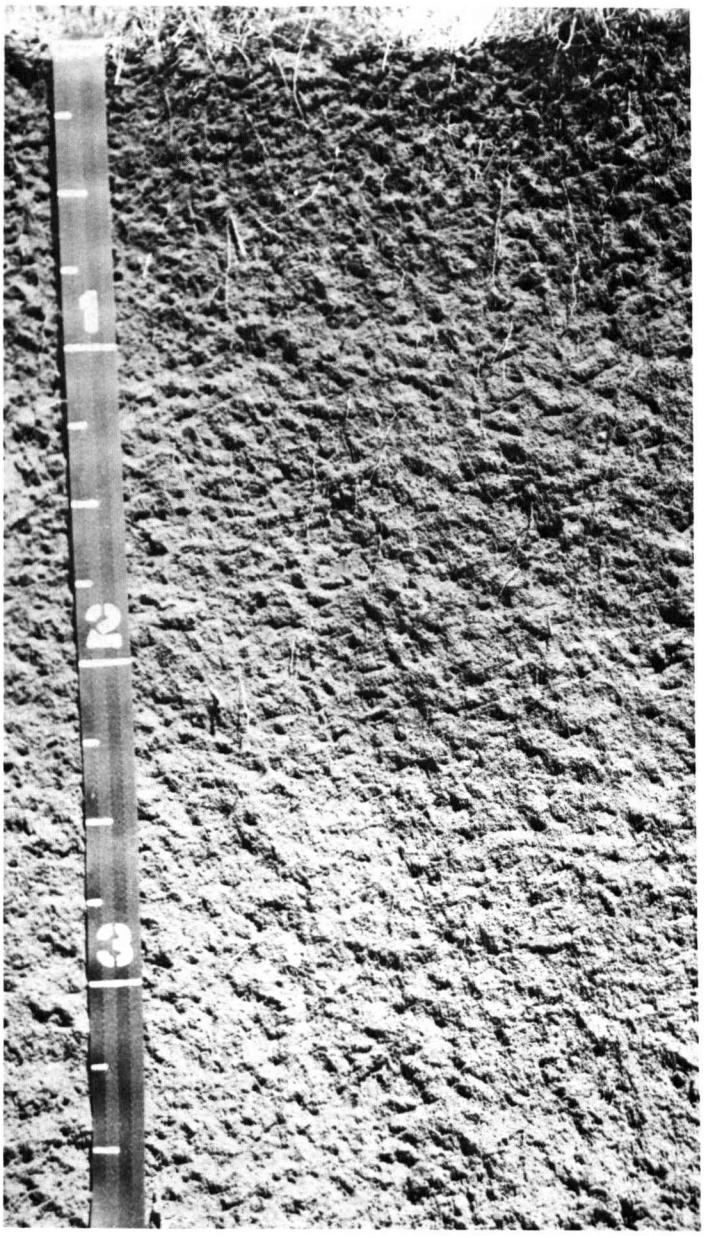

Figure 12.—**Representative profile of Dennis silt loam.**

tour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss to a minimum. Using range properly and controlling brush and trees are good management practices. Capability unit IIe–1; Loamy Upland range site; not placed in a woodland suitability group.

Dennis silt loam, 3 to 6 percent slopes (De).—This sloping soil is in narrow, elongated areas on foot slopes of shale and sandstone escarpments of the uplands. Included in mapping were small areas of Bates and Eram soils. Also included were soils that are similar to, but sandier than, Dennis soils.

Runoff is medium, and the hazard of water erosion is moderate to severe.

This soil is suited to all locally grown crops. Small grain, grain sorghum, and soybeans are the crops most commonly grown. The soil is well suited to native grasses. Areas in native grasses are used as range and hayland.

The main concerns of cropland management are controlling water erosion and maintaining good soil tilth and fertility. Such practices as terracing, contour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss to a minimum. Using range properly and controlling brush are good management practices. Capability unit IIIe–1; Loamy Upland range site; not placed in a woodland suitability group.

Dennis silty clay loam, 1 to 3 percent slopes, eroded (Df).—This gently sloping soil is in irregularly shaped areas of the uplands. The original surface layer has been thinned by water erosion and mixed with material from the upper part of the subsoil. The present surface layer is thinner and slightly more clayey than the one in the profile described as representative of the Dennis series. There are a few shallow gullies in some places. Included in mapping were small areas of Eram soils and uneroded Dennis soils. Also included were slickspots in places.

Runoff is medium, and the hazard of water erosion is moderate to severe.

This soil is suited to all locally grown crops and to native grasses. Small grain, grain sorghum, and soybeans are the crops most commonly grown.

The main concerns of cropland management are controlling water erosion and maintaining good soil tilth and fertility. Such practices as terracing, contour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss to a minimum. Using range properly and controlling brush are good management practices. Capability unit IIIe–4; Clay Upland range site; not placed in a woodland suitability group.

Dennis and Eram soils, 3 to 7 percent slopes, eroded (Dg).—This undifferentiated group consists of sloping soils on foot slopes of shale and sandstone escarpments and on convex side slopes. About 50 percent of the mapping unit is eroded Dennis soils, 30 percent is eroded Eram soils, and 20 percent is eroded Bates soils. In most places, each of these soils is adjacent to its uneroded counterpart. In some places, these soils are intermingled in an unpredictable pattern, but all are not in each mapped area.

The Dennis and Eram soils have profiles similar to those described as representative of their respective series, but their original surface layers have been thinned by water erosion and mixed with clayey subsoil material. The present surface layers are thinner and slightly more clayey. There are shallow gullies and in some places a few deep gullies that expose the underlying shale.

Runoff is rapid, and the hazard of water erosion is severe.

If intensive conservation practices are used, these soils are suited to cultivation. Close-growing crops such as small grain are the crops most commonly grown. The soils are also suited to native grasses used mainly as range.

The main concerns of cropland management are

controlling water erosion and maintaining good soil tilth and fertility. Such practices as terracing, contour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss to a minimum. Using range properly and controlling brush are good management practices. Capability unit IVe–1; Clay Upland range site; not placed in a woodland suitability group.

Dwight Series

The Dwight series consists of deep, nearly level and gently sloping, moderately well drained upland soils in areas below foot slopes and on ridgetops. These soils formed in sediment from clay shale and loess or old alluvium.

In a representative profile the surface layer is very dark brown heavy silt loam about 4 inches thick. The upper 28 inches of the subsoil is very dark grayish-brown and dark-brown, extremely firm clay, and the lower 12 inches is extremely firm, brown silty clay. The underlying material, at a depth of 44 inches, is mixed yellowish-brown and dark grayish-brown silty clay. Clay shale is at a depth of about 52 inches.

Permeability is very slow; available water capacity is low. The content of organic material and natural fertility are low.

Most of the acreage is in native grasses. A few small areas are cultivated.

Representative profile of Dwight silt loam, 0 to 2 percent slopes, in an area of native grasses, 990 feet south and 20 feet east of the northwest corner of sec. 16, T. 25 S., R. 14 E.:

A—0 to 4 inches, very dark brown (10YR 2/2) heavy silt loam, dark grayish brown (10YR 4/2) dry; moderate, fine, granular structure; hard, firm; many roots; slightly acid; abrupt, smooth boundary.

B21t—4 to 14 inches, very dark grayish-brown (10YR 3/2) clay, dark grayish brown (10YR 4/2) dry; moderate, medium, columnar structure; extremely hard, extremely firm; common roots; slightly acid; gradual, smooth boundary.

B22t—14 to 32 inches, dark-brown (10YR 3/3) clay, brown (10YR 4/3) dry; weak, coarse, blocky structure; extremely hard, extremely firm; few roots; moderately alkaline; gradual boundary.

B3—32 to 44 inches, brown (10YR 4/3) silty clay, brown (10YR 4/3) dry; weak, medium, blocky structure to massive; extremely hard, extremely firm; few roots; few nests of gypsum crystals; few shale chips; moderately alkaline; gradual boundary.

C1—44 to 52 inches, mixed yellowish-brown (10YR 5/6) and dark grayish-brown (10YR 4/2) silty clay; few faint mottles of dark gray (10YR 4/1); massive; very hard, very firm; few to common nests of gypsum crystals; moderately alkaline; gradual boundary.

C2—52 to 60 inches, variegated, mostly light olive-brown (2.5Y 5/3), gray (10YR 5/1), and yellowish-brown (10YR 5/4), mostly calcareous clay shale; few carbonates; moderately alkaline.

The solum ranges from 30 to 55 inches in thickness, and depth to shale is more than 40 inches. The A horizon is very dark brown or very dark gray silt loam or light silty clay loam 2 to 7 inches thick. It is medium acid to neutral. The B2t horizon is very dark grayish-brown or dark-brown silty clay or clay 11 to 40 inches thick. It is slightly acid to moderately alkaline. The B3 and C1 horizons are brown, dark grayish-brown, or yellowish-brown silty clay or heavy silty clay loam. They are neutral to moderately alkaline.

Dwight soils are near Kenoma and Woodson soils. They have a thinner A horizon than those soils.

Dwight silt loam, 0 to 2 percent slopes (Dw).—This soil is on broad, nearly level areas in the western half of the county. It is on ridgetops and on areas below foot slopes. It has the profile described as representative of the series. Included in mapping were small areas of Kenoma and Woodson soils.

Runoff is medium, and the hazard of water erosion is moderate.

This soil is suited mainly to native grasses. Most areas in native grasses are used as range, but a few are used as hayland. A few small areas are cultivated. Small grain and grain sorghum are the crops mostly commonly grown.

The main concerns of cropland management are controlling water erosion, especially because the surface layer is thin, and maintaining good soil tilth and fertility. Such practices as returning crop residue to the soil, using a suitable cropping system, fertilization, terracing, and contour farming improve tilth and keep soil loss to a minimum. Using range properly and controlling undesirable plants that compete with native grasses are good management practices. Capability unit IVs–1; Claypan range site; not placed in a woodland suitability group.

Eram Series

The Eram series consists of moderately deep, gently sloping to moderately steep, moderately well drained soils on uplands. These soils are gently sloping on ridgetops and sloping or moderately steep on convex side slopes. They formed in material weathered from shale.

In a representative profile the surface layer is very dark grayish-brown light silty clay loam about 10 inches thick. The subsoil is very firm silty clay about 21 inches thick. It is dark brown in the upper part and strong brown in the lower part. The underlying material is gray and light olive-brown shale at a depth of about 31 inches.

Permeability is slow; available water capacity is low. The content of organic matter and natural fertility are medium.

About three-fourths of the acreage is in native grasses. The rest is cultivated.

Representative profile of Eram silty clay loam, 4 to 7 percent slopes, in an area of native grasses, 760 feet east and 1,980 feet south of the northwest corner of sec. 25, T. 23 S., R. 15 E.:

A—0 to 10 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, dark grayish brown (10YR 4/2) dry; moderate, fine and medium, granular structure; hard, friable; common roots; medium acid; clear, smooth boundary.

B2t—10 to 23 inches, dark-brown (10YR 3/3) silty clay, brown (10YR 5/3) dry; common medium mottles of yellowish red (5YR 4/6), which become more diffuse when dry; moderate, medium, blocky structure; extremely hard, very firm; few roots; few fine sandstone fragments, mostly in upper horizon; medium acid; gradual, smooth boundary.

B3—23 to 31 inches, strong-brown (7.5YR 5/6) silty clay, reddish yellow (7.5YR 6/6) dry; common distinct mottles of gray (10YR 5/1); very weak, blocky structure to massive; extremely hard, very firm; few roots; few very soft shale particles; medium acid; abrupt boundary.

C—31 to 45 inches, alternating gray (N 5/0) and light olive-brown (2.5Y 5/6), soft shale; slightly acid.

The solum ranges from 20 to 40 inches in thickness and

coincides with depth to shale. It is slightly acid or medium acid in the upper part and strongly acid to neutral in the lower part. The A horizon is very dark grayish-brown or dark-brown silty clay loam or silt loam 6 to 12 inches thick. The B2t horizon is dark reddish-brown and reddish-brown to dark-brown and dark yellowish-brown silty clay or heavy silty clay loam. The B3 horizon is similar to the B2t horizon, except that it has slightly lighter colors.

Eram soils are near Bates, Collinsville, and Dennis soils. They are more clayey than Bates and Collinsville soils. They are deeper than Collinsville soils and less deep than Dennis soils.

Eram silty clay loam, 1 to 4 percent slopes (Eb).—This gently sloping soil is mostly on ridgetops but is on side slopes in a few places. Included in mapping were a few areas of Bates and Dennis soils. Also included were a few small areas of soils that have a dark-colored surface layer that is not so thick as the surface layer of this Eram soil.

Runoff is medium, and the hazard of water erosion is moderate.

This soil is suited to most locally grown crops and to native grasses. Areas in native grasses are used as hayland or range. Small grain, sorghum, and soybeans are the crops most commonly grown. Prolonged dry weather has an adverse effect on crops.

The main concerns of cropland management are controlling water erosion and maintaining good soil tilth and fertility. Such practices as terracing, contour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss to a minimum. Using range properly and controlling undesirable plants that compete with native grasses are good management practices. Capability unit IIIe–5; Clay Upland range site; not placed in a woodland suitability group.

Eram silty clay loam, 4 to 7 percent slopes (Ec).—This sloping soil is on convex side slopes that extend in narrow, elongated patterns. It has the profile described as representative of the series. Included in mapping were small areas of Bates and Dennis soils. Also included were a few small areas of soils that have a dark-colored surface layer that is not so thick as the surface layer of this Eram soil.

Runoff is rapid, and the hazard of water erosion is moderate to severe.

This soil is suited mainly to native grasses and used mostly as range. It is suited to such close-growing crops as small grain if intensive conservation practices are used.

The main concerns of cropland management are controlling water erosion and maintaining good soil tilth and fertility. Shale is exposed following prolonged erosion. Such practices as terracing, contour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss at a minimum. Using range properly and controlling undesirable plants that compete with native grasses are good management practices. Capability unit IVe–1; Clay Upland range site; not placed in a woodland suitability group.

Eram-Collinsville complex, 4 to 25 percent slopes (Ex).—This complex consists of sloping soils on hilltops and strongly sloping and moderately steep soils on side slopes. The hills are generally smooth but are rough and broken in some places (fig. 13). About 60

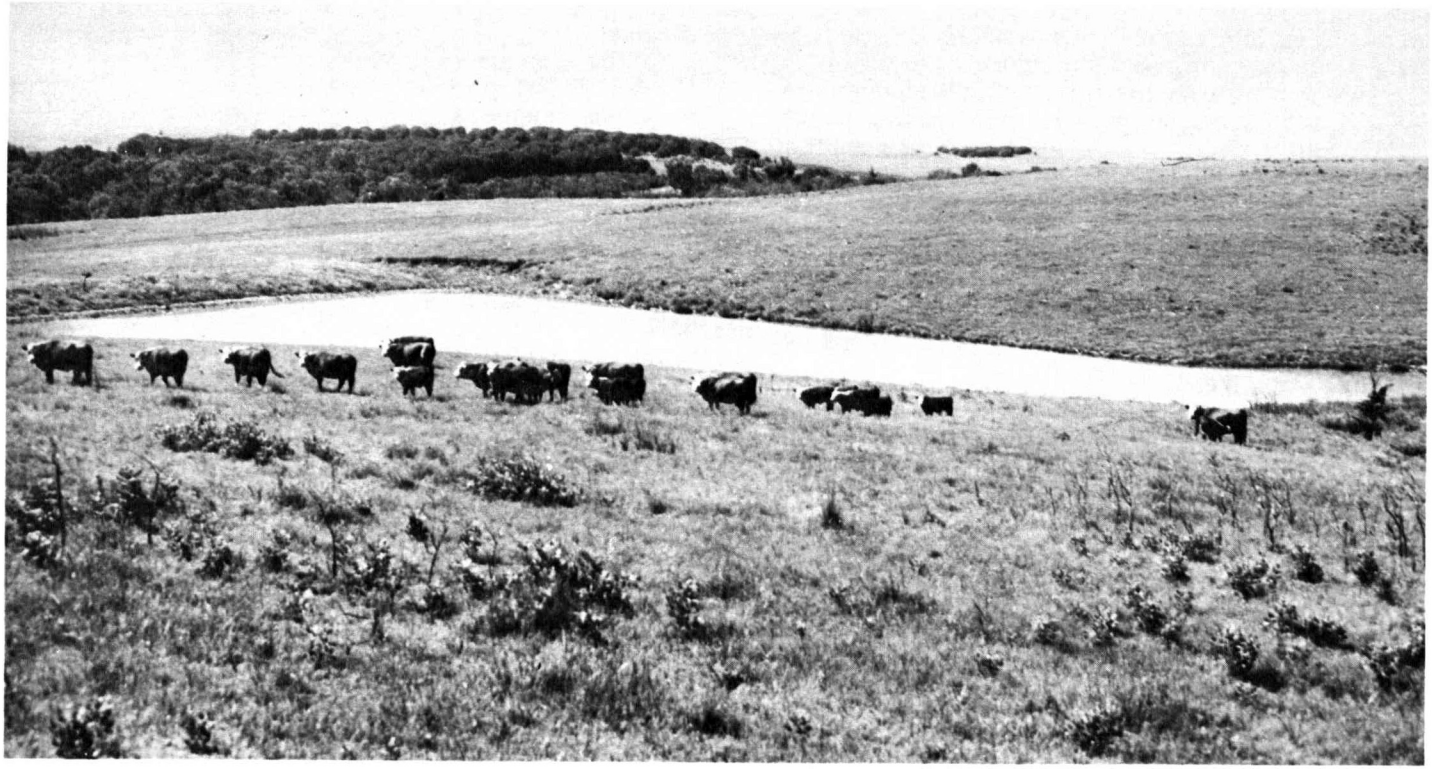

Figure 13.—**Area of Eram-Collinsville complex.**

percent of the mapping unit is Eram silty clay loam, 15 percent is Collinsville loam, and about 25 percent is Bates loam and Dennis silt loam and soils that are similar to Eram silty clay loam but that have a thinner surface layer. Collinsville soils are mainly on the hilltops, and Eram soils are on the hilltops and side slopes.

The Eram and Collinsville soils in this complex have profiles similar to those described as representative of their respective series, except that in some places in Eram soils, sandstone fragments make up as much as 15 percent of the surface layer and exposed rock covers as much as 10 percent of the soil surface.

Runoff is medium or rapid, and the hazard of water erosion is severe in areas of steeper, bare soils.

These soils are suited to native grasses. They are used mainly as range, but a few small areas are used as hayland.

The main concerns of management are using range properly and controlling undesirable plants that compete with native grasses. Capability unit VIe–2; Eram soils in Clay Upland range site, Collinsville soils in Shallow Sandstone range site; not placed in a woodland suitability group.

Hepler Series

The Hepler series consists of deep, nearly level, somewhat poorly drained soils on flood plains and low stream terraces. These soils formed in loamy alluvial sediment.

In a representative profile the surface layer is very dark gray silt loam about 7 inches thick. The subsurface layer is dark grayish-brown silt loam about 23 inches thick. The upper 7 inches of the subsoil is dark-gray, firm silt loam, and the lower 43 inches is dark-gray and very dark gray, very firm silty clay loam.

Permeability is moderately slow; available water capacity is very high. The content of organic matter and natural fertility are medium.

About three-fourths of this acreage is cultivated. Most of the rest is in native grasses, and a small acreage is wooded.

Representative profile of Hepler silt loam, in an area of native grasses, 420 feet west and 150 feet north of the southeast corner of the SW 1/4 sec. 16, T. 25 S., R. 16 E.:

A1—0 to 7 inches, very dark gray (10YR 3/1) silt loam, dark gray (10YR 4/1) dry; moderate, fine, granular structure; slightly hard, friable; many roots; slightly acid; clear, smooth boundary.

A21—7 to 18 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; few very fine mottles of dark brown (7.5YR 4/4); weak, medium, granular structure; slightly hard, friable; common roots; common fine pores; few soft, black masses; medium acid; gradual, wavy boundary.

A22—18 to 30 inches, dark grayish-brown (10YR 4/2) silt loam; light brownish gray (10YR 6/2) dry; common medium mottles of dark brown (7.5YR 4/4) and few fine mottles of very dark grayish brown (10YR 3/2); weak, medium, granular structure; slightly hard, friable; common roots; common fine pores; few soft, black masses; medium acid; gradual, wavy boundary.

B1—30 to 37 inches, dark-gray (10YR 4/1) silt loam, gray (10YR 6/1) dry; common medium mottles of dark brown (10YR 3/3); moderate, very fine, blocky structure; hard, firm; few roots; common fine pores; few saturated crayfish burrows; slightly acid; gradual, smooth boundary.

B2t—37 to 60 inches, dark-gray (10YR 4/1) silty clay loam, gray (10YR 5/1) dry; few medium mottles of dark brown (10YR 3/3); 1-inch layer of gray (10YR 5/1) silt loam in lower part; moderate, medium, blocky structure; very hard, very firm; few roots; few fine pores; few saturated crayfish burrows; slightly acid; gradual boundary.

B3—60 to 80 inches, very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; few medium mottles of dark brown (10YR 3/3); few fine, vertical streaks of gray (10YR 5/1) silt loam; weak, medium, blocky structure; extremely hard, very firm; very few roots; few fine pores; few saturated crayfish burrows; slightly acid.

The solum ranges from 40 to about 80 inches in thickness. The A1 horizon is slightly acid or medium acid. Below this layer, the solum is slightly acid to very strongly acid. The A1 horizon, 6 to 10 inches thick, is very dark gray or very dark grayish brown. The A2 horizon, 10 to 30 inches thick, is dark grayish brown or brown. The B2t horizon is very dark gray to dark grayish brown and has high-chroma mottles.

These soils are less acid in the B2 horizon than defined in the range for the series, but this difference does not alter their usefulness or behavior.

Hepler soils are near Leanna, Mason, Osage, and Verdigris soils. They contain less clay in the B horizon than Leanna and Osage soils. Their dark-colored surface layer is not so thick as the one in Mason and Verdigris soils.

Hepler silt loam (0 to 1 percent slopes) (Ha).—This soil extends mainly along Owl Creek and its tributaries in broad, flat areas of the flood plains and on low stream terraces. Included in mapping were small area of Leanna and Osage soils in similar landscape positions. Also included were areas of Verdigris soils, mainly adjacent to the stream. In some places, the Verdigris soils are on low flood plains that flood more frequently.

Runoff is slow. This soil is occasionally flooded. The water table is at or near the surface during some period in most years.

This soil is suited to all locally grown crops. Grain sorghum, soybeans, small grain, and corn are the crops most commonly grown (fig. 14). This soil is well suited to native grasses and trees. Areas in native grasses are used as range and hayland, and deciduous trees are used for lumber. Nuts are harvested from walnut trees.

The main concerns of cropland management are maintaining good soil tilth and fertility. In some places, artificial drainage is needed. Using range properly and controlling brush and trees are good management practices. Improving timber stands is important in woodland management. Capability unit IIw–3; Loamy Lowland range site; woodland suitability group 3w2.

Kenoma Series

The Kenoma series consists of deep, gently sloping and sloping, moderately well drained soils on broad upland areas. These soils formed in sediment presumed to be old alluvium.

In a representative profile the surface layer is very dark brown and very dark grayish-brown silty loam about 11 inches thick. The subsoil is very firm silty clay about 35 inches thick. It is dark brown in the upper part and light gray in the lower part. The underlying material is mixed dark grayish-brown,

Figure 14.—**Corn growing on Hepler silt loam. Double-cropped soybeans following wheat are planted on the left.**

gray, light brownish-gray, light-gray, and yellowish-brown light silty clay.

Permeability is very slow; available water capacity is moderate. The content of organic matter and natural fertility are medium.

About two-thirds of the acreage is cultivated. Most of the rest is in native grasses, and a very small acreage is wooded.

Representative profile of Kenoma silt loam, 1 to 2 percent slopes, in an area of native grasses, 320 feet east and 330 feet north of the southwest corner of the SE1/4 sec. 15, T. 26 S., R. 17 E.:

A1—0 to 6 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate very fine, granular structure; slightly hard, friable; many roots; slightly acid; gradual, smooth boundary.

A12—6 to 11 inches, very dark grayish brown (10YR 3/2) heavy silt loam, grayish brown (10YR 5/2) dry; moderate, fine, granular structure; slightly hard, friable; many roots; few very fine chert pebbles; medium acid; clear, smooth boundary.

B21t—11 to 20 inches, dark-brown (7.5YR 3/2) silty clay, dark brown (7.5YR 4/2) dry; common very fine mottles of dark reddish brown (5YR 3/3); very dark brown (10YR 2/2) silt coatings on peds in upper 2 inches; moderate, medium and coarse, blocky structure; extremely hard, very firm; common roots; thin, continuous clay films; few chert pebbles; medium acid; gradual, smooth boundary.

B22t—20 to 28 inches, dark-brown (10YR 4/3) silty clay, brown (10YR 5/3) dry; few to common fine mottles of dark yellowish brown (10YR 4/4); few streaks of very dark grayish brown (10YR 3/2); moderate, medium and coarse, blocky structure; extremely hard, very firm; few roots; thin, continuous clay films; few chert pebbles; neutral; gradual, smooth boundary.

B3—28 to 46 inches, gray (10YR 5/1) light silty clay, light gray (10YR 7/1) dry; few coarse mottles of yellowish brown (10YR 5/4); few streaks of grayish brown (10YR 5/2); weak, medium, blocky structure to massive; very hard, very firm; very few roots; few black stains; few pebbles; mildly alkaline; gradual, smooth boundary.

C1—46 to 62 inches, variegated dark grayish-brown (10YR 4/2), gray (10YR 5/1), light-gray (10YR 6/1), and yellowish-brown (10YR 5/4) light silty clay, grayish brown (10YR 5/2), light gray (10YR 7/1), and light yellowish brown (10YR 6/4) dry; very fine mottles of red (2.5YR 4/6); very weak, medium, blocky structure to massive; very hard, very firm; few chert pebbles; mildly alkaline; gradual boundary.

C2—62 to 80 inches, light brownish-gray (2.5Y 6/2) light silty clay, light gray (2.5Y 7/2) dry; few coarse mottles of yellowish brown (10YR 5/6); massive; very hard, very firm; few pebbles; mildly alkaline.

The solum ranges from 30 to 60 inches in thickness. It is strongly acid to slightly acid in the upper part, medium acid to mildly alkaline in the middle part, and slightly acid to moderately alkaline in the lower part. The A horizon is very dark brown or very dark grayish-brown silt loam or light silty clay loam 6 to 12 inches thick. The B2t horizon is dark-brown or very dark grayish-brown silty clay or clay. The C horizon is mixed dark-brown, gray, light-gray, yellowish-brown, and light brownish-gray light silty clay or heavy silty clay loam.

Kenoma soils are near Dennis, Dwight, Lula, Olpe, and Woodson soils. They do not have the thick solum of Dennis soils or the thin A horizon of Dwight soils. They have no gray colors in the upper part of the solum, unlike Woodson soils, and they do not have the reddish-brown colors of Lula soils. Unlike Olpe soils, they have no high concentration of gravel.

Kenoma silt loam, 1 to 2 percent slopes (Ka).—This gently sloping soil is on broad upland areas. It has the profile described as representative of the series. Included in mapping were small areas of Dennis and

Woodson soils. Also included were a few small areas of soils that have a light-colored subsurface layer.

Runoff is slow, and the hazard of water erosion is moderate.

This soil is suited to all locally grown crops. Grain sorghum, soybeans, and small grain are the crops most commonly grown. This soil is well suited to native grasses and used as range and hayland.

The main concerns of cropland management are controlling water erosion and maintaining good soil tilth and fertility. Such practices as terracing, contour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss to a minimum. Using range properly and controlling undesirable plants that compete with native grasses are good range management practices. Capability unit IIIe–3; Clay Upland range site; not placed in a woodland suitability group.

Kenoma-Olpe complex, 2 to 7 percent slopes (Ko).—This complex consists of gently sloping and sloping soils on low hills. Areas are long and narrow or irregularly shaped. About 50 percent of the mapping unit is Kenoma silt loam, 30 percent is Olpe silt loam, and 20 percent is Dennis silt loam and Eram silty clay loam. Olpe soils are mainly on side slopes but are also scattered erratically throughout the complex.

The Kenoma and Olpe soils have profiles similar to those described as representative of their respective series, except that the Kenoma soils contain more gravel.

Runoff is medium or rapid, and the hazard of water erosion is moderate to severe if the soils are bare.

This soil complex is suited mainly to native grasses and used as hayland and range. It is suited to close-growing crops such as small grain if intensive conservation practices are used.

The main concerns of cropland management are controlling water erosion and maintaining good soil tilth and fertility. Such practices as terracing, contour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss to a minimum. Using range properly and controlling brush are good management practices. Capability unit IVe–1; Kenoma soils in Clay Upland range site, Olpe soils in Loamy Upland range site; not placed in a woodland suitability group.

Kenoma and Woodson soils, 1 to 3 percent slopes, eroded (Kw).—This undifferentiated group consists of gently sloping soils in small, irregularly shaped areas. About 60 percent of the mapping unit is eroded Kenoma soils, 30 percent is eroded Woodson soils, and 10 percent is eroded Dennis and Dwight soils. In most places, each of these soils is adjacent to its uneroded counterpart. All are not present in each mapped area.

The Kenoma and Woodson soils have profiles similar to those described as representative of their respective series, but the original surface layers have been thinned by water erosion and mixed with subsoil material. The present surface layer is silty clay loam. The subsoil is exposed in many places. A few shallow gullies are in some places.

Runoff is slow, and the hazard of water erosion is moderate.

These soils are suited to most locally grown crops when intensive conservation treatment is used. Crops such as small grain and grain sorghum are the crops most commonly grown. These soils are also suited to native grasses. Areas in native grasses are used mainly as range.

The main concerns of cropland management are controlling water erosion and maintaining good soil tilth and fertility. Such practices as terracing, contour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss at a minimum. Using range properly and controlling brush are good management practices. Capability unit IVe–2; Clay Upland range site; not placed in a woodland suitability group.

Leanna Series

The Leanna series consists of deep, nearly level, poorly drained and somewhat poorly drained soils on flood plains and low stream terraces. These soils formed in clayey alluvial sediment.

In a representative profile the surface layer is very dark gray heavy silt loam about 9 inches thick. The subsurface layer, about 7 inches thick, is dark-gray heavy silt loam. The subsoil is very firm silty clay about 36 inches thick. It is very dark gray in the upper part and dark grayish brown in the lower part. The underlying material to a depth of 80 inches is dark grayish-brown silty clay loam (fig. 15).

Permeability is very slow; available water capacity is moderate. The content of organic matter and natural fertility are medium.

About three-fourths of the acreage is cultivated. Most of the rest is in native grasses, and a small acreage is wooded.

Representative profile of Leanna silt loam, in an area of native grasses, 135 feet east and 1,300 feet south of the northwest corner of sec. 14, T. 25 S., R. 16 E.:

A1—0 to 9 inches, very dark gray (10YR 3/1) heavy silt loam, gray (10YR 5/1) dry; moderate, fine granular structure; slightly hard, friable; common roots; medium acid; clear, smooth boundary.

A2—9 to 16 inches, dark-gray (10YR 4/1) heavy silt loam, gray (10YR 6/1) dry; few faint mottles of dark grayish brown (10YR 4/2); weak, fine, granular structure; hard, friable; common roots; strongly acid; clear, smooth boundary.

B2t—16 to 32 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; few fine, faint mottles of dark brown (10YR 4/3); moderate, medium, blocky structure; very hard, very firm; few roots; medium acid; gradual boundary.

B3—32 to 52 inches, dark grayish-brown (10YR 4/2) light silty clay, grayish brown (10YR 5/2) dry; common fine, distinct mottles of yellowish brown (10YR 5/4); weak, medium, blocky structure to massive; very hard, very firm; few roots; medium acid; diffuse boundary.

C—52 to 80 inches, dark grayish-brown (2.5Y 4/2) silty clay loam, grayish brown (2.5Y 5/2) dry; common medium, distinct mottles of yellowish brown (10YR 5/4) and gray (10YR 6/1); massive; very hard, very firm; few roots; slightly acid.

The solum ranges from about 30 to 70 inches in thickness. The A horizon and the upper part of the B horizon are strongly acid to slightly acid, and the lower part of the B horizon and the C horizon are medium acid to neutral. The A1 horizon is very dark gray or very dark grayish-brown silt loam or silty clay loam 6 to 14 inches thick. The A2 horizon is dark-gray or dark grayish-brown silt loam or silty clay loam 4

Figure 15.—**Representative profile of Leanna silt loam. The light-colored subsurface layer is indicated by markers.**

to 12 inches thick. The B horizon is very dark gray to grayish-brown silty clay, silty clay loam, or clay.

Leanna soils are near Hepler and Osage soils. They contain more clay in the B horizon than Hepler soils. They have an A2 horizon, unlike Osage soils.

Leanna silt loam (0 to 1 percent slopes) (La).—This soil is on moderately broad flood plains and low stream terraces. Areas are generally a few hundred feet from stream channels, extending toward the uplands, but in some places, this soil extends to the stream channels. Included in mapping were small areas of Hepler and Osage soils. Also included were a few slickspots.

Runoff is slow. This soil is occasionally flooded. It has a temporary perched water table during some part of most years.

This soil is suited to all locally grown crops. Soybeans, small grain, and grain sorghum are the crops most commonly grown. Legumes drown out during prolonged periods of wetness. This soil is well suited to native grasses and used as hayland and range and to deciduous trees used for lumber. Nuts are harvested from walnut trees.

The main concerns of cropland management are maintaining good tilth and fertility. In some places, artificial drainage is needed. Using range properly and controlling brush and trees are good management practices. Improving timber stands is important in woodland management. Capability unit IIw–2; Clay Lowland range site; woodland suitability group 3w2.

Lula Series

The Lula series consists of deep, nearly level and gently sloping, well-drained soils on uplands. These soils are on ridgetops above limestone ledges. They formed in material weathered from limestone.

In a representative profile the surface layer is very dark grayish-brown heavy silt loam about 9 inches thick. The upper 9 inches of the subsoil is dark-brown, friable silty clay loam. The next 24 inches is dark reddish-brown, firm silty clay loam. The lower 15 inches is reddish-brown, very firm silty clay loam. Hard limestone bedrock is at a depth of about 57 inches (fig. 16).

Permeability is moderate; available water capacity is high. The content of organic matter and natural fertility are medium.

About three-fourths of the acreage is cultivated. Most of the rest is in native grasses, and a very small acreage is wooded.

Representative profile of Lula silt loam, 0 to 2 percent slopes, in an area of native grasses, 660 feet east and 100 feet north of the southwest corner of sec. 29, T. 25 S., R. 14 E.:

A1—0 to 9 inches, very dark grayish-brown (10YR 3/2) heavy silt loam, dark grayish brown (10YR 4/2) dry; moderate, very fine, granular structure; slightly hard, friable; few roots; common wormcasts; slightly acid; gradual, smooth boundary.

B1—9 to 18 inches, dark-brown (7.5YR 3/2) silty clay loam, dark brown (7.5YR 4/3) dry; strong, fine, granular structure; slightly hard, friable; few roots; many open pores; medium acid; gradual, smooth boundary.

B21t—18 to 26 inches, dark reddish-brown (5YR 3/4) silty clay loam, reddish brown (5YR 4/4) dry; moderate, fine, subangular blocky structure; hard, firm; thin, continuous clay films; few roots; few black shot concretions; few black stains; medium acid; gradual, smooth boundary.

B22t—26 to 42 inches, dark reddish-brown (5YR 3/4) silty clay loam, reddish brown (5YR 5/4) dry; common medium mottles of yellowish red (5YR 4/6); weak, fine and medium, blocky structure; hard, firm; common black shot concretions; few black stains; medium acid; gradual, smooth boundary.

B3—42 to 57 inches, reddish-brown (5YR 4/4) silty clay loam, reddish brown (5YR 5/4) dry; many fine mottles of yellowish red (5YR 4/6); weak, medium, blocky struc-

Figure 16.—**Representatiive profile of Lula silt loam. Limestone bedrock is indicated by the marker.**

ture to massive; very hard, very firm; common black shot concretions; common black stains; neutral.
R—57 inches, hard limestone bedrock.

The solum ranges from 40 to 60 inches in thickness. The A and B1 horizons are medium acid or slightly acid, and the Bt and B3 horizons are strongly acid to slightly acid in the upper part and medium acid to neutral in the lower part. The A1 horizon, 6 to 14 inches thick, is very dark grayish brown or dark brown. The B1 horizon is dark reddish-brown or dark-brown silty clay loam or silt loam 6 to 14 inches thick. The Bt horizon, 22 to 40 inches thick, is dark reddish brown or reddish brown. The B3 horizon, 0 to 20 inches thick, is reddish brown or yellowish red.

Lula soils are near Clareson, Kenoma, Olpe, Ringo, Sogn, and Summit soils. They do not have the flaggy limestone in the solum that is characteristic of Clareson soils or the abrupt textural change characteristic of Kenoma soils. Unlike Olpe soils, they contain no gravel. They do not have the silty clay B2t horizon characteristic of Ringo and Summit soils or the limestone bedrock at a depth of less than 20 inches characteristic of Sogn soils.

Lula silt loam, 0 to 2 percent slopes (Lb).—This nearly level and gently sloping soil is on ridgetops above limestone ledges. It has the profile described as representative of the series. Included in mapping were small areas of Clareson and Kenoma soils. Also included were small areas of soils that are similar to this soil, except that limestone bedrock is at a depth of 20 to 40 inches. These included soils usually extend along the edges of limestone outcrops.

Runoff is slow, and the hazard of water erosion is slight to moderate. Soil blowing is a slight hazard.

This soil is suited to all locally grown crops. Small grain, soybeans, grain sorghum, and alfalfa are the crops most commonly grown. Prolonged dry weather has adverse effects on crops, especially corn. This soil is well suited to native grasses. Areas in native grasses are used as range and hayland.

The main concerns of cropland management are controlling water erosion and soil blowing and maintaining good soil tilth and fertility. Such practices as terracing, contour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss to a minimum. Using range properly and controlling undesirable plants that compete with native grasses are good management practices. Capability unit IIe–3; Loamy Upland range site; not placed in a woodland suitability group.

Lula-Dwight complex, 0 to 2 percent slopes (Ld).—This complex consists of nearly level and gently sloping soils on moderately broad areas in the western half of the county. About 45 percent of the mapping unit is Lula silt loam, 30 percent is Dwight silt loam, 20 percent is Kenoma silt loam, and 5 percent is Clareson silty clay loam. These soils are intermingled in unpredictable patterns.

Runoff is medium, and the hazard of water erosion is moderate.

This soil complex is suited to locally grown crops. Small grain, grain sorghum, and soybeans are the crops most commonly grown. Prolonged dry weather has adverse effects on crops, especially corn. These soils are suited to native grasses. Areas in native grasses are used as range and hayland.

The main concerns of cropland management are controlling water erosion and maintaining good soil tilth and fertility. Such practices as terracing, contour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss to a minimum. Using range properly and controlling brush are good management practices. Capability unit IIIe–6; Lula soils in Loamy Upland range site, Dwight soils in Claypan range site; not placed in a woodland suitability group.

Mason Series

The Mason series consists of deep, nearly level, well-drained soils on high flood plains and low stream terraces. These soils formed in loamy alluvial sediment.

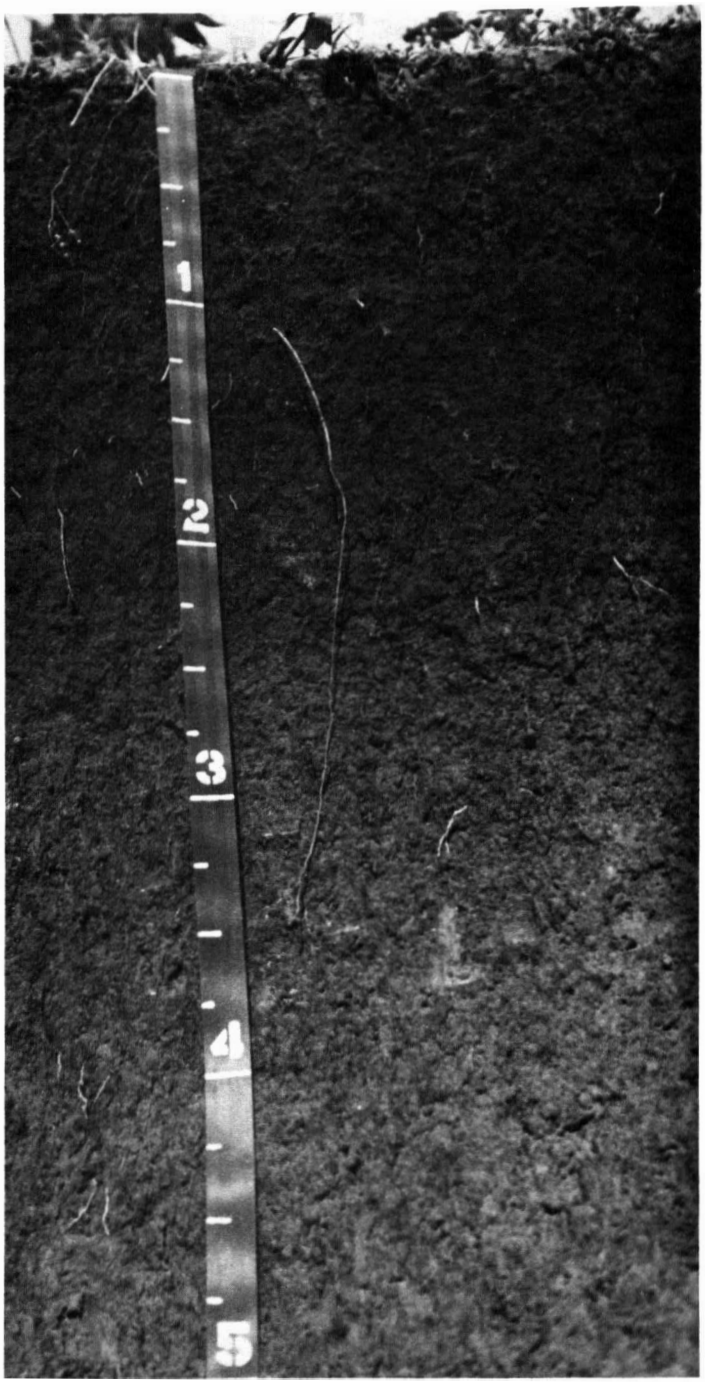

Figure 17.—**Representative profile of Mason silt loam.**

In a representative profile the surface layer is very dark grayish-brown silt loam about 12 inches thick. The upper 8 inches of the subsoil is very dark grayish-brown, firm, heavy silt loam, and the lower 26 inches is dark-brown and dark yellowish-brown, firm silty clay loam. The underlying material is yellowish-brown heavy clay loam (fig. 17).

Permeability is moderately slow; available water capacity is high. The content of organic matter and natural fertility are medium to high.

Most of the acreage is cultivated. Most of the rest is in native grasses, and a small acreage is wooded.

Representative profile of Mason silt loam, in a cultivated field, 100 feet south and 1,560 feet east of the northwest corner of sec. 26, T. 26 S., R. 15 E.:

A—0 to 12 inches, very dark grayish-brown (10YR 3/2) silt loam, brown (10YR 5/3) dry; moderate, very fine, granular structure; slightly hard, friable; common roots; medium acid; gradual, smooth boundary.

B1—12 to 20 inches, very dark grayish-brown (10YR 3/2) heavy silt loam, brown (10YR 5/3) dry; moderate, fine, granular structure; hard, firm; common roots; slightly acid; gradual, smooth boundary.

B21t—20 to 32 inches, dark-brown (10YR 3/3) light silty clay loam, brown (10YR 5/3) dry; few fine, faint mottles of strong brown (7.5YR 5/6); moderate, fine and medium, subangular blocky structure; hard, firm; few roots; slightly acid; gradual, smooth boundary.

B22t—32 to 46 inches, dark yellowish-brown (10YR 4/4) silty clay loam, yellowish brown (10YR 5/4) dry; few faint mottles of strong brown (7.5YR 5/6); weak, medium, subangular blocky structure; hard, firm; few roots; few black shot concretions; medium acid; diffuse boundary.

C—46 to 60 inches, yellowish-brown (10YR 5/4) heavy clay loam, light yellowish brown (10YR 6/4) dry; few medium mottles of grayish brown (10YR 5/2); massive; hard, firm; very few roots; few black shot concretions; few black stains; medium acid.

The solum ranges from about 35 to 60 inches in thickness. The A horizon is neutral to medium acid, the B2t horizon is slightly acid to strongly acid, and the C horizon is slightly acid to very strongly acid. The A1 horizon, 10 to 20 inches thick, is very dark grayish brown or dark brown. The B1 horizon is very dark grayish-brown or dark-brown heavy silt loam or light silty clay loam 0 to 10 inches thick. The B2t horizon is very dark grayish-brown, dark-brown, or dark yellowish-brown silty clay loam or clay loam. The C horizon is yellowish-brown, brown, or strong-brown silty clay loam or clay loam.

Mason soils are near Cleora, Hepler, and Verdigris soils. They are less sandy than Cleora soils. They do not have the light-colored A2 horizon of Hepler soils or the stratified layers of Verdigris soils.

Mason silt loam (0 to 1 percent slopes) (Ma).—This soil is on moderately narrow, high flood plains and low terraces mainly along the upper ends of most streams in the county. Included in mapping were small areas of Verdigris soils adjacent to the streams and Hepler soils that occur erratically throughout the area.

Runoff is slow. This soil is subject to flooding.

This soil is suited to all locally grown crops. Corn, grain sorghum, soybeans, small grain, and alfalfa are the crops most commonly grown. This soil is also suited to native grasses and trees. Areas in native grasses are used as range and hayland. Some deciduous trees are used for lumber. Nuts are harvested from walnut trees.

The main concerns of cropland management are maintaining good soil tilth and fertility. Using range properly and controlling brush and trees are good management practices. Improving timber stands is important in woodland management. Capability unit I-1; Loamy Lowland range site; woodland suitability group 3o1.

Niotaze Series

The Niotaze series consists of moderately deep, sloping to steep, somewhat poorly drained soils on uplands. These soils are on the caps and side slopes of

Figure 18.—**Representative profile of Niotaze fine sandy loam. The light-colored subsurface layer and shale are at a depth of about 30 inches.**

sandstone and shale escarpments. They formed in material weathered from shale that was interbedded with sandstone.

In a representative profile the surface layer is very dark brown loam about 5 inches thick. The subsurface layer is brown loam about 4 inches thick. The subsoil is dark-brown, very firm light silty clay about 15 inches thick. The underlying material, at a depth of 24 inches, is gray and yellowish-brown soft clayey shale (fig. 18).

Permeability is slow; available water capacity is low. The content of organic matter and natural fertility are low.

Nearly all of this acreage is wooded. Small areas of native grasses are interspersed with the trees.

Representative profile of Niotaze loam, in an area of Niotaze-Stephenville complex, 4 to 25 percent slopes, in a wooded area, 575 feet east and 20 feet north of the southwest corner of the NW1/4 sec. 25, T. 26 S., R 14 E.:

A1—0 to 5 inches, very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) dry; weak, very fine, granular structure; soft, very friable; many roots; 5 percent small sandstone fragments; strongly acid; gradual, smooth boundary.

A2—5 to 9 inches, brown (10YR 4/3) loam, pale brown (10YR 6/3) dry; very weak, fine, subangular blocky structure breaking to weak, fine, granular; slightly hard, friable; common roots; few small sandstone fragments; strongly acid; abrupt, wavy boundary.

IIB2t—9 to 24 inches, dark-brown (7.5YR 4/4) light silty clay, brown (7.5YR 5/4) dry; common fine mottles of yellowish red (5YR 5/6) and grayish brown (10YR 5/2); moderate, medium and coarse, blocky structure; very hard, very firm; few coarse roots; very few sandstone fragments; very strongly acid; gradual boundary.

IIC—24 inches, gray (N 5/0) and yellowish-brown (10YR 5/4) soft clayey (soapy) shale in about equal proportions.

The solum ranges from 20 to 40 inches in thickness and coincides with depth to shale. The A horizon is very dark grayish-brown or very dark brown cobbly loam or loam 2 to 5 inches thick. It is slightly acid to strongly acid. The A2 horizon is pale-brown or brown cobbly loam or loam 2 to 10 inches thick. It is medium acid or strongly acid. The IIB2t horizon is dark-brown, brown, or reddish-brown silty clay or silty clay loam 10 to 19 inches thick. It is very strongly acid to slightly acid.

Niotaze soils are near Darnell and Stephenville soils. They are deeper than Darnell soils and have a more clayey Bt horizon than Stephenville soils.

Niotaze-Stephenville complex, 4 to 25 percent slopes (Ns).—This complex consists of sloping soils on hilltops and of strongly sloping and moderately steep soils on side slopes. The hills are smooth or rough and broken (fig. 19). About 50 percent of the mapping unit is Niotaze loam, 40 percent is Stephenville fine sandy loam, and 10 percent is Darnell fine sandy loam. Stephenville soils are mostly on hilltops, and Niotaze soils are on side slopes. Darnell soils are scattered throughout the complex.

The Niotaze soil has the profile described as representative of its series. The surface layer of the Niotaze soil is loam and fine sandy loam that have sandstone fragments making up less than 15 percent of the soil mass, or it is cobbly loam and cobbly fine sandy loam that have sandstone fragments making up 15 to 50 percent of the soil mass. Exposed rock covers as much as 10 percent of the soil surface. The Stephenville soil has a profile similar to the one described as representative of its series, but the surface layer is loam in some places.

Runoff is medium or rapid, and the hazard of water erosion is severe in areas of steeper soils if the soil is bare.

This soil complex is suited to trees and native grasses. It is used mainly for livestock grazing, recreation, and wildlife habitat.

Controlling water erosion by maintaing a good soil cover and controlling grazing are good management practices. Capability unit VIe-1; Savannah range site; Niotaze soils in woodland suitability group 5r2, Stephenville soils in woodland suitability group 5d1.

Olpe Series

The Olpe series consists of deep, sloping and strongly sloping, well-drained soils on uplands. These soils are on rolling hills. They formed in old gravelly

Figure 19.—Typical area of Niotaze-Stephenville complex surrounding Lake Fegan.

sediment believed to be ancient alluvium mixed with some loess.

In a representative profile the upper 6 inches of the surface layer is very dark grayish-brown silt loam, and the lower 9 inches is dark-brown gravelly silt loam. The upper 9 inches of the subsoil is reddish-brown, very firm gravelly heavy silty clay loam. To a depth of 60 inches, the subsoil is reddish-brown, reddish-yellow, and red, very firm gravelly heavy clay loam (fig. 20).

Permeability is slow; available water capacity is moderate. The content of organic matter and natural fertility are low.

Nearly all of the acreage is in native grasses. A small acreage is wooded.

Representative profile of Olpe silt loam in an area of Olpe soils, 4 to 15 percent slopes, in an area of native grasses, 100 feet south of the northeast corner of the SE1/4 sec. 10, T. 26 S., R. 17 E.:

A11—0 to 6 inches, very dark grayish-brown (10YR 3/2) silt loam, brown (10YR 5/3) dry; moderate, very fine, granular structure; slightly hard, friable; common roots; 10 percent smooth chert pebbles; slightly acid; gradual, wavy boundary.

A12—6 to 15 inches, dark-brown (7.5YR 3/3) gravelly silt loam, brown (10YR 5/3) dry; moderate, very fine, granular structure; slightly hard, friable; common roots; 40 percent smooth chert pebbles; medium acid; gradual, wavy boundary.

B1—15 to 24 inches, reddish-brown (5YR 4/4) gravelly heavy silty clay loam, reddish brown (5YR 4/4) dry; moderate, fine and medium, blocky structure; very hard, very firm; few roots; 60 percent smooth chert pebbles; medium acid; gradual, wavy boundary.

B2t—24 to 45 inches, reddish-brown (5YR 4/4) gravelly heavy clay loam, yellowish red (5YR 5/6) dry; streaks of very dark gray (N 3/0); moderate, medium, blocky structure; extremely hard, very firm; few roots; 60 percent smooth chert pebbles; medium acid; gradual boundary.

B3—45 to 60 inches, mixed reddish-yellow (7.5YR 6/6) and red (2.5YR 5/6) gravelly heavy clay loam, reddish yellow (7.5YR 7/6) and light red (2.5YR 6/6) dry; common medium mottles of yellowish brown (10YR 5/4); weak, medium, blocky structure; very hard, very firm; very few roots; few black stains; 20 percent smooth chert pebbles; medium acid.

The solum is 60 inches or more thick. The A horizon is strongly acid to slightly acid. The upper part of the B horizon is medium acid or slightly acid, and the lower part of the B horizon is medium acid to neutral. The A horizon, 8 to 24 inches thick, is dark-brown or very dark grayish-brown silt loam or gravelly silt loam in the upper part and gravelly silt loam or gravelly silty clay loam in the lower part. The B horizon is reddish brown or brown in the upper part and reddish yellow and red in the lower part. It is gravelly heavy clay loam, gravelly heavy silty clay loam, or gravelly silty clay that contains more than 35 percent gravel.

Olpe soils are near Kenoma and Lula soils. They contain more gravel than those soils.

Olpe soils, 4 to 15 percent slopes (Od).—This mapping unit consists of sloping and strongly sloping soils in small areas on smooth, rolling hills in the southeast and southwest corners of the county. Included in mapping were small areas of Kenoma and Lula soils. Also included were small areas of soils similar to Olpe soils but less clayey.

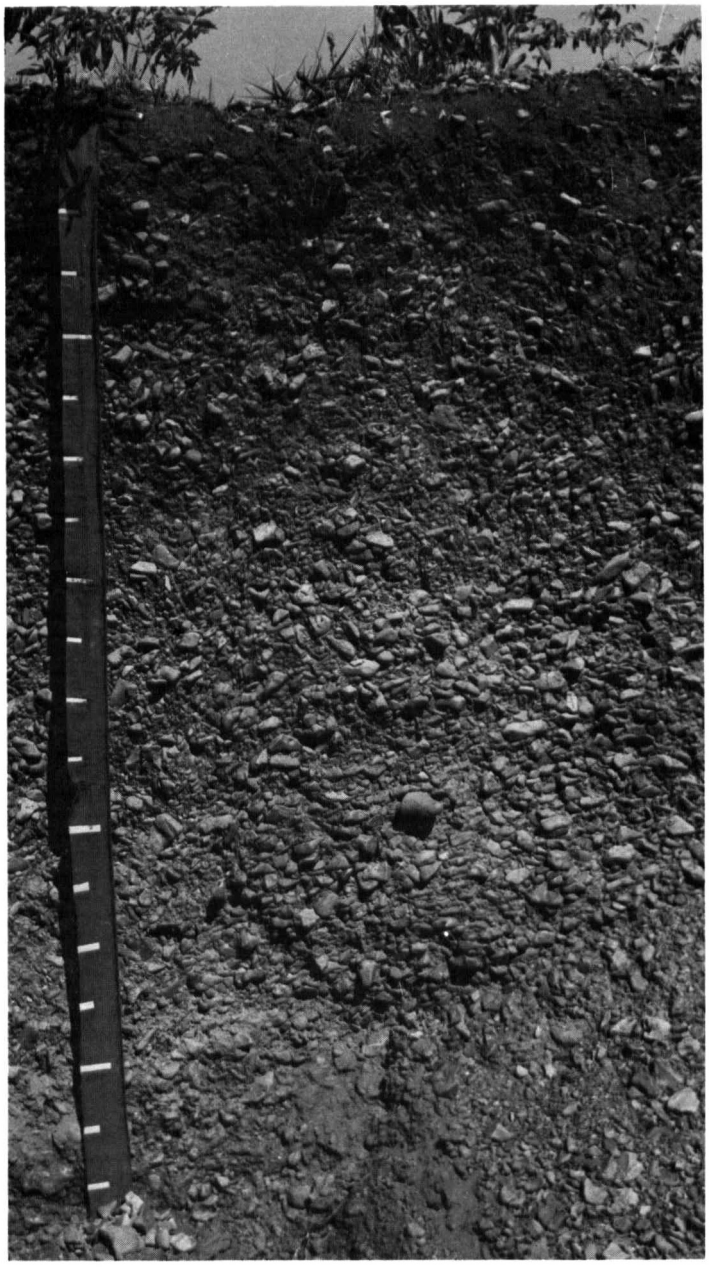

Figure 20.—**Representative profile of Olpe gravelly silt loam.**

Runoff is rapid, and the hazard of erosion is slight unless the soils are bare.

These soils are suited to native grasses and trees. Areas in native grasses are used as range and hayland. The woodland areas are used for recreation, wildlife habitat, and livestock grazing.

Controlling water erosion by maintaining a good soil cover and using range properly and controlling brush and trees are good management practices. Capability unit VIe–2; Loamy Upland range site; not placed in a woodland suitability group.

Osage Series

The Osage series consists of deep, nearly level, poorly drained soils on flood plains. These soils formed in thick, clayey alluvial sediment.

In a representative profile the surface layer is very dark gray silty clay about 18 inches thick. The upper 14 inches of the subsoil is very dark gray, extremely firm silty clay, and the lower 38 inches is dark-gray, extremely firm silty clay. The underlying material to a depth of about 90 inches is gray silty clay.

Permeability is very slow; available water capacity is moderate. The content of organic matter is medium or high. Natural fertility is medium.

Most of this acreage is cultivated. The rest is wooded or in native grasses.

Representative profile of Osage silty clay, in a cultivated field, 100 feet south and 100 feet west of the northeast corner of the NW1/4 sec. 21, T. 23 S., R. 17 E.:

Ap—0 to 7 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; moderate, medium, blocky structure breaking to coarse, granular; very hard, very firm; few roots; medium acid; gradual, smooth boundary.

A12—7 to 18 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; weak, blocky structure to massive; extremely hard, extremely firm; few roots; few black shot concretions; medium acid; diffuse boundary.

B21g—18 to 32 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; common fine mottles of olive brown (2.5Y 4/4) and very dark gray (N 3/0); weak, fine and medium, blocky structure; extremely hard, extremely firm; few black shot concretions; slightly acid; diffuse boundary.

B22g—32 to 70 inches, dark-gray (N 4/0) silty clay, dark gray (N 4/0) when dry; common fine mottles of olive brown (2.5Y 4/4); moderate, fine, blocky structure; extremely hard, extremely firm; slightly acid; diffuse boundary.

C—70 to 90 inches, gray (10YR 5/1) silty clay, gray (10YR 5/1) dry; few fine mottles of yellowish brown (10YR 5/4); massive; extremely hard, very firm; neutral.

The solum ranges from 40 to 70 inches in thickness. The A horizon is strongly acid to neutral, the B2g horizon is medium acid to neutral, and the C horizon is slightly acid to mildly alkaline. The A horizon, 15 to 28 inches thick, is very dark gray or black. The B2g horizon, 35 to 70 inches thick, is very dark gray in the upper part and very dark gray or dark gray in the lower part. The C horizon is gray or dark gray.

Osage soils are near Hepler, Leanna, and Verdigris soils. They do not have the loamy A horizon characteristic of Hepler, Leanna, and Verdigris soils or the loamy AC or C horizon characteristic of Verdigris soils.

Osage silty clay (0 to 1 percent slopes) (Og).—This soil is generally a few hundred feet from the stream channels, extending toward the uplands on broad flood plains. In some places, this soil extends to the stream channels. It occurs mainly along the Neosho River, but a few areas are along the Verdigris River and the larger creeks. It has the profile described as representative of the series. Included in mapping were small areas of Leanna and Verdigris soils and Osage silty clay loam.

Runoff is very slow. This soil is occasionally flooded. A small area in the backwater area of Toronto Reservoir is occasionally inundated for one month or more. Wetness is a moderately severe concern. The soil is sticky if worked when too wet and hard if worked when too dry.

This soil is suited to most locally grown crops. Sorghum and soybeans are the crops most commonly grown. Yields are affected by prolonged wetness, and

legumes are sometimes drowned. This soil is well suited to native grasses and trees. Areas in native grasses are used mainly as hayland, but a few are used as range. Some deciduous trees are used for lumber. Nuts are harvested from pecan and walnut trees.

The main concerns of cropland management are maintaining good tilth and fertility. Most areas need artificial drainage. Using range properly and controlling brush and trees are good management practices. Improving timber stands is important in woodland management. Capability unit IIIw-1; Clay Lowland range site; woodland suitability group 5w3.

Osage silty clay loam (0 to 1 percent slopes) (Os).—This soil has a surface layer of silty clay loam, but its profile is otherwise similar to the one described as representative of the series. It is in small to moderate-sized areas scattered irregularly in the flood plains of the larger streams. Included in mapping were small areas of Leanna and Verdigris soils and Osage silty clay.

Runoff is very slow. This soil is subject to flooding. A few small areas in the backwater area of Toronto Reservoir are occasionally inundated for one month or more.

This soil is suited to all locally grown crops. Corn, sorghum, and soybeans are the crops most commonly grown. Yields are affected sometimes by prolonged wetness. This soil is well suited to native grasses and trees. Areas in native grasses are used as hayland and range. Some deciduous trees are used for lumber. Nuts are harvested from pecan and walnut trees.

The main concerns of cropland management are maintaining good tilth and fertility. In some places, artificial drainage is needed. Using range properly and controlling brush and trees are good management practices. Improving timber stands is important in woodland management. Capability unit IIw-2; Loamy Lowland range site; woodland suitability group 4w2.

Ringo Series

The Ringo series consists of deep, sloping and strongly sloping, well-drained soils on uplands. These soils are on the side slopes of limestone escarpments and on slightly concave foot slopes. They formed in clayey sediment weathered from calcareous shale.

In a representative profile the surface layer is black heavy silty clay loam about 8 inches thick. The upper 4 inches of the subsoil is very dark grayish-brown, very firm silty clay, and the lower 38 inches is dark grayish-brown and olive, calcareous, firm and very firm silty clay. The underlying material, at a depth of about 50 inches, is light olive-brown, very soft, calcareous shale.

Permeability is very slow; available water capacity is moderate. The content of organic matter is high, and natural fertility is medium.

About three-fourths of this acreage is in native grasses. Most of the rest is cultivated, but a small acreage is wooded.

Representative profile of Ringo silty clay loam, 4 to 7 percent slopes, in an area of native grasses, 330 feet east and 50 feet south of the northwest corner of the NE1/4 sec. 22, T. 25 S., R. 14 E.:

A—0 to 8 inches, black (10YR 2/1) heavy silty clay loam, very dark gray (10YR 3/1) dry; moderate, medium, granular structure; hard, firm; many roots; neutral; gradual, smooth boundary.

B1—8 to 12 inches, very dark grayish-brown (2.5Y 3/2) silty clay, dark grayish brown (2.5Y 4/2) dry; few black (10YR 2/1) coatings on peds; moderate, medium, subangular blocky structure; very hard, very firm; common roots; few fine concretions of calcium carbonate; mildly alkaline; gradual, smooth boundary.

B21—12 to 23 inches, dark grayish-brown (2.5Y 4/2) silty clay, grayish brown (2.5Y 5/2) dry; few very dark grayish-brown (2.5Y 3/2) coatings on peds; moderate, medium, blocky structure; very hard, firm; few roots; few concretions of calcium carbonate; calcareous, slight effervesence; mildly alkaline; gradual, smooth boundary.

B22—23 to 37 inches, olive (5Y 4/3) silty clay, olive (5Y 5/3) dry; common medium mottles of dark gray (N 4/0) and olive brown (2.5Y 4/4); few very dark grayish-brown (2.5Y 3/2) coatings on peds; weak, medium, blocky structure; very hard, very firm; few roots; few concretions of calcium carbonate and soft accumulations of lime; calcareous, strong effervesence; moderately alkaline; gradual, smooth boundary.

B3—37 to 50 inches, olive (5Y 4/3) silty clay, pale olive (5Y 6/3) dry; few fine mottles of light olive brown (2.5Y 5/6); few very dark grayish-brown (2.5Y 3/2) coatings on peds; massive; very hard, firm; few concretions of calcium carbonate and soft accumulations of lime; calcareous, strong effervesence; moderately alkaline; gradual boundary.

C—50 to 60 inches, light olive-brown (2.5Y 5/4) very soft shale, light yellowish brown (2.5Y 6/4) dry; calcareous, strong effervesence; moderately alkaline.

The solum ranges from 40 to 60 inches in thickness and coincides with depth to shale. The A horizon is slightly acid to mildly alkaline, the B1 horizon is neutral to moderately alkaline, the B2 horizon is mildly alkaline or moderately alkaline, and the C horizon is moderately alkaline or strongly alkaline. The A horizon is black or very dark grayish-brown heavy silty clay loam or silty clay 7 to 12 inches thick. The B1 horizon, 4 to 10 inches thick, is very dark grayish brown or black. The B2 horizon is dark grayish-brown, olive-brown, or olive silty clay or clay 16 to 32 inches thick.

These soils have a thicker solum and are deeper to shale than defined in the range for the series, but this difference does not alter their usefulness or behavior.

Ringo soils are near Lula, Sogn, and Summit soils. They do not have the textural change in the upper part of the solum that is characteristic of Lula and Summit soils. Unlike Sogn soils, they do not have limestone bedrock at a depth of less than 20 inches.

Ringo silty clay loam, 4 to 7 percent slopes (Rc).—This sloping soil is on side slopes and slightly concave foot slopes below limestone ledges. It is in moderately wide, elongated areas that extend along limestone outcrops. It has the profile described as representative of the series. Included in mapping were small areas of Summit soils and soils that are similar to Ringo soils, except that the subsoil is reddish in color and is underlain by reddish shale.

Runoff is rapid, and the hazard of water erosion is moderate to severe.

This soil is suited to all locally grown crops. Grain sorghum, soybeans, and small grain are the crops most commonly grown. This soil is well suited to native grasses.

The main concerns of cropland management are controlling water erosion and maintaining good soil tilth and fertility. Such practices as terracing, contour farming, returning crop residue to the soil, using

a suitable cropping system, and fertilizing improve tilth and keep soil loss at a minimum. Using range properly and controlling undesirable plants that compete with native grasses are good management practices. Capability unit IIIe–7; Clay Upland range site; not placed in a woodland suitability group.

Ringo-Sogn complex, 4 to 15 percent slopes (Rd).—This complex consists of sloping and strongly sloping soils on limestone ledges and side slopes of limestone escarpments. It is in narrow, elongated areas that extend along limestone outcrops. About 50 percent of the mapping unit is Ringo silty clay loam, 30 percent is Sogn silty clay loam, and 20 percent is Clareson silty clay loam and Summit silty clay loam. Sogn soils are mainly above the limestone ledges. Ringo soils are on the side slopes below the limestone ledges. Exposed rock covers as much as 10 percent of the soil surface.

Runoff is rapid, and the hazard of water erosion is severe if soil cover is lacking.

This soil complex is suited to native grasses and used mainly as range. A few areas are used as hayland.

Using range properly and controlling undesirable plants that compete with native grasses are good management practices. Capability unit VIe–2; Ringo soils in Clay Upland range site, Sogn soils in Shallow Limy range site; not placed in a woodland suitability group.

Sogn Series

The Sogn series consists of very shallow and shallow, gently sloping and sloping, somewhat excessively drained soils mainly above limestone escarpments but also on smooth side slopes. The soils formed in material weathered from limestone.

In a representative profile the surface layer is very dark brown silty clay loam about 9 inches thick. It overlies limestone bedrock.

Permeability is moderate; available water capacity is very low. The content of organic matter is high. Natural fertility is medium.

Nearly all of the acreage is in native grasses and used as range.

In Woodson County, Sogn soils are mapped only in complex with Clareson and Ringo soils.

Representative profile of Sogn silty clay loam, in an area of Clareson-Sogn complex, 1 to 8 percent slopes, in an area of native grasses, 165 feet north and 100 feet west of the southeast corner of the SW1/4 sec. 15, T. 25 S., R. 17 E.:

A—0 to 9 inches, very dark brown (7.5YR 2/2) silty clay loam, dark brown (7.5YR 3/2) dry; moderate, fine and very fine, granular structure; hard, firm; few roots; few small limestone fragments; neutral; abrupt, wavy boundary.

R—9 inches, hard limestone bedrock.

The solum ranges from 4 to 20 inches in thickness, which coincides with depth to hard limestone. It is slightly acid to mildly alkaline. The A horizon is very dark brown or dark-brown silty clay loam or silty loam. In some places, the soil contains limestone fragments, but the fragments are less than 35 percent of the soil volume.

Sogn soils are near Clareson, Lula, Ringo, and Summit soils. They are less deep than these soils. Also, Sogn soils are underlain by limestone, whereas Ringo and Summit soils are underlain mainly by shale.

Stephenville Series

The Stephenville series consists of moderately deep, gently sloping and sloping, well-drained soils on uplands. These soils are gently sloping on ridgetops and sloping on convex side slopes. They formed in material weathered from sandstone.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam about 5 inches thick. The subsurface layer is dark-brown fine sandy loam about 9 inches thick. The subsoil is dark-brown and reddish-brown, friable sandy clay loam about 17 inches thick. The underlying material, at a depth of about 31 inches, is sandstone.

Permeability is moderate; available water capacity is low. The content of organic matter and natural fertility are low.

Most of this acreage is wooded. Small areas of native grasses are interspersed with the trees. A very small acreage is cultivated or in orchards.

Representative profile of Stephenville fine sandy loam, 1 to 4 percent slopes, in a wooded area, 1,200 feet south and 100 feet east of the northwest corner of the SW1/4 sec. 10, T. 26 S., R. 15 E.:

A1—0 to 5 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, dark grayish brown (10YR 4/2) dry; moderate, very fine, granular structure; slightly hard, very friable; many fine roots; leaf litter on surface; medium acid; gradual, smooth boundary.

A2—5 to 14 inches, dark-brown (10YR 4/3) fine sandy loam, pale brown (10YR 6/3) dry; weak, very fine, granular structure; slightly hard, very friable; common roots; medium acid; clear, smooth boundary.

B21t—14 to 22 inches, dark-brown (7.5YR 4/4) sandy clay loam, brown (7.5YR 5/4) dry; weak, fine, subangular blocky structure; slightly hard, friable; common roots; common open pores; few small sandstone fragments in upper part; strongly acid; gradual, smooth boundary.

B22t—22 to 31 inches, reddish-brown (5YR 4/4) sandy clay loam, strong brown (7.5YR 5/6) dry; weak, fine, subangular blocky structure; slightly hard, friable; common roots; common open pores; few soft sandstone fragments (2.5YR in hue) in lower horizon; strongly acid; abrupt, irregular boundary.

C—31 inches, brown (7.5YR 4/4) sandstone.

The solum ranges from 20 to 40 inches in thickness, which coincides with depth to sandstone. It is slightly acid to strongly acid. The A1 horizon, 3 to 7 inches thick, is very dark grayish brown or dark brown. The A2 horizon, 3 to 13 inches thick, is dark brown or reddish brown. The B2t horizon, 10 to 30 inches thick, is dark brown, reddish brown, or yellowish red.

Stephenville soils are near Darnell and Niotaze soils. They have a thickner solum than Darnell soils and a less clayey Bt horizon than Niotaze soils.

Stephenville fine sandy loam, 1 to 4 percent slopes (Sa).—This gently sloping soil is on ridgetops and side slopes. Included in mapping were small areas of Darnell and Niotaze soils.

Runoff is medium, and the hazard of water erosion is moderate.

This soil is suited mainly to small grain and grain sorghum. It also has potential for horticultural crops. Prolonged dry weather has an adverse effect on crops. This soil is suited to native grasses used mostly for livestock grazing, and to trees.

The main concerns of cropland management are

controlling water erosion and maintaining good soil tilth and fertility. Such practices as terracing, contour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss to a minimum. Using range properly and controlling brush and trees are good management practices. Capability unit IIe–2; Savannah range site; woodland suitability group 5d1.

Summit Series

The Summit series consists of deep, gently sloping and sloping, somewhat poorly drained soils on uplands. These soils are on foot slopes that are slightly concave below limestone ledges. They formed in clayey alkaline shale that was interbedded in places with limestone.

In a representative profile the surface layer is black silty clay loam about 12 inches thick. The upper 4 inches of the subsoil is black, firm heavy silty clay loam, and the lower 24 inches is very dark grayish-brown and dark grayish-brown, very firm silty clay. The underlying material is mixed dark grayish-brown and olive-brown silty clay.

Permeability is slow; available water capacity is moderate. The content of organic matter is high. Natural fertility is medium.

About half of the acreage is in native grasses. Most of the rest is cultivated, and a small acreage is wooded.

Representative profile of Summit silty clay loam, 1 to 4 percent slopes, in an area of native grasses, 120 feet west and 900 feet north of the southeast corner of the NE1/4 sec. 1, T. 26 S., R. 13 E.:

A11—0 to 6 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; moderate to strong, fine, granular structure; hard, firm; many roots; slightly acid; gradual, smooth boundary.

A12—6 to 12 inches, black (10YR 2/1) silty clay loam; very dark gray (10YR 3/1) dry; moderate to strong, medium, granular structure; hard, firm; many roots; sightly acid; gradual, smooth boundary.

B1—12 to 16 inches, black (10YR 2/1) heavy silty clay loam, very dark gray (10YR 3/1) dry; moderate to strong, subangular blocky structure; very hard, firm; common roots; slightly acid; gradual, smooth boundary.

B21t—16 to 28 inches, very dark grayish-brown (2.5Y 3/2) silty clay, dark grayish brown (2.5Y 4/2) dry; few streaks of black (10YR 2/1) on vertical faces of peds; few stains of olive brown (2.5Y 4/4) surround shot concretions below a depth of 19 inches and increase in number with depth; moderate, fine, blocky structure; very hard, very firm; thin clay film; common roots; neutral; gradual, smooth boundary.

B22t—28 to 40 inches, dark grayish-brown (2.5Y 4/2) silty clay, grayish brown (2.5Y 5/2) dry; few streaks of black (10YR 2/1) on vertical faces of peds; few fine stains of olive brown (2.5Y 4/4) mostly surrounding shot concretions; weak, medium, blocky structure; very hard, very firm; neutral; gradual, smooth boundary.

C11—40 to 54 inches, dark grayish-brown (2.5Y 4/2) and olive-brown (2.5Y 4/4) silty clay, grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/4) dry; few streaks of black (10YR 2/1) on vertical faces of peds; massive; very hard, very firm; very few roots; few black and brown shot concretions; few concretions of calcium carbonate; moderately alakline; gradual boundary.

C12—54 to 64 inches, olive-brown (2.5Y 4/4) silty clay, light olive brown (2.5Y 5/4) dry; few fine mottles of dark gray (N 4/0); massive; few ferromanganese shot concretions; few concretions of calcium carbonate; moderately alkaline.

The solum ranges from 30 to 50 inches in thickness. Depth to bedrock is more than 40 inches. The A horizon is slightly acid or medium acid. The B2t horizon is slightly acid or neutral in the upper part and neutral or mildly alkaline in the lower part, and the C horizon is neutral to moderately alkaline. The A horizon is black, very dark brown, very dark gray, or very dark grayish-brown silty clay loam or light silty clay 8 to 14 inches thick. The B1 horizon is 4 to 12 inches thick and is similar in color to the A1 horizon. It contains more clay than the A horizon. The B2t horizon, 18 to 36 inches thick, is very dark grayish brown or dark grayish brown. The C horizon is dark grayish brown and olive brown.

Summit soils are near Lula, Ringo, Sogn, and Woodson soils. They do not have the reddish-brown colors of Lula soils or the calcareous B horizon of Ringo soils. They are deeper to limestone bedrock than Sogn soils. They do not have the abrupt textural change characteristic of Woodson soils.

Summit silty clay loam, 1 to 4 percent slopes (Sd).—This gently sloping soil is on the lower foot slopes that extend along limestone outcrops. It has the profile described as representative of the series. Included in mapping were a few small areas of Ringo and Woodson soils. Also included were a few small areas of soils underlain by limestone at a depth of 20 to 40 inches and a few cultivated areas of soils that have a more clayey surface layer and that do not have the moderate to strong structure typical of soils under native grasses.

Runoff is medium, and the hazard of water erosion is moderate.

This soil is suited to all locally grown crops. Sorghum, soybeans, corn, and small grain are the crops most commonly grown. This soil is well suited to native grasses and used as range or hayland.

The main concerns of cropland management are controlling water erosion and maintaining good soil tilth and fertility. Cracks in the soil are common during dry weather (fig. 21). Such practices as terracing, contour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss to a minimum. Using range properly and controlling brush are good management practices. Capability unit IIe–1; Loamy Upland range site; not placed in a woodland suitability group.

Summit silty clay loam, 4 to 7 percent slopes (Se).—This sloping soil is on slightly concave foot slopes below limestone ledges. Included in mapping were a few small areas of Ringo soils. Also included were a few cultivated areas of soils that have a more clayey surface layer and that do not have the moderate to strong structure typical of soils under native grasses.

Runoff is rapid, and the hazard of water erosion is moderate to severe.

This soil is suited to all locally grown crops. Sorghum, soybeans, and small grain are the crops most commonly grown. This soil is well suited to native grasses and used mostly as range. A few areas are used as hayland.

The main concerns of cropland management are controlling water erosion and maintaining good soil tilth and fertility. Such practices as terracing, contour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss to a minimum. Using range properly and controlling undesirable plants that compete with native grasses are good management prac-

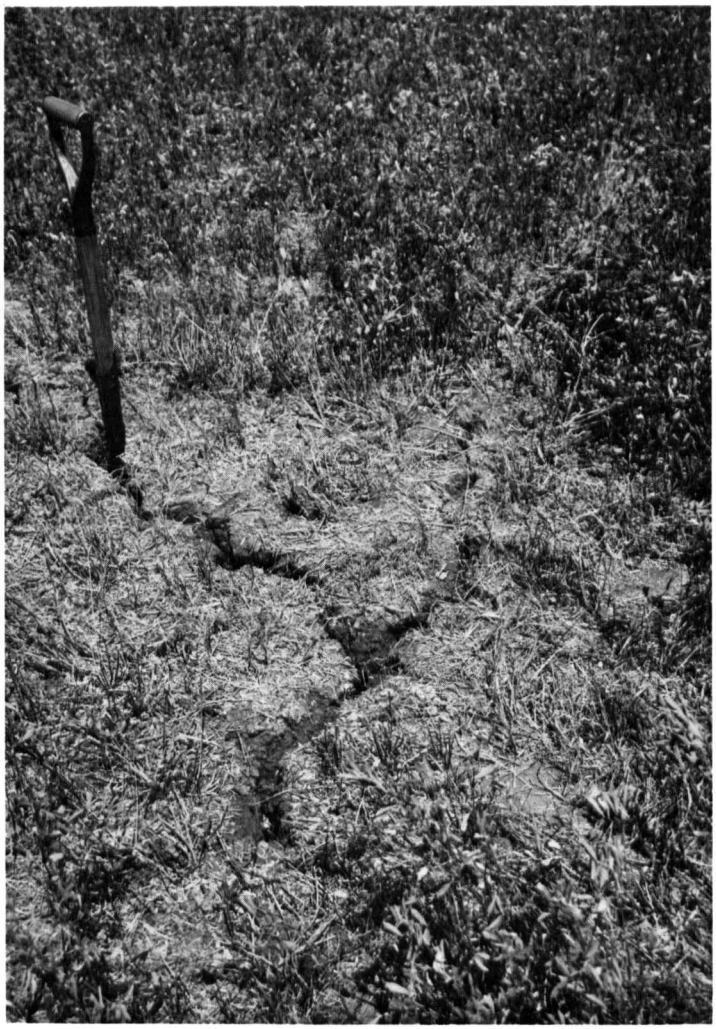

Figure 21.—**Summit soils crack during dry periods, especially in alfalfa fields.**

tices. Capability unit IIIe–1; Loamy Upland range site; not placed in a woodland suitability group.

Verdigris Series

The Verdigris series consists of deep, nearly level, moderately well drained soils on flood plains. These soils extend in an area a few hundred feet wide along both sides of the larger streams of the county. They formed in loamy alluvium.

In a representative profile the surface layer is very dark grayish-brown silt loam and silty clay loam about 25 inches thick. The next layer is dark grayish-brown, friable silty clay loam about 25 inches thick. The underlying material to a depth of 82 inches is very dark grayish-brown silty clay loam.

Permeability is moderate; available water capacity is high. The content of organic matter and natural fertility are medium to high.

Most of this acreage is cultivated. The rest is wooded or in native grasses.

Representative profile of Verdigris silt loam in a cultivated field, 990 feet south and 100 feet east of the center of sec. 24, T. 23 S., R. 16 E.:

A11—0 to 6 inches, very dark grayish-brown (10YR 3/2) heavy silt loam, grayish brown (10YR 5/2) dry; weak, fine, granular structure; slightly hard, friable; few roots; slightly acid; gradual, smooth boundary.

A12—6 to 25 inches, very dark grayish-brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) dry; weak, medium, granular structure; hard, friable; few roots; slightly acid; gradual, smooth boundary.

AC—25 to 50 inches, dark grayish-brown (10YR 4/2) light silty clay loam, light brownish gray (10YR 6/2) dry; faintly stratified with slightly darker colors; very weak, subangular blocky structure; hard, friable; neutral; diffuse boundary.

C—50 to 82 inches, very dark grayish-brown (10YR 3/2) heavy silty clay loam; grayish brown (10YR 5/2) dry; massive; very hard, firm; neutral.

The solum ranges from 24 to 50 inches in thickness. It is medium acid to neutral throughout. The A1 horizon is very dark grayish-brown or dark-brown silt loam or silty clay loam 10 to 34 inches thick. The AC horizon has streaks of slightly lighter and slightly darker colors. The C horizon is very dark grayish-brown to brown silty clay loam or silty loam.

Verdigris soils are near Cleora, Hepler, Mason, and Osage soils. They are less sandy than Cleora soils. They do not have the light-colored A2 horizon characteristic of Hepler soils. They contain stratified layers, unlike Mason soils. They are less clayey than Osage soils.

Verdigris silt loam (0 to 1 percent slopes (Va).—This nearly level soil is mainly on flood plains, but in a few places it is on short slopes along old abandoned stream channels and low, narrow benches. It extends in an area a few hundred feet wide along the Neosho and Verdigris rivers and along the larger creeks of the county. It has the profile described as representative of the series. Included in mapping were areas of Hepler, Mason, and Osage soils and areas of soils similar to Verdigris soils, except that they have a thinner surface layer. Also included were a few small areas of Verdigris soils in the backwater area of Toronto Reservoir. These soils are occasionally flooded for periods of one month or more.

Runoff is slow. This soil is occasionally flooded.

This soil is suited to all locally grown crops. Corn, grain sorghum, soybeans, small grain, and alfalfa are the crops most commonly grown. This soil is well suited to native grasses and trees. Some deciduous trees are used for lumber. Nuts are harvested from pecan and walnut trees.

The main concerns of cropland management are maintaining good soil tilth and high fertility. Using range properly and controlling brush and trees are good management practices. Improving timber stands is important in woodland management. Capability unit I–1; Loamy Lowland range site; woodland suitability group 3o2.

Verdigris soils, channeled (0 to 8 percent slopes) (Vc).—This mapping unit is on narrow, nearly level flood plains that have short, gently sloping and sloping side slopes. It extends along the small drainageways of the county in elongated areas that are about 100 to 300 feet wide and that are dissected by small, meandering channels. The soils have a profile similar to the one described as representative of the series, except that the underlying material contains more discernible strata darker or lighter in color. Included in mapping were small areas of Hepler and Leanna soils. Also included on the side slopes were soils

similar to the upland soils that surround areas of this soil.

Runoff is medium. The soils in this mapping unit are occasionally to frequently flooded for short periods. Water velocity is moderately rapid. The hazard of water erosion is moderate to severe, especially on the short side slopes where the soils are bare.

This mapping unit is suited to native grasses and trees. Areas in native grasses are used mainly as range, but a few are used as hayland. Farm ponds are often located in these soils, which are also used for waterways for constructed terrace outlets.

The main concern of management is controlling water erosion if soil cover is lacking. Using range properly and controlling brush and trees are good management practices. Capability unit VIw-1; Loamy Lowland range site; woodland suitability group 3o2.

Woodson Series

The Woodson series consists of deep, nearly level and gently sloping, somewhat poorly drained soils on broad upland areas. These soils formed in sediment presumed to be old alluvium. In places the sediment contains loess in the upper part and grades into residuum weathered from shale in the lower part.

In a representative profile the surface layer is very dark gray silt loam about 8 inches thick. The very firm silty clay subsoil, about 39 inches thick, is very dark gray in the upper part and gray in the lower part. The underlying material to a depth of 65 inches is gray light silty clay mottled with yellowish brown. Below this, to a depth of 75 inches, it is mixed gray and dark-brown light silty clay (fig. 22).

Permeability is very slow; available water capacity is moderate. The content of organic matter and natural fertility are medium.

About three-fourths of the acreage is cultivated. Most of the rest is in native grasses, and a very small acreage is wooded.

Representative profile of Woodson silt loam, 0 to 2 percent slopes, in an area of native grasses, 165 feet east and 600 feet north of the southwest corner of the NW1/4 sec. 16, T. 24 S., R. 17 E.:

A—0 to 8 inches, very dark gray (10YR 3/1) heavy silt loam, gray (10YR 5/1) dry; moderate, very fine, granular structure; hard, friable; many roots; medium acid; clear, smooth boundary.

B21t—8 to 22 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; few fine, faint mottles of dark yellowish brown (10YR 3/4); weak, medium, columnar structure breaking to moderate, medium, blocky; extremely hard, very firm; many roots; thin, continuous clay film; slightly acid; gradual, smooth boundary.

B22t—22 to 29 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; few, fine, faint mottles of dark yellowish brown (10YR 3/4); moderate, medium, blocky structure; extremely hard, very firm; common roots; thin, continuous clay films; neutral; gradual, smooth boundary.

B3—29 to 47 inches, gray (10YR 6/1) silty clay, light gray (10YR 7/1) dry; few vertical streaks of dark gray (10YR 4/1); few medium, distinct mottles of dark yellowish brown (10YR 4/4); weak, medium, blocky structure; very hard, very firm; very few roots; few fine and medium wormcasts; very few fine, smooth chert pebbles; slightly acid; diffuse boundary.

C1—47 to 65 inches (10YR 6/1) light silty clay; light gray (10YR 7/1) dry; few vertical streaks of dark grayish brown (10YR 4/2); common fine, distinct mottles of yellowish brown (10YR 5/6); weak, blocky structure to massive; very hard, firm; few roots; few fine and medium wormcasts; few fine, smooth chert pebbles; few black stains; slightly acid; diffuse boundary.

C2—65 to 75 inches, mixed gray (10YR 5/1) and dark-brown (7.5YR 4/4) light silty clay, light gray (10YR 6/1) and brown (7.5YR 4/4) dry; massive; very hard, firm; very few roots; few to common wormcasts; few black stains; slightly acid.

Figure 22.—**Representative profile of Woodson silt loam.**

The solum ranges from 30 to 60 inches in thickness. It is medium acid or slightly acid in the upper part and medium acid to mildly alkaline in the lower part. The A horizon is very dark gray or black silt loam or light silty clay loam 6 to

14 inches thick. The B2t horizon is silty clay or clay 16 to 35 inches thick and is very dark gray or black in the upper part and very dark gray or dark gray in the lower part. The B3 and C horizons are mixed gray, grayish brown, and dark brown.

Woodson soils are near Dennis, Dwight, Kenoma, and Summit soils. They do not have the gradual textural change characteristic of Dennis and Summit soils. They do not have the thin A horizon characteristic of Dwight soils or the brown colors characteristic of Kenoma soils.

Woodson silt loam, 0 to 2 percent slopes (Wa).—This nearly level and gently sloping soil is on broad upland areas. Included in mapping were small areas of Kenoma and Summit soils.

Runoff is slow, and the hazard of water erosion is moderate.

This soil is suited to all locally grown crops. Soybeans, grain sorghum, and small grain are the crops most commonly grown. This soil is well suited to native grasses and used as hayland and range.

The main concerns of cropland management are controlling water erosion and maintaining good soil tilth and fertility. Such practices as terracing, contour farming, returning crop residue to the soil, using a suitable cropping system, and fertilizing improve tilth and keep soil loss to a minimum. Using range properly and controlling brush are good management practices. Capability unit IIs–1; Clay Upland range site; not placed in a woodland suitability group.

Use and Management of the Soils

The soils in Woodson County are used mainly for cropland, range, and woodland. In this section management for these uses is explained, and predicted yields for the important crops are given. In addition, management of the soils for wildlife, for recreational sites, and for the building of highways, farm ponds, and other engineering structures is explained.

Use of Soils for Crops[2]

About 40 percent of Woodson County is cultivated. The principal crops are grain sorghum, soybeans, wheat, and alfalfa. Other corps are corn, oats, rye, barley, red clover, sweetclover, and lespedeza. A few strawberries and apples are also grown.

Management of soils involves a combination of practices that will reduce water erosion, maintain good soil structure, maintain adequate content of organic matter and high fertility, and conserve moisture. Erosion control and water conservation are successful if a proper combination of practices is used.

Using grasses, waterways, terracing, and contouring reduces water erosion and helps conserve moisture on upland soils in the county. Proper management of crop residues helps maintain good soil structure, increases the infiltration of water, and helps control water erosion. A cover of residue on the surface helps hold the soil in place and reduces the puddling effect of beating raindrops. Minimum or reduced tillage helps prevent the breakdown of soil aggregates and maintains more residue on the surface.

Cropping systems that include more frequent use of close-growing crops and legumes help reduce soil loss on soils that have a hazard of erosion. Addition of fertilizer when necessary is important for vigorous growth. Artificial drainage is needed on some bottom land soils to provide a good environment in which crops can grow.

Capability grouping

Some readers, particularly those who farm on a large scale, may find it practical to use and manage alike some of the different kinds of soil on the farm. These readers can make good use of the capability classification system, a grouping that shows, in a general way, the suitability of the soils for most kinds of farming (*9*).

The grouping is based on permanent limitations of soils when used for field crops, the risk of damage when they are farmed, and the way the soils respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops 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 for range, for forest trees, or for engineering.

In the capability system, all kinds of soil are grouped at three levels: the class, the subclass, and the unit. The broadest grouping, the capability class, is designated by Roman numerals I to VIII. In class I are the soils that have the fewest limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products. The subclass indicates major kinds of limitations within the classes. Within most of the classes there can be up to four subclasses. The subclasses are indicated 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* means that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c* indicates 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 or no limitations. Class V can contain, at the most, only subclasses *w*, *s*, and *c* because the soils are subject to little or no erosion but have other limitations that confine their use largely to pasture, range, or wildlife.

[2] EARL J. BONDY, conservation agronomist, Soil Conservation Service, assisted in the preparation of this section.

Subclasses are further divided into groups called capability units. These are groups of soils that are so much alike that they are suited to the same crops and pasture plants, require about the same management, and have generally similar productivity and other response to management. Capability units are generally identified by numbers assigned locally, for example, IIe–1 or IIIe–4.

The eight classes in the capability system and the subclasses and units in Woodson County are described in the list that follows. The unit designation for each soil is given in the "Guide to Mapping Units." For a complete explanation of capability classification, see Agriculture Handbook No. 210, *Land Capability Classification* (*9*).

Class I—Soils have few limitations that restrict their use (no subclasses).
- Unit I–1—Deep, nearly level, well drained and moderately well drained loamy soils; on stream terraces and flood plains.

Class II—Soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.
- Subclass IIe—Soils subject to moderate erosion unless protected.
  - Unit IIe–1—Deep, gently sloping, moderately well drained to somewhat poorly drained clayey soils; on uplands.
  - Unit IIe–2—Moderately deep, gently sloping, well drained loamy soils; on uplands.
  - Unit IIe–3—Deep, gently sloping, well-drained loamy soils; on uplands.
- Subclass IIw—Soils moderately limited because of excess water.
  - Unit IIw–1—Deep, nearly level, well-drained loamy soils; on flood plains.
  - Unit IIw–2—Deep, nearly level, poorly drained and somewhat poorly drained clayey soils; on flood plains and low stream terraces.
  - Unit IIw–3—Deep, nearly level, somewhat poorly drained loamy soils; on flood plains and low stream terraces.
- Subclass IIs—Soils moderately limited because of slow permeability.
  - Unit IIs–1—Deep, nearly level, somewhat poorly drained clayey soils; on uplands.

Class III—Soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both.
- Subclass IIIe—Soils subject to severe erosion if they are cultivated and not protected.
  - Unit IIIe–1—Deep, sloping, moderately well drained and somewhat poorly drained clayey soils; on uplands.
  - Unit IIIe–2—Moderately deep, sloping, well-drained loamy soils; on uplands.
  - Unit IIIe–3—Deep, gently sloping, moderately well drained clayey soils; on uplands.
  - Unit IIIe–4—Deep, gently sloping, moderately well drained, moderately eroded clayey soils; on uplands.
  - Unit IIIe–5—Moderately deep, gently sloping, moderately well drained clayey soils; on uplands.
  - Unit IIIe–6—Deep, gently sloping, moderately well drained, dense clayey soils and well-drained loamy soils; on uplands.
  - Unit IIIe–7—Deep, sloping, well-drained clayey soils; on uplands.
- Subclass IIIw—Soils severely limited for cultivation because of excess water.
  - Unit IIIw–1—Deep, nearly level, poorly drained clayey soils; on flood plains.

Class IV—Soils have very severe limitations that reduce the choice of plants, require very careful management, or both.
- Subclass IVe—Soils subject to very severe erosion if they are cultivated and not protected.
  - Unit IVe–1—Deep and moderately deep, sloping, moderately well drained and well drained, uneroded and eroded clayey soils; on uplands.
  - Unit IVe–2—Deep, gently sloping, moderately well drained and somewhat poorly drained, moderately eroded clayey soils; on uplands.
- Subclass IVs—Soils very severely limited because of high salinity or poor tilth.
  - Unit IVs–1—Deep, nearly level, moderately well drained, dense clayey soils; on uplands.

Class V—Soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use largely to pasture, range, woodland, or wildlife habitat (none in Woodson County).

Class VI—Soils have severe limitations that make them generally unsuited to cultivation and that restrict their use largely to pasture, range, woodland, or wildlife habitat.
- Subclass VIe—Soils severely limited, chiefly by hazard of erosion, unless protective cover is maintained.
  - Unit VIe–1—Moderately deep, sloping to moderately steep, well-drained loamy soils and somewhat poorly drained clayey soils; on uplands.
  - Unit VIe–2—Very shallow to deep, gently sloping to moderately steep, moderately well drained, dense clayey soils; on uplands.
- Subclass VIw—Soils severely limited, chiefly by frequent flooding with a hazard of erosion, unless protective cover is maintained.
  - Unit VIw–1—Deep, nearly level to sloping, well-drained loamy soils; on flood plains that have side slopes.

Class VII—Soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to range, woodland, or wildlife habitat.
- Subclass VIIs—Soils very severely limited, chiefly by shallowness, unless protective cover is maintained.
  - Unit VIIs–1—Shallow and moderately deep, steep and moderately steep, somewhat excessively drained and somewhat poorly drained loamy and clayey soils; on uplands.

Class VIII—Soils and landforms have limitations that

preclude their use for commercial crop production and that restrict their use to recreation, wildlife habitat, or water supply (none in Woodson County).

Predicted yields

Table 2 gives the predicted average yields per acre of the principal crops grown in the county. The yields are estimated averages over a period of years. They are based on information received from farmers' records, county extension agents' test plots, and observations of conservationists.

Crop yields vary widely and are greatly influenced by management practices, weather, and damage from insects or disease. In estimating yields, the effects of all factors except management were minimized. These yields are expected under improved management, or management used by farmers when they apply most of the latest proven practices. These practices are suggested under "Use of Soils for Crops." Generally, they are practices that protect the soil from erosion and conserve water. They include terracing, contouring, using minimum tillage, returning crop residue to the soil, and using a suitable cropping system. Other practices are planting adapted crop varieties, using fertilizer properly, and controlling insects and weeds.

Use of Soils for Woodland[3]

Discussed in this section are woodland suitability groups, their potential productivity, some hazards and limitations in management, and suitability of tree species.

There are about 20,000 acres of woodland in Woodson County, about 5 percent of the total land area. An estimated 70 percent of the woodland is used for grazing.

Approximately half of the woodland is in the uplands, mostly in the southwest part of the county, and some small areas are scattered in the western half. The remaining woodland is in bottom land areas.

The upland woodland is an oak-hickory plant association with an understory of grasses. This is commonly referred to as a savannah type of plant association. Blackjack and post oaks produce more than 90 percent of the annual woody production. Hickory and red oaks, with a slight amount of sumac and buckbrush, produce the remainder; little and big bluestem provide 75 percent of the annual grass yields; and the rest comes from Indiangrass, sedges, switchgrass, Virginia wildrye, rosette panicums, and a variety of lesser species. Total herbage yields, by types of vegetation, vary according to percent of the soil surface covered by tree canopies. When the canopy cover is 0 to 25 percent, trees produce 10 to 25 percent of the total herbage yield. Trees produce 90 to 100 percent of the total herbage yield when the canopy cover ranges from 76 to 100 percent. Refer to table 4, under Shallow Savannah range site, for the herbage production in relation to percent of canopy coverage.

The use and management of Darnell soils, in woodland suitability group 5d2, is also discussed under Shallow Savannah range site, and of Niotaze soils, in woodland suitability group 5r2, and Stephenville soils, in woodland suitability group 5dl, are discussed under Savannah range site in the section "Range."

[3] LEONARD J. JURGENS, range conservationist, Soil Conservation Service, assisted in the preparation of this section.

TABLE 2.—*Predicted average yields per acre of principal crops grown under a high level of management*

[Absence of a yield indicates that the crop is not commonly grown on the specified soil. Soils not listed are not generally used for the crops shown]

Soil	Grain sorghum	Soybeans	Wheat	Corn	Alfalfa	Pasture
	Bu	*Bu*	*Bu*	*Bu*	*Ton*	*AUM*[1]
Bates loam, 1 to 4 percent slopes	55	23	32	50	3.1	5.0
Bates loam, 4 to 7 percent slopes	50	20	30	45	2.6	4.8
Cleora fine sandy loam	55	30	32	60	4.0	7.5
Dennis silt loam, 1 to 3 percent slopes	68	32	40	60	4.0	5.8
Dennis silt loam, 3 to 6 percent slopes	66	26	35	55	3.5	5.5
Dennis silty clay loam, 1 to 3 percent slopes, eroded	55	22	30	50	3.1	4.8
Dennis and Eram soils, 3 to 7 percent slopes, eroded	35	15	20	30	1.9	4.0
Dwight silt loam, 0 to 2 percent slopes	37	11	21	26	1.7	3.2
Eram silty clay loam, 1 to 4 percent slopes	50	23	28	46	3.0	5.5
Eram silty clay loam, 4 to 7 percent slopes	39	20	22	37	2.6	4.8
Hepler silt loam	68	33	35	66	4.2	7.5
Kenoma silt loam, 1 to 2 percent slopes	66	24	31	57	2.9	5.0
Kenoma-Olpe complex, 2 to 7 percent slopes	38	18	23	36	1.9	4.5
Kenoma and Woodson soils, 1 to 3 percent slopes, eroded	52	20	25	44	2.5	4.0
Leanna silt loam	61	26	31	57	3.1	7.0
Lula silt loam, 0 to 2 percent slopes	65	30	40	60	3.5	6.5
Lula-Dwight complex, 0 to 2 percent slopes	50	20	30	40	2.3	4.5
Mason silt loam	70	33	42	67	4.2	7.5
Osage silty clay	60	26	28	54	2.0	4.5
Osage silty clay loam	70	31	35	66	2.8	6.0
Ringo silty clay loam, 4 to 7 percent slopes	50	24	30	50	3.0	5.1
Stephenville fine sandy loam, 1 to 4 percent slopes	45	22	28	46	2.6	5.2
Summit silty clay loam, 1 to 4 percent slopes	65	30	35	60	3.5	5.8
Summit silty clay loam, 4 to 7 percent slopes	60	25	30	55	3.1	5.5
Verdigris silt loam	73	35	41	75	4.8	8.0
Woodson silt loam, 0 to 2 percent slopes	66	24	31	57	2.9	5.0

[1] Animal-unit-months is a term used to express the carrying capacity of pasture. It is the length of time that one animal unit (one cow, steer, or horse; five hogs; or seven sheep or goats) can graze 1 acre without damaging the pasture.

Woodland suitability groups

Some soils of Woodson County that have potential for use as woodland have been placed in woodland suitability groups to assist owners in planning the use of their soils for wood crops. Each group is made up of soils that are suited to the same kinds of trees, that need approximately the same kind of management when the vegetation on them is similar, and that have about the same potential productivity.

Each woodland group is identified by a three-part symbol, such as 1w5, 2c8, or 3r2. The first part of the symbol, a number, indicates the relative potential productivity of the soils in the group: 1 = very high; 2 = high; 3 = moderately high; 4 = moderate; and 5 = low. These ratings are based on field determinations of the average site index of an indicator forest type or species. Site index is the height, in feet, that the dominant trees of a given species, on a specified kind of soil, reach in a natural, unmanaged stand in a stated number of years. For the merchantable hardwoods and softwoods in this county, the site index is the height reached in 50 years, except for cottonwood, for which the index is height reached in 30 years.

The second part of the symbol identifying a woodland group is a small letter. This letter indicates an important soil property that imposes a slight to severe hazard or limitation in managing soils of the group for wood crops. A letter *c* shows that the main limitation is the kind or amount of clay in the upper part of the soils in the group; *o* shows that the soils have few limitations that restrict their use for trees; *r* shows that the main limitation is steep slopes; *s* shows that the soils are sandy and dry, have little or no difference in texture between the surface layer and the subsoil, have low available water capacity, and generally have a low supply of plant nutrients; *w* shows that water in or on the soil, either seasonally or year round, is the chief limitation; and *d* shows that the main limitation is restricted depth to root zone, due to depth to rock or shale.

The third part of the symbol indicates the degree of hazard or limitation. The numeral *1* indicates soils that have no limitations, or only slight limitations, the numeral *2* indicates soils that have one or more moderate limitations, the numeral *3* indicates soils that have one or more severe limitations, and the numeral *0* indicates that the soils are not suitable for producing timber commercially.

Factors that affect management of soils for woodland in Woodson County are hazards of windthrow and erosion, equipment restrictions, seedling mortality, and plant competition.

To facilitate management, the soils of Woodson County have been placed in woodland groups, which are described in this section. Important to the description of each woodland group are the ratings made for hazard of windthrow, hazard of erosion, restrictions to use of equipment, hazard of seedling mortality, and risk of competition from undesirable plants. These ratings are always *slight, moderate,* or *severe.* The following explanations of these ratings apply to all woodland suitability groups in Woodson County.

Erosion hazard refers to the potential hazard of soil losses in woodland. The hazard is *slight* if expected soil losses are small; *moderate* if some losses are expected and care is needed during logging and construction to reduce soil losses; *severe* if special methods of operation are necessary for preventing excessive soil losses. In Woodson County, only the steep soils are subject to severe erosion.

Equipment restrictions are rated on the basis of soil characteristics that limit or prohibit the use of equipment commonly used in tending and harvesting trees. In Woodson County the soil characteristics having the most limiting effects are drainage, depth to water table, slope, and texture of the surface layer. *Slight* means that there is no restriction in the kind of equipment or in the time of year it is used; *moderate* means that use of equipment is restricted for less than three months of the year; and *severe* means that special equipment is needed, and its use is restricted for more than three months of the year.

Seedling mortality refers to the expected degree of mortality of planted seedlings as influenced by kinds of soil when plant competition is not a limiting factor. Considered in the ratings are depth to the water table, hazard of flooding, drainage, soil depth and structure, and degree of erosion. Normal rainfall, good planting stock, and proper planting are assumed. A rating of *slight* indicates an expected loss of less than 25 percent of the planted seedlings; *moderate,* a loss of 25 to 50 percent; and *severe,* a loss of more than 50 percent. Special preparation of the site is needed before planting on soils rated severe and on most soils rated moderate.

Plant competition is rated on the basis of the degree to which unwanted plants invade openings in the tree canopy. Considered in the ratings are available water capacity, fertility, drainage, and degree of erosion. A rating of *slight* means that competition from other plants is not a problem; *moderate,* that plant competition delays development of fully stocked stands of desirable trees; and *severe,* that plant competition prevents establishment of a desirable stand unless intensive site preparation and such practices as weeding are used to control undesirable plants.

Windthrow hazard measures the effect of the soils on root development and the ability of the soil to hold trees firmly. The hazard is *slight* when effective rooting depth is more than 20 inches and the tree withstands most wind; *moderate* when effective rooting depth is 10 to 20 inches and some trees are blown down during periods of excessive soil wetness and strong wind; *severe* when effective rooting depth is 10 inches or less and trees will not stand alone in strong wind.

In Table 3 the soils are placed in woodland suitability groups, management limitations for particular soils are given, and some of the preferred timber species and their average site indexes are shown.

In the following paragraphs, the woodland suitability groups in Woodson County are described.

WOODLAND SUITABILITY GROUP 2o2

This group consists of deep, well-drained loamy soils on bottom lands that are subject to occasional flooding. Available water capacity is high and natural fertility is medium. Productivity is high. Important species are cottonwood and red oak. The main limitation is moderate plant competition.

TABLE 3.—*Woodland suitability*

[Soil series not listed are not extensively used for woodland]

Soil series	Woodland suitability group	Important species	Site index	Erosion hazard	Equipment restrictions	Seedling mortality	Plant competition	Windthrow hazard	Trees to favor in existing stands	Trees to plant
Cleora series.	2o2	Cottonwood Red oak Sweetgum	100 80 90	Slight	Slight	Slight	Moderate	Slight	Cottonwood, black walnut, sycamore.	Black walnut, cottonwood, sycamore.
Darnell series.	5d2	Post oak Blackjack oak	45 40	Moderate	Moderate	Slight	Slight	Moderate	Upland oaks	Upland oaks.
Hepler series.	3w2	Upland oaks Hackberry Pin oak Green ash Cottonwood	67 76 80 73 90	Slight	Moderate	Moderate	Moderate	Slight	Upland oaks, hackberry, green ash, pecan, sycamore.	Pecan, green ash, sycamore.
Leanna series.	3w2	Upland oaks Hackberry Cottonwood Green ash Pin oak	65 75 85 75 85	Slight	Moderate	Moderate	Moderate	Slight	Upland oaks, hackberry, sycamore, green ash, pecan, hickory.	Pecan, green ash, sycamore, cottonwood.
Mason series.	3o1	Sweetgum Red oak Green ash Black walnut Cottonwood	80 65 75 75 90	Slight	Slight	Slight	Slight	Slight	Sweetgum, red oak, green ash, black walnut, cottonwood.	Sweetgum, red oak, green ash, black walnut.
Niotaze series.	5r2	Post oak Blackjack oak Red oak Bur oak Hickory	50 45 48 48 48	Moderate	Moderate	Slight	Slight	Moderate	Upland oaks, hickory.	Upland oaks.
Osage series: Silty clay loam.	4w2	Pin oak Bur oak Green ash Hackberry Hickory Pecan	74 56 70 66 59 74	Slight	Moderate	Moderate	Moderate	Slight	Pin oak, bur oak, green ash, hackberry, pecan.	Green ash, pecan, pin oak.
Silty clay.	5w3	Pin oak Pecan	50 40	Slight	Severe	Moderate	Moderate	Slight	Pin oak, bur oak, green ash, hackberry, pecan.	Green ash, pecan, pin oak.
Stephenville series.	5d1	Post oak Blackjack oak	50 45	Slight	Slight	Slight	Slight	Slight	Upland oaks	Upland oaks.
Verdigris series.	3o2	Upland oaks Hackberry Black walnut Soft maple Green ash Cottonwood Hickory Pin oak	56 69 70 61 60 87 73 85	Slight	Moderate	Slight	Moderate	Slight	Upland oaks, hackberry, black walnut, green ash, cottonwood.	Cottonwood, sycamore, pin oak.

WOODLAND SUITABILITY GROUP 3o1

This group consists of deep, well-drained loamy soils on bottom lands and terraces that are subject to occasional flooding. Available water capacity is high, and natural fertility is medium to high. These soils are well suited to trees, and productivity is moderately high. Important species are black walnut, red oak, cottonwood, and green ash.

WOODLAND SUITABILITY GROUP 3o2

This group consists of deep, moderately well drained loamy soils on bottom lands that are subject to occasional flooding. Available water capacity is very high, and natural fertility is medium to high. Productivity is moderately high. Important species are black walnut, cottonwood, green ash, and hackberry. The main limitations are restrictions on use of equipment and invasion by weedy plants.

WOODLAND SUITABILITY GROUP 3w2

This group consists of deep, poorly drained and somewhat poorly drained soils on bottom lands that are subject to occasional flooding. The soils have a surface layer of silt loam and subsoil of silty clay loam or silty clay. Available water capacity is high where the subsoil is silty clay loam and moderate where the subsoil is silty clay. Natural fertility is medium. Productivity is moderately high. Important species in a natural stand are cottonwood, green ash, and hackberry. The main limitation is the hazard of flooding, which affects stand development and control of weeds, trees, and vines.

WOODLAND SUITABILITY GROUP 4w2

This group consists of deep, poorly drained soils on bottom lands. The soils have a surface layer of silty clay loam and a subsoil of silty clay and are subject to occasional flooding. Available water capacity is moderate, and natural fertility is medium. Productivity is moderate. Important species are pin oak, bur oak, hackberry, and pecan. The main limitations are seedling mortality and invasion by weedy plants.

WOODLAND SUITABILITY GROUP 5d1

This group consists of moderately deep, gently sloping and sloping, well-drained loamy soils on uplands. Available water capacity is low, and natural fertility is low. Productivity is low. Important species are post oak and blackjack oak. The main limitation is restricted rooting depth.

WOODLAND SUITABILITY GROUP 5d2

This group consists of shallow, sloping and steep, well-drained and somewhat excessively drained loamy soils on uplands. Available water capacity is very low, and natural fertility is low. Productivity is low. Important species are post oak and blackjack oak. The main limitations are soil depth and steepness of slope, which affect the hazards of erosion and windthrow and restrict use of equipment.

WOODLAND SUITABILITY GROUP 5r2

This group consists of moderately deep, somewhat poorly drained soils on uplands. The soils have a surface layer of loam and a subsoil of silty clay. Available water capacity and natural fertility are low. Productivity is low. Important species are post oak and blackjack oak. The main limitation is steepness of slope, which affects the hazards of erosion, seedling mortality, and plant competition.

WOODLAND SUITABILITY GROUP 5w3

This group consists of deep, poorly drained, clayey soils on bottom lands that are subject to occasional flooding. Available water capacity is moderate, and natural fertility is medium. Productivity is low. Important species are pin oak, bur oak, hackberry, and pecan. The main limitations are wetness, flooding, and clayey texture, which restrict use of equipment and affect seedling mortality.

Range[4]

Woodson County has approximately 142,500 acres of range, about 45 percent of its total land area. An additional 10,300 acres of land classed as upland woodland is used as range and is discussed in the Savannah and Shallow Savannah range site descriptions as well as in the section "Use of Soils for Woodland." Another 23,500 acres of pasture has been established in the county. Range, pasture, and upland woodland together make up about 55 percent of the total land area of the county. On this land the principal farm income is derived from grazing of livestock, but some is derived from harvest of hay.

Livestock operations consists primarily of cow-calf units. Stocker-feeder programs and yearling operations are also used by a number of ranches. A major feedlot with capacity for 20,000 head is also located in the county. More than 7 million dollars in beef sales is recorded in the county each year. This represents approximately 60 percent of the total farm income of the county.

Range is also used by whitetail deer, as well as by prairie chicken, quail, and rabbit, which depend on it for food and cover.

In Woodson County the soils that formed in limestone and associated shale differ significantly from soils that formed in sandstone and associated shale. Range vegetation is influenced by these soil differences, and, where significant, these differences are noted in the individual range site descriptions. Figures 23 and 24 show the relationship of major soils and range sites on the limestone and sandstone landscapes, respectively.

Bottom-land or alluvial soils are present in both landscapes. These are the most productive soils in the county. In many places these soils have been converted to pasture, hayland, or cropland to provide forage and feed used for livestock.

Range sites and condition classes

The climax plant community is the native plant community best adapted to the particular environmental complex of the site. It is relatively stable and in equilibrium with the environment. Variability within reasonable limits is the rule rather than the exception as the plant community responds to seasonal and annual climatic conditions.

Most of the soils in Woodson County support climax vegetation that is suitable for use by grazing animals. Soils that produce similar kinds and amounts of climax vegetation are grouped into range sites for inventory and management purposes. Most of the soils in the county are dominated by grasses and forbs in climax condition. Woody vegetation is a climax component on some soils.

A range site is a distinctive kind of range that differs from other kinds of range in its potential to produce native plants. In the absence of abnormal disturbance and site deterioration, a range site supports a plant community different from other range

[4] By LEONARD J. JURGENS, range conservationist, Emporia, Kansas.

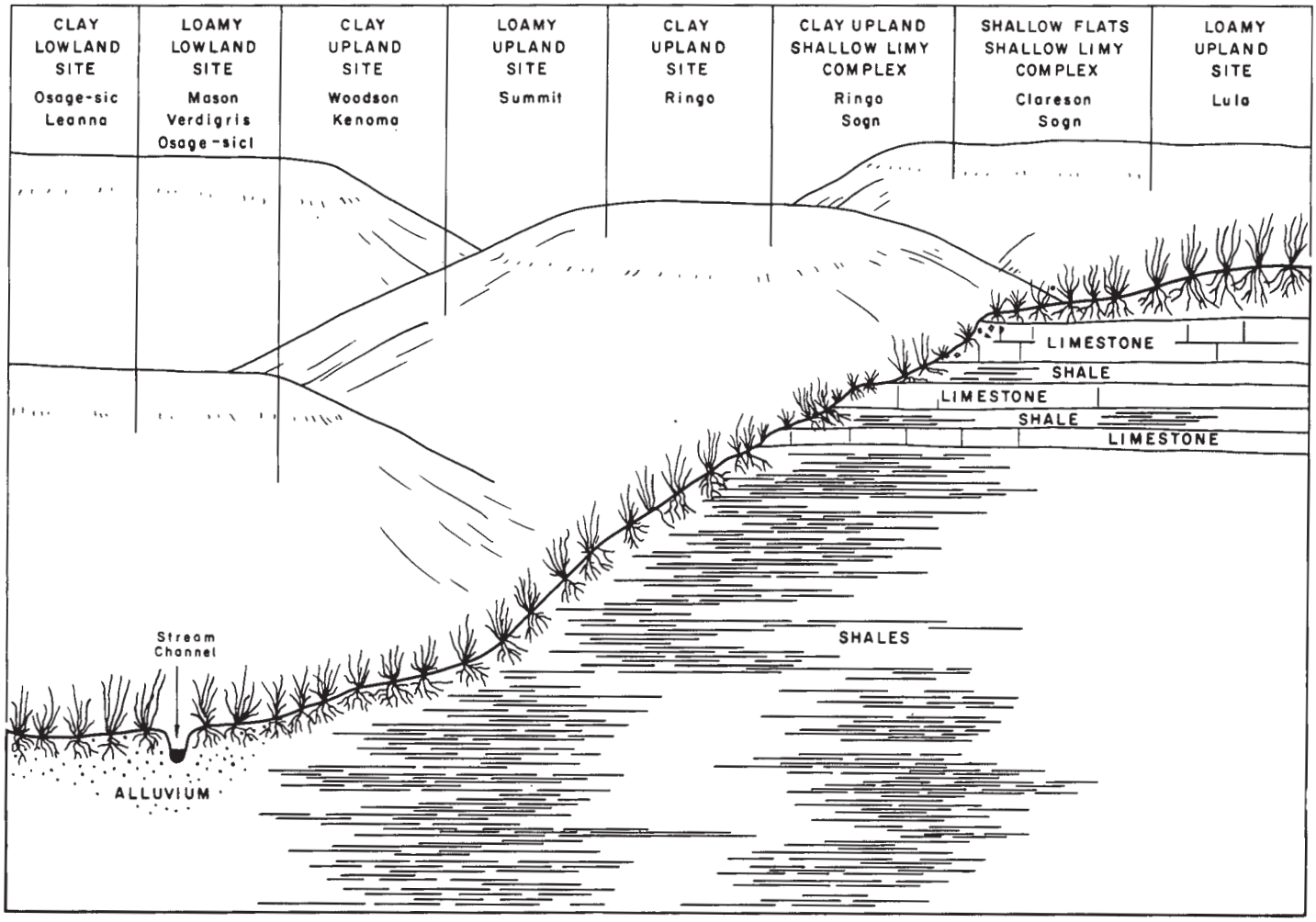

***Figure 23.*—Major range sites and soils overlying limestone in Woodson County.**

sites in terms of kind or proportion of species or in total annual yield.

Range condition is the present state of the vegetation of a range site in relation to the climax plant community for that site.

Range condition classes are an expression of the degree to which the present composition, expressed in percent, has departed from that of the climax plant community of a range site. Four range condition classes are recognized: *excellent*, which means that 76 to 100 percent of the climax vegetation is present; *good*, which means that 51 to 75 percent is present; *fair*, which means that 26 to 50 percent is present; and *poor*, which means that 0 to 25 percent is present.

The purpose of determining range condition is to approximately measure changes that have taken place in the plant cover and thereby provide a basis for predicting the nature and direction of changes in the plant community to be expected from management.

The range condition of an area of land within a range site is determined by comparing present vegetation with the climax plant community, as indicated by the range condition guide for the site. To facilitate this process, components of the plant community are segregated according to their response to grazing. These component categories are decreaser, increaser, and invader plants.

Decreaser plants are species in the climax plant community that decrease in relative abundance when such a community is subject to continued excessive grazing. Usually the decrease results from excessive grazing associated with high animal preference for the species. The total of all such species is counted in determining range condition class.

Increaser plants are species in the climax plant community that usually increase in relative abundance when the community is subject to continued excessive grazing. Plants that have a moderately high grazing value may initially increase, then decrease as grazing pressure continues. Others of low or negligible grazing value may continue to increase. Under prolonged excessive grazing, increaser plants may dominate the site. In determining range condition, only that portion of increaser species in the climax plant community is counted.

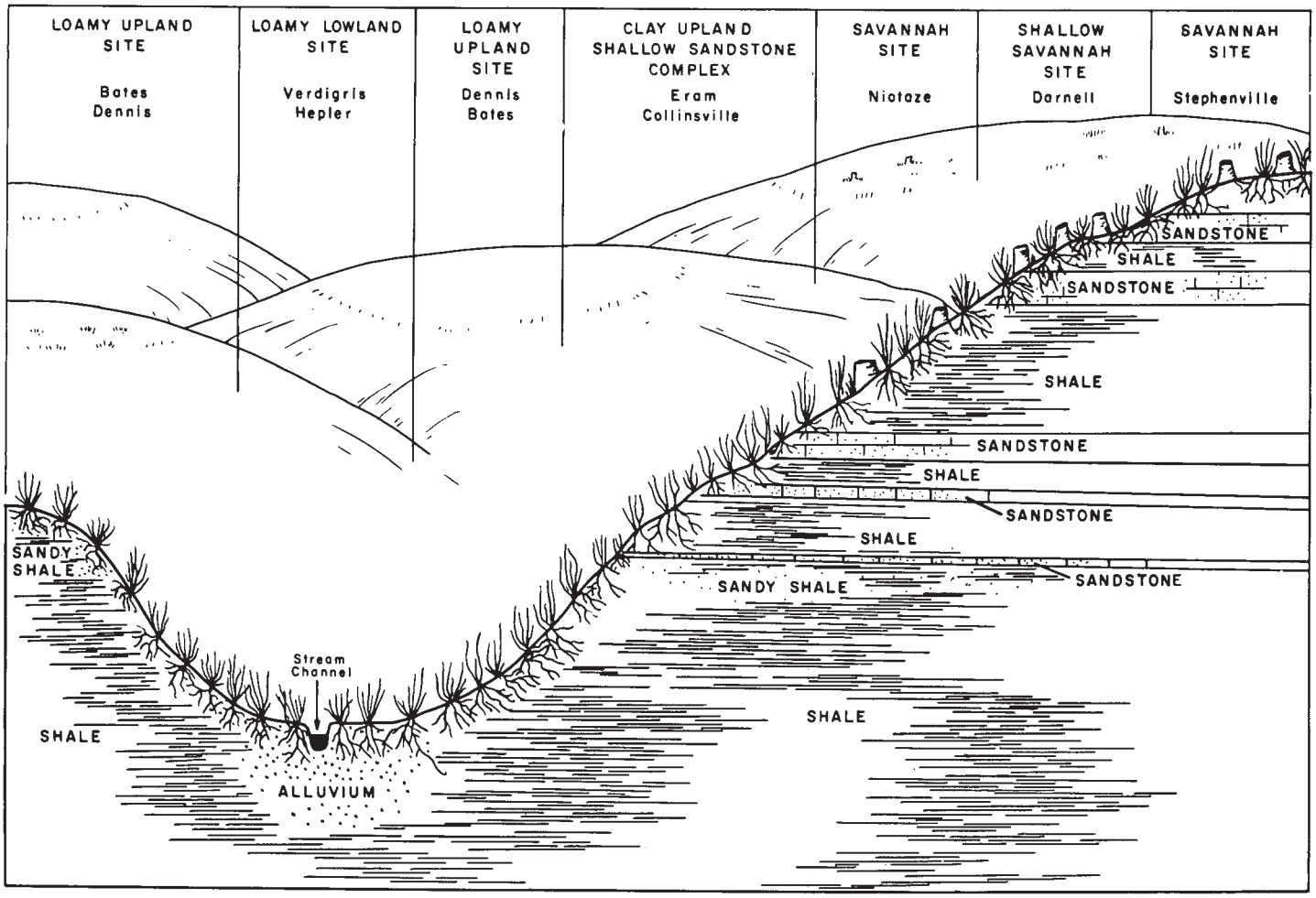

***Figure 24.*—Major range sites and soils overlying sandstone in Woodson County.**

Invader plants are not members of the climax plant community for the site. They invade the community as a result of various kinds of disturbances. They are not restricted to exotics, and may be normal components of the climax plant community of other range sites in the same locality. They may be annual or perennial, woody or herbaceous. Their forage value or grazing value may be high or low. Invader plants are not counted in determining range condition class.

Descriptions of range sites

The Loamy Upland and Clay Upland range sites are the most widely distributed range sites in Woodson County. The Clay Lowland and Loamy Lowland range sites are limited to the flood plains. The Shallow Flats and Shallow Limy range sites are found on the limestone-derived soils, and the Savannah, Shallow Sandstone, and Shallow Savannah range sites are associated with the sandstone-derived soils. The Claypan range site occurs as an inclusion in other sites, or it is found as an individual mapping unit and used primarily as range. Where significant, management practices on particular soils are listed in the individual range site descriptions. For a more complete description of the various soils in these range sites, review the section "Descriptions of the Soils."

CLAY LOWLAND RANGE SITE

Osage silty clay and Leanna silt loam are the only soils in this range site. These soils are occasionally flooded. They are used for native meadow, cultivated crops, and range. The climax plant community on this site is about 30 percent prairie cordgrass; 20 percent eastern gamagrass; 10 percent each, switchgrass, big bluestem, and indiangrass, and 5 percent each, tall dropseed, Maximilian sunflower, forb decreasers, and sedges. Production ranges from 10,000 pounds of air-dry forage per acre in favorable years to 4,000 pounds per acre in unfavorable years. All species provide forage for livestock.

Heavy grazing causes eastern gamagrass, big bluestem, and indiangrass to decrease. As grazing pressure continues, prairie cordgrass and switchgrass also decrease. Tall dropseed and ironweed are the major increasers. Invaders, such as sumpweed, lanceleaf ragweed, barnyardgrass, annual three-awn, and weed trees, move in.

Continued heavy use results in a plant community consisting mainly of weed trees, tall dropseed, purpletop, barnyardgrass, sumpweed, lanceleaf ragweed, annual three-awn, and other low-quality annual grasses and forbs. All of these are poor quality forage for livestock.

Most grazed areas of this site are in poor to fair condition. Brush and weed control, along with deferred grazing, are necessary to restore productivity on this site. If an area of this site is large enough to manage separately from the surrounding range sites, it should be fenced separately for proper grazing management.

On Leanna soils slickspots are common. On these slickspot areas, western wheatgrass is the principal species, and sedge and rush species provide most of the remaining herbage.

CLAY UPLAND RANGE SITE

This site consists of the soils of the Eram, Kenoma, Ringo, and Woodson series and of eroded Dennis soils. The climax plant community on this site is about 25 percent big bluestem; 20 percent little bluestem; 15 percent each, indiangrass and switchgrass; 5 percent each, Virginia wildrye, side-oats grama, and tall dropseed; 3 percent each, sedges and forb decreasers; and 2 percent each, rosette panicums and leadplant amorpha. Production ranges from approximately 7,500 pounds of air-dry forage per acre in favorable years to 2,500 pounds per acre in unfavorable years. All species provide forage for livestock.

Light summer grazing favors little bluestem at the expense of big bluestem. Under heavy grazing big bluestem, little bluestem, and indiangrass are replaced by tall dropseed and some side-oats grama. As heavy grazing continues, tall dropseed and heath aster increase. Invaders, such as annual three-awn, annual bromes, annual ragweed, and lanceleaf ragweed, come in. Tall dropseed, heath aster, and annuals dominate when range condition is reduced to fair or poor.

Abandoned cultivated fields on this range site, consisting of eroded Dennis and Eram soils, need treatment and reseeding. Their present cover, mostly annual three-awn, provides little soil protection and inhibits the establishment of climax species.

CLAYPAN RANGE SITE

Dwight soils and small included slickspots of Dennis and Leanna soils are in this range site. The climax plant community on this site is about 20 percent switchgrass; 15 percent each, side-oats grama and little bluestem; 10 percent each, tall dropseed and western wheatgrass; 5 percent each, blue grama, buffalograss, sedges, forb increasers, and forb decreasers; 3 percent Virginia wildrye; and 2 percent Canada wildrye. Production ranges from 4,000 pounds of air-dry forage per acre in favorable years to 1,500 pounds per acre in unfavorable years. All species provide forage for livestock.

Species composition is affected by the variable alkalinity and salinity in these soils and because livestock frequently graze this site heavily. Under heavy grazing, rapid degeneration occurs, and little bluestem, switchgrass, and side-oats grama are replaced by blue grama and occasionally by buffalograss. Tall dropseed, western ragweed, and annual grasses invade. Tall dropseed, annual three-awn, annual bromes, annual dropseed, and lanceleaf ragweed dominate under conditions of severe overuse.

This site responds slowly to management but will provide excellent forage if used in a planned grazing system.

LOAMY LOWLAND RANGE SITE

This range site, in climax condition, is the most productive site in the county. It consists of the soils of the Cleora, Hepler, Mason, and Verdigris series and Osage silty clay loam. These soils are limited in extent and are used mostly for cultivated crops, pasture, and hay. The climax plant community on this site is about 20 percent each, big bluestem and eastern gamagrass; 15 percent indiangrass; 10 percent switchgrass; 5 percent each, prairie cordgrass, tall dropseed, sedges, forb decreasers, forb increasers, and woody increasers; 3 percent Virginia wildrye; and 2 percent Canada wildrye. Production ranges from 10,000 pounds of air-dry forage per acre in favorable years to 6,000 pounds per acre in unfavorable years. All species except the forbs and woody increasers provide forage for livestock.

Grazed areas in this range site are generally overgrazed because of their accessibility and position in the landscape. Eastern gamagrass and other decreaser forbs quickly decrease under heavy grazing. Following in the decline are big bluestem, indiangrass, switchgrass, and wildryes. These species are replaced by buckbrush, tall dropseed, forb increasers, and weed trees. As grazing pressure continues and a canopy of weed trees develops, the site is reduced to weed trees, annual grasses, buckbrush, green muhly, and sedges.

Brush control and controlled burning are used to restore this site on many areas. Reseeding is necessary to obtain adequate production of the climax species on some areas.

LOAMY UPLAND RANGE SITE

This site consists of soils of the Bates, Dennis, Lula, Olpe, and Summit series. It is the largest and the most productive upland range site in the county. The climax plant community on this site is about 30 percent big bluestem; 25 percent little bluestem; 15 percent indiangrass; 10 percent switchgrass; 5 percent each, tall dropseed, forb decreasers, and forb increasers; 3 percent side-oats grama; and 2 percent rosette panicums. Production ranges from 7,500 pounds of air-dry forage per acre in favorable years to 3,500 pounds per acre in unfavorable years. All species provide forage for livestock.

With excessive grazing, big bluestem, little bluestem, indiangrass, and switchgrass are reduced and replaced by tall dropseed, side-oats grama, and forb increasers. Broomsedge and blackberry increase on the Dennis and Bates soils on the sandstone landscapes. On the Summit and Lula soils in the limestone landscapes, tall dropseed and side-oats grama are major increasers. As grazing pressure continues, the vegetation is reduced to tall dropseed, buckbrush, annual bromes, annual three-awn, broomweed, annual ragweed, and other annuals.

Areas in poor condition frequently need brush control before significant improvement can be made in range condition. Abandoned, formerly cultivated fields on this range site can be restored by reseeding.

SAVANNAH RANGE SITE

This range site consists of soils of the Niotaze and Stephenville series. The climax plant community on this site is made up of about 25 percent each, big bluestem and little bluestem; 15 percent post oak and blackjack oak; 10 percent indiangrass; 5 percent each, switchgrass, forb decreasers, and woody increasers; 3 percent each, tall dropseed and rosette panicums; and 2 percent each, Virginia wildrye and sedges. Production ranges from 5,000 pounds of air-dry forage per acre in favorable years to 2,500 pounds per acre in unfavorable years All except the woody species provide forage for cattle. Sheep and goats readily eat the sprouts of the woody species, and deer make very light use of these species.

Under heavy grazing by cattle, woody plants, broomsedge, purpletop, and annual grasses replace little bluestem, big bluestem, indiangrass, and switchgrass. The woody sprouts are eliminated along with climax grasses when the site is overgrazed by goats and sheep. The result is an overstory of post oak and blackjack oak and an understory of annual grasses, broomsedge, silver bluestem, and purpletop.

SHALLOW FLATS RANGE SITE

This range site consists only of Clareson soils in the Clareson-Sogn complex. The climax plant community on this site is about 30 percent little bluestem; 15 percent each, big bluestem and side-oats grama; 10 percent indiangrass; and 5 percent each, switchgrass, tall dropseed, blue and hairy grama, forb decreasers, forb increasers, and woody increasers. Production ranges from 5,000 pounds of air-dry forage per acre in favorable years to 2,500 pounds per acre in unfavorable years. All species except the woody increasers provide forage for livestock.

Under excessive grazing, big bluestem, indiangrass, switchgrass, and little bluestem decrease. Tall dropseed, woody increasers, forb increasers, and side-oats grama increase. Annual grasses, broomsedge, buckbrush, and silver bluestem invade. Continued heavy grazing reduces the plant composition to sumac species, skunkbush, buckbrush, and other woody invaders, along with broomweed, silver bluestem, annual three-awn, and annual bromes. Brush control, along with deferred grazing, is the best method of restoration because tillage operations are not feasible.

SHALLOW LIMY RANGE SITE

Only Sogn soils are in this range site. The climax plant community on this site is about 25 percent side-oats grama; 20 percent little bluestem; 10 percent each, blue grama and big bluestem; and 5 percent each, indiangrass, switchgrass, buffalograss, hairy grama, forb decreasers, forb increasers, and woody increasers. Production ranges from 3,500 pounds of air-dry forage per acre in favorable years to 1,500 pounds per acre in unfavorable years. All species except the woody increasers provide forage for livestock.

When this site is overgrazed, plant composition changes rapidly on this site. Little bluestem, indiangrass, switchgrass, and decreaser forbs are replaced by buffalograss, blue grama, and hairy grama. Side-oats grama increases slowly, but as grazing pressure is continued or increased, it also declines. When the site is in poor condition, most of the vegetation consists of silver bluestem, buffalograss, hairy grama, smooth sumac, skunkbush, annual bromes, and prickly pear. As much as 20 percent of the soil surface is covered by limestone rock, which makes use of mechanical equipment difficult. Land treatment consists primarily of good range management practices.

SHALLOW SANDSTONE RANGE SITE

This range site consists of Collinsville soils that are in complex with Eram soils. The climax plant community on this site is made up of about 30 percent little bluestem; 25 percent big bluestem; 10 percent each, indiangrass and switchgrass; 5 percent each, forb decreasers, forb increasers, and woody increasers; 3 percent each, broomsedge and rosette panicums; and 2 percent each, purple lovegrass and sedges. Production ranges from 4,000 pounds of air-dry forage per acre in favorable years to 2,000 pounds per acre in unfavorable years. All except the woody increasers provide forage for cattle, but sheep and goats readily utilize these species.

When this range site is overgrazed, blackberry, sumac, broomsedge, and purple lovegrass increase, followed by annual three-awn, annual broomweed, lanceleaf ragweed, and purpletop. If grazing pressure continues, the vegetation degenerates to woody shrubs, broomsedge, purpletop, annual grasses, and some forb increasers. Overgrazing by sheep and goats causes the forbs and woody species to be grazed out, and broomsedge, purple lovegrass, purpletop, and annual grasses are the main remaining plants. Small sandstone rocks on the surface and in the soil make equipment use difficult. When this site is in poor or fair range condition, brush control and deferred grazing during the growing season are the best methods to restore it to excellent condition.

SHALLOW SAVANNAH RANGE SITE

This range site occurs only in complex with the Savannah range site. Darnell soils are the only soils in the Shallow Savannah range site in Woodson County. The climax plant community on this site is about 35 percent little bluestem; 20 percent post oak and blackjack oak; 10 percent big bluestem; 5 percent each, indiangrass, forb decreasers, forb increasers, and woody increasers; 3 percent each, switchgrass, tall dropseed, and rosette panicum; and 2 percent each, Virginia wildrye, Canada wildrye, and sedges. Production, quite variable due to soils and weather limitations, ranges from 3,500 pounds of air-dry forage per acre in favorable years to 1,500 pounds per acre in unfavorable years. If the site is in excellent condition, about 75 percent of the forage, all but the woody species, provides grazing for cattle.

Under heavy grazing by cattle, little bluestem, big bluestem, indiangrass, switchgrass, and forb decreasers are replaced by blackberry, sumac, buckbrush, broomsedge, purpletop, and annuals. With continued heavy grazing, post oak and blackjack oak form a dense canopy that allows very limited growth of sedges, buckbrush, purpletop, and shade-tolerant annuals in the understory. Overgrazing by sheep and goats eliminates the woody species, oak sprouts, most forbs, and the climax grasses. the result is an overstory of post oak and blackjack oak and an understory of annual bromes, annual three-sawn, broomsedge, and tall dropseed. A high percentage of sandstone rock is at or near the surface, and large boulders occur in some areas.

If only cattle graze the Shallow Savannah and Savannah range sites, brush control is needed to maintain climax vegetation. A combination of light summer grazing by sheep and goats with moderate dormant-season grazing by cattle is an effective method of maintaining these range sites near climax. Brush control is needed to restore pastures in poor and fair range condition.

The following comparisons of herbage yields of trees and shrubs and of grasses and forbs, according to percentage of canopy coverage, are based on clipping data obtained during the period 1966–70. Herbage on trees and shrubs consists of leaves, twigs, and floral parts produced during a growing season.

Under 0- to 25- percent canopy, the herbage yield is 5 to 30 percent for trees and shrubs and 70 to 95 percent for grasses and forbs.

Under 26- to 50- percent canopy, the yield is 30 to 65 percent for trees and shrubs and 35 to 70 percent for grasses and forbs.

Under 51- to 75-percent canopy, the yield is 65 to 90 percent for trees and shrubs and 10 to 35 percent for grasses and forbs.

Under 76- to 100-percent canopy, the yield is 90 to 95 percent for trees and shrubs and 5 to 10 percent for grasses and forbs.

The maximum herbage yield obtained is under a 10- to 20-percent canopy cover.

Wildlife[5]

In table 4, the soils are rated according to their capacity to produce habitat for three basic kinds of wildlife—openland, wetland, and rangeland wildlife.

Farms and cropland have long been recognized as a major habitat of many species of wildlife. Widely

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

TABLE 4.—*Potential of*

Soil series and map symbols	Elements of wildlife habitat			
	Grain and seed crops	Domestic grasses and legumes	Wild herbaceous plants	Hardwood trees
Bates: Bb, Bc	Fair	Good	Good	Good
Clareson: Ca	Poor	Poor	Good	Good
Cleora: Cd	Good	Good	Good	Good
Collinsville	Very poor	Very poor	Poor	Poor
Mapped only in complex with Eram soils.				
Darnell: Da	Very poor	Very poor	Poor	Poor
Interpretations apply also to Niotaze part.				
Dennis: Dd, De, Df, Dg	Good	Good	Good	Good
Dwight: Dw	Good	Good	Good	Good
Eram: Eb, Ec, Ex	Fair	Good	Good	Good
Hepler: Ha	Fair	Good	Good	Good
Kenoma:				
Ka	Good	Good	Good	Good
Ko	Good	Good	Good	Good
Kw	Good	Good	Good	Good
Leanna: La	Fair	Good	Good	Good
Lula:				
Lb	Good	Good	Good	Good
Ld	Good	Good	Good	Good
Mason: Ma	Good	Good	Good	Good
Niotaze: Ns	Fair	Good	Good	Good
Olpe: Od	Fair	Good	Good	Good
Osage:				
Og	Poor	Fair	Fair	Fair
Os	Poor	Fair	Fair	Fair
Ringo:				
Rc	Fair	Fair	Fair	Good
Rd	Poor	Poor	Fair	Fair
Sogn	Very poor	Very poor	Poor	Poor
Mapped only in complex with Clareson and Ringo soils.				
Stephenville: Sa	Fair	Good	Good	Good
Summit: Sd, Se	Fair	Good	Good	Good
Verdigris: Va, Vc	Good	Good	Good	Good
Woodson: Wa	Fair	Good	Good	Good

varied habitat patterns on lands of irregular topography are favorable to certain birds and mammals commonly known as farm wildlife. Typical of such species in Woodson County are cottontail rabbit, fox squirrel, mourning dove, and bobwhite quail. This does not discount the importance of songbirds and other nongame animals.

Because of the large acreage of grasses in Woodson County, large populations of prairie chicken exist in their native habitat.

Proper range management is essential to the multiple-use concept of optimum livestock-wildlife populations. In judging range, consideration of all products of the land is basic. All factors that affect stream flow, siltation, water yield, wildlife production, and recreation must be evaluated.

The effects on wildlife of livestock grazing may be competitive, beneficial, or neutral, depending upon many variables. Such factors as type of vegetation, kinds and combinations of livestock, topography, soils, and availability of water are involved.

Wildlife populations respond favorably to the close association of "life essentials" that permit an animal to satisfy its requirements with a minimum of movement and a maximum of security. The more cover types that are broken up and mixed together, the more individual "home ranges" there will be.

Many farm ponds are scattered throughout the county, most serving a multipurpose use for livestock and wildlife. The main lakes in the county are Toronto Reservoir, Yates Center City Reservoir, and State Lake. The major rivers and creeks in the county are the Verdigris River, Neosho River, Big and Little Sandy Creeks, East and West Buffalo Creeks, and Owl Creek. Fishing is excellent in Woodson County.

Openland wildlife are animals of cropland, pastures, meadows, lawns, and areas overgrown with grasses, herbs, shrubs, and vines. They include bobwhite quail, meadowlark, field sparrow, killdeer, cottontail rabbit, red fox, and woodchuck. Elements of wildlife habitat considered in rating soils for openland wildlife are grain and seed crops, domestic grasses and legumes, wild herbaceous plants, and shrubs.

Wetland wildlife are animals of swampy, marshy, or open-water areas. They include ducks, geese, herons, shorebirds, rails, kingfishers, muskrat, and beaver. Elements of wildlife habitat considered in rating soils for wetland wildlife are wetland plants and shallow-water areas.

Rangeland wildlife are animals of natural range areas. They include antelope, mule deer, bison, prairie chicken, coyote, jackrabbit, prairie dog, and lark bunting. Elements of wildlife habitat considered in

soils for wildlife habitat

Elements of wildlife habitat—Continued				Kinds of wildlife		
Coniferous plants	Shrubs	Wetland plants	Shallow-water areas	Openland	Wetland	Rangeland
Good	Good	Poor	Very poor	Fair	Very poor	Good.
Good	Good	Very poor	Very poor	Fair	Very poor	Good.
Good	Good	Poor	Very poor	Good	Very poor	Good.
Poor	Fair	Very poor	Very poor	Very poor	Very poor	Fair.
Poor	Fair	Very poor	Very poor	Very poor	Very poor	Fair.
Good	Good	Poor	Poor	Good	Poor	Good.
Good	Good	Poor	Poor	Good	Poor	Good.
Good	Good	Poor	Poor	Fair	Poor	Good.
Good	Good	Fair	Fair	Fair	Fair	Good.
Good	Good	Poor	Poor	Good	Poor	Good.
Good	Good	Poor	Poor	Good	Poor	Good.
Good	Good	Poor	Poor	Good	Poor	Good.
Good	Good	Fair	Fair	Fair	Fair	Good.
Good	Good	Poor	Very poor	Good	Very poor	Good.
Good	Good	Poor	Poor	Good	Poor	Good.
Good	Good	Poor	Very poor	Good	Very poor	Good.
Good	Good	Fair	Fair	Fair	Fair	Good.
Good	Good	Poor	Very poor	Fair	Very poor	Good.
Fair	Fair	Poor	Good	Poor	Fair	Fair.
Fair	Fair	Good	Good	Poor	Good	Fair.
Good	Good	Poor	Very poor	Fair	Very poor	Fair.
Fair	Fair	Very poor	Very poor	Poor	Very poor	Fair.
Poor	Fair	Very poor	Very poor	Very poor	Very poor	Poor.
Good	Good	Poor	Very poor	Fair	Very poor	Good.
Good	Good	Fair	Poor	Fair	Poor	Good.
Good	Good	Poor	Poor	Good	Poor	Good.
Good	Good	Fair	Fair	Fair	Fair	Good.

rating soils for rangeland wildlife are domestic grasses and legumes, wild herbaceous plants, hardwood trees, coniferous plants, and shrubs.

Recreation[6]

Woodson County is served by two major U.S. highways. Transecting the county in a north-south direction is U.S. Highway 75, and U.S. Highway 54 crosses the county in an east-west direction. All-weather access roads provide adequate access to approximately 98 percent of the county.

An appraisal of potential outdoor recreational development in Woodson County indicated that five of eleven categories of recreation rated a high potential: vacation cabins, cottages, homesites, hunting areas, and camping areas. Other categories such as water sports areas (fig. 25), vacation farms and ranches, and natural scenic and historic areas were rated as having medium potential, while golf courses, riding stables, and picnic areas were rated as having low potential.

Knowledge of soils is necessary in planning, developing, and maintaining areas used for recreation. In table 5 the soils of Woodson County are rated according to limitations that affect their suitability for camp areas, picnic areas, playgrounds, and paths and trails.

In table 5 the soils are rated as having *slight*, *moderate*, or *severe* limitations for specified uses. For all of these ratings, it is assumed that a good cover of vegetation can be established and maintained. A rating of *slight* means that soil properties are generally favorable, and limitations are so minor that they easily can be overcome. *Moderate* limitations can be overcome or modified by planning, by design, or by special maintenance. A rating of *severe* means that costly soil reclamation, special design, intense maintenance, or a combination of these is required.

Camp areas are used intensively for tents and small camp trailers and the accompanying activities of outdoor living. Little preparation of the site is required, other than shaping and leveling tent and parking areas. Camp areas are subject to heavy foot traffic and limited vehicular traffic. The best soils have gentle slopes, good drainage, and a surface free of rocks and coarse fragments. They are not subject to flooding during periods of heavy use and have a surface that is firm when wet but not dusty when dry.

Picnic areas are attractive natural or landscaped tracts used primarily for preparing meals and eating outdoors. These areas are subject to heavy foot traffic. Most of the vehicular traffic, however, is confined to access roads. The best soils are firm when wet but not dusty when dry; are free of flooding during the season of use; and do not have slopes or stoniness that greatly increase the cost of levelling sites or of building access roads.

Playgrounds are areas used intensively for baseball, football, badminton, and similar organized games. Soils suitable for this use need to withstand intensive foot traffic. The best soils are nearly level and have a surface free of coarse fragments and rock outcrops, have good drainage, are not subject to flooding during periods of heavy use, and have a surface that is firm when wet but not dusty when dry. If grading and leveling are required, depth to rock is important.

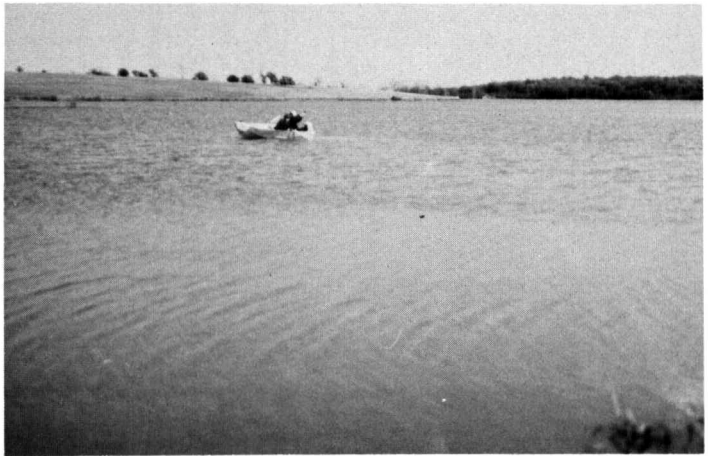

***Figure 25.*—Yates Center Reservoir is used for fishing, boating, water skiing, and hunting. A golf course is in the background.**

Paths and trails are used for local and cross-country travel by foot or horseback. Design and layout should require little or no cutting and filling. The best soils are at least moderately well drained, are firm when wet but not dusty when dry, are flooded not more than once during the season of use, have slopes of less than 15 percent, and have few or no rocks or stones on the surface.

Engineering Uses of the Soils[7]

This section is useful to those who need information about soils used as structural material or as a foundation upon which structures are built. Among those who can benefit from this section are planning commissions, county commissioners, town and city managers, land developers, engineers, contractors, and farmers.

Among properties of soils highly important in engineering are permeability, strength, compaction characteristics, soil drainage condition, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to the water table, depth to

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

[7] CHARLES D. CHEEK and JAMES W. WILKES, engineers, Soil Conservation Service, assisted in the preparation of this section.

TABLE 5.—*Limitations and features affecting use of soils for recreation*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil, which may have different properties and limitations. The reader should follow carefully the instructions for referring to another series in this column]

Soil series and map symbols	Camp areas	Picnic areas	Playgrounds	Paths and trails
Bates: Bb, Bc	Slight	Slight	Moderate: bedrock at a depth of 20 to 40 inches; dominant slope is more than 2 percent.	Slight.
*Clareson: Ca For Sogn part, see Sogn series.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer; bedrock at a depth of 20 to 40 inches.	Moderate: silty clay loam surface layer.
Cleora: Cd	Severe: flooding	Moderate: flooding	Moderate: flooding	Slight.
Collinsville Mapped only in complex with Eram soils.	Moderate where slope is less than 15 percent. Severe where slope is more than 15 percent.	Moderate where slope is less than 15 percent. Severe where slope is more than 15 percent.	Severe: slope; stoniness	Severe: stoniness.
Darnell: Da Ratings also apply to the Niotaze part of Da.	Severe: slope is more than 25 percent.	Severe: slope is more than 25 percent.	Severe: slope is more than 25 percent.	Severe: slope is more than 25 percent.
*Dennis: Dd, De, Df, Dg For Eram part of Dg, see Eram series.	Moderate: wetness; slow permeability.	Slight	Moderate: wetness; slow permeability; dominant slope is more than 2 percent.	Slight.
Dwight: Dw	Severe: very slow permeability.	Moderate: wetness	Severe: very slow permeability.	Slight.
*Eram: Eb, Ec, Ex For Collinsville part of Ex, see Collinsville series.	Moderate where slope is less than 15 percent: wetness; slow permeability; silty clay loam surface layer; stones in places. Severe where slope is more than 15 percent.	Moderate where slope is less than 15 percent: silty clay loam surface layer; stones in places. Severe where slope is more than 15 percent.	Moderate where slope is less than 6 percent: wetness; slow permeability; stones in places. Severe where slope is more than 6 percent.	Moderate: silty clay loam surface layer.
Hepler: Ha	Severe: wetness; flooding.	Moderate: wetness; flooding.	Severe: wetness; flooding.	Moderate: wetness; flooding.
*Kenoma: Ka, Ko, Kw For Olpe part of Ko and Woodson part of Kw, see Olpe and Woodson series.	Severe: very slow permeability.	Slight	Severe: very slow permeability.	Slight.
Leanna: La	Severe: wetness; flooding; very slow permeability.	Severe: wetness	Severe: wetness; flooding; very slow permeability.	Moderate: wetness; flooding.
*Lula: Lb, Ld For Dwight part of Ld, see Dwight series.	Slight	Slight	Slight	Slight.
Mason: Ma	Moderate: moderately slow permeability.	Slight	Moderate: moderately slow permeability.	Slight.
*Niotaze: Ns For Stephenville part, see Stephenville series.	Moderate where slope is less than 15 percent: wetness; slow permeability. Severe where slope is more than 15 percent.	Moderate where slope is less than 15 percent: wetness. Severe where slope is more than 15 percent.	Severe: wetness; most slopes are more than 6 percent.	Moderate: wetness.
Olpe: Od	Moderate: slow permeability.	Slight where slope is less than 8 percent. Moderate where slope is more than 8 percent.	Moderate where slope is less than 6 percent: slow permeability. Severe where slope is more than 6 percent.	Slight.
Osage: Og	Severe: wetness; flooding; very slow permeability; silty clay surface layer.	Severe: wetness; flooding; silty clay surface layer.	Severe: wetness; flooding; very slow permeability; silty clay surface layer.	Severe: wetness; silty clay surface layer.
Os	Severe: wetness; flooding; very slow permeability.	Severe: wetness; flooding.	Severe: wetness; flooding; very slow permeability.	Severe: wetness.
*Ringo: Rc, Rd For Sogn part of Rd, see Sogn series.	Severe: very slow permeability.	Moderate: silty clay loam surface layer.	Severe: very slow permeability.	Moderate: silty clay loam surface layer.
Sogn Mapped only in complex with Clareson and Ringo soils.	Moderate: silty clay loam surface layer; stoniness.	Moderate: silty clay loam surface layer; stoniness.	Severe: shallow to bedrock.	Moderate: silty clay loam surface layer; stoniness.

TABLE 5.—*Limitations and features affecting use of soils for recreation—Continued*

Soil series and map symbols	Camp areas	Picnic areas	Playgrounds	Paths and trails
Stephenville: Sa	Slight	Slight	Moderate: most slopes are more than 2 percent; moderate depth to bedrock.	Slight.
Summit: Sd, Se	Moderate: wetness; slow permeability; silty clay loam surface layer.	Moderate: wetness; silty clay loam surface layer.	Moderate: wetness; silty clay loam surface layer; most slopes are more than 2 percent.	Moderate: wetness; silty clay loam surface layer.
Verdigris: Va, Vc	Severe: flooding	Moderate: flooding	Moderate: flooding	Slight.
Woodson: Wa	Severe: very slow permeability.	Moderate: wetness	Severe: very slow permeability.	Moderate: wetness.

TABLE 6.—*Estimated soil properties*

[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, which may table. The symbol > means greater

Soil series and map symbols	Depth to—		Depth from surface of typical profile	USDA texture	Classification		Percentage less than 3 inches passing sieve—			
	Bedrock	Seasonal high water table			Unified	AASHTO	No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)
	Inches	*Feet*	*Inches*							
Bates: Bb, Bc	20–40	>6	0–10	Loam	ML or CL	A–4 or A–6	100	100	85–100	60–80
			10–16	Loam	ML or CL	A–4 or A–6	100	100	85–100	60–75
			16–33	Clay loam; gravelly.	CL	A–6	100	80–100	85–100	60–80
			33	Sandstone.[1]						
*Clareson: Ca	20–40	>6	0–9	Silty clay loam.	CL	A–4 or A–6	90–100	90–100	80–90	75–85
For Sogn part, see Sogn series.			9–16	Flaggy silty clay loam.[2]	CL	A–4 or A–6	80–100	80–100	80–90	75–85
			16–25	Flaggy silty clay.[3]	CL or CH	A–7	80–100	80–100	80–90	75–85
			25	Limestone.						
Cleora: Cd	>60	>6	0–18	Fine sandy loam.	SC, SM, or ML	A–4	100	100	70–85	40–55
			18–90	Fine sandy loam.	SC, SM, or ML	A–4	100	100	70–85	40–55
Collinsville	10–20	>6	0–12	Loam	ML or CL	A–4	80–100	80–100	60–95	60–75
Mapped only in complex with Eram soils.			12	Sandstone.						
*Darnell: Da	12–20	>6	0–17	Fine sandy loam.	SM or ML	A–4	90–100	90–100	70–95	40–55
For Niotaze part, see Niotaze series.			17	Sandstone.						
*Dennis: Dd, De, Df, Dg	>60	>6	0–10	Silt loam	ML or CL	A–4, A–6, or A–7	100	100	90–100	70–90
For Eram part of Dg, see Eram series.			10–15	Silty clay loam.	CL	A–6 or A–7	100	100	95–100	75–95
			15–74	Silty clay	CL or CH	A–6 or A–7	100	100	95–100	75–100
Dwight: Dw	>40	>6	0–4	Silt loam	ML or CL	A–4 or A–6	100	100	90–100	70–90
			4–44	Clay	CH	A–7	100	100	90–100	75–95
*Eram: Eb, Ec, Ex	20–40	>6	0–10	Silty clay loam.	CL	A–6 or A–7	100	100	95–100	85–95
For Collinsville part of Ex, see Collinsville series.			10–31	Silty clay	CL or CH	A–6 or A–7	100	100	95–100	90–95
			31	Shale.						

bedrock, and slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soil on which they are built, for the purpose of predicting performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to contruction in a particular area.

Most of the information in this section is presented in tables 6, 7, and 8, which show, respectively, several estimated soil properties significant to engineering; interpretations for various engineering uses; and results of engeering laboratory tests on soil samples.

This information, however, does not eliminate the need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths greater than 6 feet. Also, inspection of sites, especially the small ones, is needed because many

significant to engineering

have different properties. The reader should follow carefully the instructions for referring to another series in the first column of this than; < means less than]

Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
						Uncoated steel	Concrete
		Inches per hour	*Inches per inch of soil*	*pH*			
20–40	3–12	0.6–2.0	0.16–0.18	5.1–6.5	Low	Low	Low to moderate.
25–40	8–20	0.6–2.0	0.16–0.18	5.1–6.5	Low to moderate	Low	Low to moderate.
25–40	11–30	0.6–2.0	0.17–0.19	5.1–6.0	Moderate	Moderate	Moderate.
30–40	8–18	0.6–2.0	0.21–0.23	5.6–7.3	Low to moderate	Moderate	Low to moderate.
30–40	8–18	0.6–2.0	0.21–0.23	5.6–7.3	Low to moderate	Moderate	Low to moderate.
40–60	18–35	0.2–0.6	0.11–0.13	5.6–6.5	Moderate to high	Moderate	Moderate.
[1]NP–30	NP–10	2.0–6.0	0.16–0.18	5.6–6.5	Low	Low	Moderate.
NP–30	NP–10	2.0–6.0	0.15–0.17	5.6–6.5	Low	Low	Moderate.
4–30	NP–10	2.0–6.0	0.20–0.22	5.1–6.5	Low	Low	Moderate.
NP–26	NP–6	2.0–6.0	0.15–0.18	5.1–7.3	Low	Low	Low to moderate.
21–41	1–15	0.6–2.0	0.22–0.24	4.5–6.0	Low to moderate	High	Moderate to high.
33–50	13–26	0.2–0.6	0.18–0.20	4.5–6.0	Moderate	High	Moderate to high.
33–65	13–35	0.06–0.2	0.10–0.12	5.6–7.8	Moderate to high	Moderate	Low to moderate.
25–40	7–15	0.2–0.6	0.22–0.24	5.6–7.3	Moderate to low	High	Low to moderate.
50–65	30–45	<0.06	0.09–0.11	6.1–8.4	High	High	Low.
30–50	11–25	0.6–2.0	0.21–0.23	5.6–6.5	Moderate	High	Moderate.
35–65	13–35	0.06–0.2	0.11–0.13	5.1–7.3	Moderate to high	High	Low to moderate.

TABLE 6.—*Estimated soil properties*

[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, which may
table. The symbol > means greater

Soil series and map symbols	Depth to—		Depth from surface of typical profile	USDA texture	Classification		Percentage less than 3 inches passing sieve—			
	Bedrock	Seasonal high water table			Unified	AASHTO	No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)
Hepler: Ha	>60	0–1.5	0–37	Silt loam	ML or CL	A–4 or A–6	100	100	90–100	70–95
			37–60	Silty clay loam.	CL	A–6 or A–7	100	100	95–100	85–100
*Kenoma: Ka, Ko, Kw	>40	>6	0–11	Silt loam	ML or CL	A–4 or A–6	100	100	90–100	70–90
			11–46	Silty clay	CH	A–7	100	100	95–100	90–100
For Olpe part of Ko and Woodson part of Kw, see Olpe and Woodson series.										
Leanna: La	>60	4–5	0–16	Silt loam	ML or CL	A–4 or A–6	100	100	90–100	70–90
			16–52	Silty clay	CH	A–7	100	100	95–100	90–95
*Lula: Lb, Ld	40–60	>6	0–9	Silt loam	ML or CL	A–4 or A–6	100	100	90–100	70–90
			9–57	Silty clay loam.	CL	A–6 or A–7	100	100	95–100	85–95
For Dwight part of Ld, see Dwight series.			57	Limestone.						
Mason: Ma	>60	>6	0–20	Silt loam	ML or CL	A–4 or A–6	100	100	100	90–95
			20–60	Silty clay loam.	ML or CL	A–5 or A–6	100	100	100	90–100
*Niotaze: Ns	20–40	>6	0–9	Loam	ML or CL	A–4	80–100	80–100	75–85	50–65
			9–24	Silty clay	CL or CH	A–7	100	100	95–100	90–95
For Stephenville part, see Stephenville series.			24	Shale.						
Olpe: Od	>60	>6	0–6	Silt loam	ML or CL	A–4	70–100	65–95	65–95	60–90
			6–15	Gravelly silt loam.	GC or SC	A–2 or A–4	30–65	25–60	20–55	15–50
			15–60	Gravelly heavy silty clay loam.	GC or SC	A–2 or A–4	30–65	25–60	20–55	15–50
Osage:										
Og	>60	0–1.5	0–60	Silty clay	CH	A–7	100	100	95–100	90–100
Os	>60	0–1.5	0–30	Silty clay loam.	CH	A–7	100	100	95–100	90–100
			30–60	Silty clay	CH	A–7	100	100	95–100	90–100
*Ringo: Rc, Rd	>40	>6	0–50	Silty clay	CL or CH	A–7	100	100	95–100	90–95
For Sogn part of Rd, see Sogn series.			50	Shale.						
Sogn	6–20	>6	0–9	Silty clay loam.	CL	A–4 or A–7	100	100	95–100	85–95
Mapped only in complex with Clareson and Ringo soils.			9	Limestone.						
Stephenville: Sa	20–40	>6	0–14	Fine sandy loam.	SM or ML	A–4	100	100	95–100	40–55
			14–31	Sandy clay loam.	SC or CL	A–4 or A–6	100	100	80–100	40–55
			31	Sandstone.						
Summit: Sd, Se	>40	>6	0–16	Silty clay loam.	CL	A–6 or A–7	100	100	95–100	85–95
			16–60	Silty clay	CH	A–7	100	100	95–100	90–95
			60	Shale.						
Verdigris: Va, Vc	>60	>6	0–6	Silt loam	CL or ML	A–4 or A–6	100	100	90–100	70–90
			6–60	Silty clay loam.	CL	A–6	100	100	95–100	85–95
Woodson: Wa	>60	>6	0–8	Silt loam	ML or CL	A–4 or A–6	100	100	90–100	75–95
			8–60	Silty clay	CH, CL or MH–CH	A–6 or A–7	100	100	95–100	90–100

[1] 10 percent fragments more than 3 inches.
[2] 30 percent fragments more than 3 inches.

significant to engineering

have different properties. The reader should follow carefully the instructions for referring to another series in the first column of this than; < means less than]

Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
						Uncoated steel	Concrete
20–40	1–15	0.6–2.0	0.22–0.24	5.6–6.5	Low	High	Moderate.
35–50	13–26	0.2–0.6	0.18–0.20	4.5–6.5	Moderate	High	Moderate to high.
30–45	10–20	0.2–0.6	0.22–0.24	5.1–6.5	Low	High	Moderate.
50–65	25–45	<0.06	0.11–0.13	5.6–8.4	High	High	Low to moderate.
30–40	10–20	0.2–0.6	0.22–0.24	5.1–6.5	Low to moderate	High	Moderate.
50–65	40–50	<0.06	0.11–0.13	5.1–7.3	High	High	Low to moderate.
21–37	1–15	0.6–2.0	0.22–0.24	5.6–6.5	Low	Moderate	Low to moderate.
33–50	13–26	0.6–2.0	0.18–0.20	5.6–7.3	Moderate	Moderate	Low to moderate.
20–35	1–12	0.6–2.0	0.22–0.24	5.1–6.5	Low	Moderate	Moderate.
30–50	8–20	0.2–0.6	0.18–0.20	5.1–6.5	Moderate	Moderate	Low to moderate.
18–30	2–10	2.0–6.0	0.20–0.22	5.1–6.5	Low	High	Moderate to high.
45–65	22–40	0.06–0.2	0.11–0.13	4.5–7.3	High	High	Moderate to high.
15–30	7–10	0.6–2.0	0.14–0.18	5.1–6.5	Low	Low	Low to moderate.
15–30	7–10	0.6–2.0	0.06–0.12	5.6–6.5	Low	Low	Moderate.
20–40	11–25	0.06–0.2	0.04–0.10	5.6–7.3	Low	Low	Low to moderate.
55–78	30–55	<0.06	0.11–0.13	5.1–7.8	High	Very high	Low to moderate.
55–78	30–55	<0.06	0.21–0.23	5.1–7.3	High	Very high	Low to moderate.
55–78	30–55	<0.06	0.10–0.12	5.6–7.8	High	Very high	Low to moderate.
40–60	20–35	<0.06	0.11–0.13	6.1–8.4	High	High	Low.
35–50	8–20	0.6–2.0	0.21–0.23	6.1–7.8	Moderate	Low	Low.
<20	NP	2.0–6.0	0.16–0.18	5.1–6.5	Low	Low	Moderate.
25–40	5–15	0.6–2.0	0.16–0.18	5.1–6.5	Low	Low	Low to moderate.
35–50	13–35	0.2–0.6	0.21–0.23	5.6–6.5	Low to moderate	High	Low to moderate.
50–65	25–35	0.06–0.2	0.11–0.13	6.6–7.8	High	High	Low.
25–35	8–18	0.6–2.0	0.22–0.24	5.6–7.3	Low	Moderate	Low to moderate.
25–35	8–18	0.6–2.0	0.18–0.20	5.6–7.3	Moderate	Moderate	Low to moderate.
25–40	5–20	0.6–2.0	0.22–0.24	5.6–6.5	Low to moderate	High	Low.
48–65	25–45	<0.06	0.11–0.13	5.6–7.8	High	High	Low.

[3] 60 percent fragments more than 3 inches.

TABLE 7.—*Interpretations of*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil, which may series in the

Soil series and map symbols	Degree and kind of limitation for—						
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings without basements	Local roads and streets	Trench type sanitary landfill[1]	Area type sanitary landfill
Bates: Bb, Bc	Severe: bedrock at a depth of 20 to 40 inches.	Severe: bedrock at a depth of 20 to 40 inches.	Moderate: rippable bedrock at a depth of 20 to 40 inches.	Moderate: low to moderate shrink-swell potential; bedrock at a depth of 20 to 40 inches.	Moderate: fair subgrade; sandstone bedrock at a depth of 20 to 40 inches.	Moderate: bedrock at a depth of 20 to 40 inches.	Slight
*Clareson: Ca For Sogn part, see Sogn series.	Severe: bedrock at a depth of 20 to 40 inches; subsoil more than 35 percent coarse fragments.	Severe: bedrock at a depth of 20 to 40 inches; subsoil more than 35 percent coarse fragments.	Severe: bedrock at a depth of 20 to 40 inches; subsoil more than 35 percent coarse fragments.	Moderate: bedrock at a depth of 20 to 40 inches; subsoil more than 35 percent coarse fragments; moderate shrink-swell potential.	Moderate to severe: moderate shrink-swell potential; limestone bedrock at a depth of 20 to 40 inches; subsoil more than 35 percent coarse fragments.	Severe: bedrock at a depth of 20 to 40 inches; subsoil more than 35 percent coarse fragments; silty clay material below a depth of 16 inches.	Slight
Cleora: Cd	Severe: subject to occasional flooding; moderately rapid permeability.	Severe: subject to occasional flooding; moderately rapid permeability.	Severe: subject to occasional flooding.	Severe: subject to occasional flooding.	Severe: flooded more than once in 5 years.	Severe: subject to occasional flooding; moderately rapid permeability.	Severe: subject to occasional flooding; moderately rapid permeability.
Collinsville Mapped only in complex with Eram soils.	Severe: bedrock at a depth of less than 20 inches.	Severe: bedrock at a depth of less than 20 inches; moderately rapid permeability.	Severe: bedrock at a depth of less than 20 inches; rocks in surface layer.	Severe: bedrock at a depth of less than 20 inches.	Severe: sandstone bedrock at a depth of less than 20 inches.	Severe: bedrock at a depth of less than 20 inches; moderately rapid permeability; rocks in surface layer.	Severe: moderately rapid permeability.
*Darnell: Da For Niotaze part, see Niotaze series.	Severe: bedrock at a depth of less than 20 inches.	Severe: bedrock at a depth of less than 20 inches; moderately rapid permeability.	Severe: bedrock at a depth of less than 20 inches; rocks in surface layer.	Moderate: rippable bedrock at a depth of less than 20 inches.	Moderate: rippable sandstone bedrock at a depth of less than 20 inches.	Severe: moderately rapid permeability; rippable bedrock at a depth of less than 20 inches.	Severe: moderately rapid permeability.
*Dennis: Dd, De, Df, Dg For Eram part of Dg, see Eram series.	Severe: slow permeability.	Moderate: slopes of 3 to 6 percent.	Severe: silty clay material below a depth of 15 inches.	Moderate to severe: moderate to high shrink-swell potential.	Moderate to severe: moderate to high shrink-swell potential.	Severe: silty clay material below a depth of 15 inches.	Slight
Dwight: Dw	Severe: very slow permeability.	Moderate: bedrock at a depth of 40 to 60 inches.	Severe: clay material.	Severe: high shrink-swell potential.	Severe: high shrink-swell potential.	Severe: clay material; bedrock at a depth of 40 to 60 inches.	Slight

engineering properties of the soils

have different properties and interpretations. For this reason the reader should follow carefully the instructions for referring to another first column]

Suitability as source of—					Soil features affecting—				
Sanitary landfill cover material	Topsoil	Sand and gravel	Road subgrade	Road fill	Highway location	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation
Fair: thin layer of material.	Fair: 8 to 16 inches thick.	Unsuited	Fair: medium load-supporting capacity.	Good	Sandstone bedrock at a depth of 20 to 40 inches.	Bedrock at a depth of 20 to 40 inches; some seepage.	Fair compaction characteristics; medium to low shear strength.	Bedrock at a depth of 20 to 40 inches.	Bedrock at a depth of 20 to 40 inches.
Poor: subsoil more than 35 percent coarse fragments.	Poor: more than 15 percent coarse fragments.	Unsuited	Poor: poor compaction characteristics.	Fair: fair workability.	Limestone bedrock at a depth of 20 to 40 inches; subsoil more than 35 percent coarse fragments.	Bedrock at a depth of 20 to 40 inches.	Fair to poor compaction characteristics.	Subsoil more than 35 percent coarse fragments; bedrock at a depth of 20 to 40 inches.	Bedrock at a depth of 20 to 40 inches.
Good	Good	Poor: improbable source of sand. Unsuited for gravel.	Good	Good	Subject to occasional flooding; erodible.	Moderately rapid permeability.	Moderate permeability when compacted; high susceptibility to piping.	Nearly level; subject to occasional flooding.	Subject to occasional flooding; moderately rapid permeability.
Poor: less than 20 inches of material; rocks in surface layer.	Fair to poor: less than 20 inches of material; rocks in surface layer.	Unsuited	Good	Poor: less than 20 inches of material.	Sandstone bedrock at a depth of less than 20 inches; erodible.	Bedrock at a depth of less than 20 inches; moderately rapid permeability.	Bedrock at a depth of less than 20 inches; rocks in surface layer; susceptibility to piping.	Bedrock at a depth of less than 20 inches; rocks in surface layer.	Bedrock at a depth of less than 20 inches; very low available water capacity; rocks in surface layer.
Poor: less than 20 inches of material; rocks in surface layer.	Fair to poor: less than 20 inches of material; rocks in surface layer.	Unsuited	Good	Poor: less than 20 inches of material.	Sandstone bedrock at a depth of less than 20 inches; erodible.	Bedrock at a depth of less than 20 inches; moderately rapid permeability.	Bedrock at a depth of less than 20 inches; rocks in surface layer; medium to high susceptibility to piping.	Bedrock at a depth of less than 20 inches; rocks in surface layer.	Bedrock at a depth of less than 20 inches; very low available water capacity; rocks in surface layer.
Poor: silty clay material below a depth of 15 inches.	Fair: 15 inches of material.	Unsuited	Fair: medium load-supporting capacity; medium plasticity.	Fair: fair shear strength.	All features favorable.	All features favorable.	Fair to poor compaction characteristics.	All features favorable.	Slow intake rate; slopes of 1 to 6 percent.
Poor: clay material.	Poor: less than 8 inches of material.	Unsuited	Poor: high plasticity; low load-supporting capacity.	Poor: poor shear strength; possible dispersion.	Nearly level to gently sloping; slow internal drainage; difficult to revegetate.	Nearly level to gently sloping.	Fair to poor compaction characteristics; medium to low shear strength.	Likely exposure of clayey subsoil.	Very slow intake rate.

Soil series and map symbols	Degree and kind of limitation for—						
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings without basements	Local roads and streets	Trench type sanitary landfill[1]	Area type sanitary landfill
*Eram: Eb, Ec, Ex For Collinsville part of Ex, see Collinsville series.	Severe: shale at a depth of 20 to 40 inches; slow permeability.	Severe: shale at a depth of 20 to 40 inches.	Severe: shale at a depth of 20 to 40 inches; silty clay material below a depth of 10 inches.	Severe: high shrink-swell potential; low strength.	Severe: high shrink-swell potential.	Severe: silty clay material.	Slight
Hepler: Ha	Severe: moderately slow permeability: subject to occasional flooding.	Severe: subject to occasional flooding.	Severe: somewhat poorly drained; subject to occasional flooding.	Severe: subject to occasional flooding.	Severe: flooded more than once every 5 years; subject to frost heave.	Severe: subject to occasional flooding.	Severe: subject to occasional flooding.
*Kenoma: Ka, Ko, Kw For Olpe part of Ko and Woodson part of Kw, see Olpe and Woodson series.	Severe: very slow permeability.	Moderate: bedrock at a depth of 40 to 70 inches.	Severe: silty clay material below a depth of 11 inches.	Severe: high shrink-swell potential; CH material.	Severe: high shrink-swell potential.	Severe: silty clay material below a depth of 11 inches; bedrock at a depth of 40 to 70 inches.	Slight
Leanna La	Severe: subject to occasional flooding; very slow permeability.	Severe: subject to occasional flooding.	Severe: subject to occasional flooding; poorly drained; silty clay material.	Severe: subject to occasional flooding; poorly drained; high shrink-swell potential.	Severe: flooded more than once every 5 years; poorly drained; high shrink-swell potential.	Severe: subject to occasional flooding; silty clay material; poorly drained.	Severe: poorly drained.
*Lula: Lb, Ld For Dwight part of Ld, see Dwight series.	Moderate to severe: bedrock at a depth of 40 to 60 inches.	Moderate: moderate permeability; bedrock at a depth of 40 to 60 inches.	Moderate: bedrock at a depth of 40 to 60 inches.	Moderate: moderate shrink-swell potential.	Moderate to severe: moderate shrink-swell potential; low load-supporting capacity.	Severe: bedrock at a depth of 40 to 60 inches.	Slight
Mason: Ma	Severe: moderately slow permeability.	Slight	Moderate: subject to rare flooding.	Severe: subject to rare flooding.	Moderate: flooded less than once every 5 years; moderate shrink-swell potential.	Moderate: subject to rare flooding; silty clay loam material.	Moderate: subject to rare flooding.
*Niotaze: Ns For Stephenville part, see Stephenville series.	Severe: shale at a depth of 20 to 40 inches; slow permeability; slopes of more than 15 percent in places.	Severe: shale at a depth of 20 to 40 inches; slopes of more than 7 percent.	Severe: shale at a depth of 20 to 40 inches; silty clay material below a depth of 9 inches; slopes of more than 15 percent in places; somewhat poorly drained.	Severe: high shrink-swell potential; slopes of more than 15 percent in places.	Moderate to severe: high shrink-swell potential; slopes of more than 15 percent in places.	Severe: shale at a depth of 20 to 40 inches; silty clay material below a depth of 9 inches.	Moderate to severe: slopes of more than 15 percent in places.
Olpe: Od	Severe: slow permeability.	Severe: slopes of more than 7 percent in places; more than 50 percent coarse fragments.	Severe: gravelly material.	Moderate: slopes of 4 to 15 percent.	Moderate: slopes of 4 to 15 percent.	Moderate: heavy clay loam material.	Moderate: slopes of 4 to 15 percent.

Suitability as source of—					Soil features affecting—				
Sanitary landfill cover material	Topsoil	Sand and gravel	Road subgrade	Road fill	Highway location	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation
Poor: silty clay material.	Fair: 10 inches of silty clay loam material.	Unsuited	Fair: medium load-supporting capacity; medium plasticity.	Fair: fair shear strength.	Shale at a depth of 20 to 40 inches; difficult to revegetate.	Shale at a depth of 20 to 40 inches.	Fair to poor compaction characteristics; medium to low shear strength.	Shale at a depth of 20 to 40 inches.	Slow intake rate; slopes of 1 to 7 percent.
Fair: silty clay loam material.	Good	Unsuited	Fair: medium load-supporting capacity.	Good	Subject to occasional flooding; nearly level.	Subject to occasional flooding.	Fair compaction characteristics.	Nearly level; subject to occasional flooding.	Subject to occasional flooding; slow intake rate.
Poor: silty clay material below a depth of 11 inches.	Fair: 11 inches of silt loam material.	Unsuited	Poor: low load-supporting capacity; high plasticity.	Fair: fair shear strength.	Slow internal drainage.	Nearly level to gently sloping.	Fair to poor compaction characteristics; medium to low shear strength.	Likely exposure of clayey subsoil.	Very slow intake rate.
Poor: less than 20 inches of material.	Good	Unsuited	Poor: high plasticity; low load-supporting capacity.	Fair: fair shear strength.	Subject to occasional flooding; nearly level.	Subject to occasional flooding.	Fair to poor compaction characteristics; medium to low shear strength.	Nearly level; subject to occasional flooding.	Subject to occasional flooding; very slow intake rate.
Fair: silty clay loam material below a depth of 9 inches.	Fair: 9 inches of silt loam material.	Unsuited	Poor: low load-supporting capacity.	Fair: moderate plasticity; fair shear strength.	Limestone at a depth of 40 to 60 inches.	Moderate permeability; bedrock at a depth of 40 to 60 inches.	Fair to good compaction characteristics; medium to low shear strength.	All features favorable.	High available water capacity; moderate available root zone.
Fair: silty clay loam material below a depth of 20 inches.	Good	Unsuited	Fair: medium load-supporting capacity.	Good	Subject to rare flooding; nearly level.	Nearly level.	Fair to good compaction characteristics; medium to low shear strength.	All features favorable.	Subject to rare flooding; high available water capacity.
Poor: silty clay material below a depth of 9 inches; slopes of more than 15 percent in places.	Fair to poor: 9 inches of material; slopes of more than 15 percent in places.	Unsuited	Fair: medium load-supporting capacity.	Fair: fair shear strength.	Shale at a depth of 20 to 40 inches; slopes of more than 15 percent in places; difficult to revegetate.	Shale at a depth of 20 to 40 inches.	Fair to poor compaction characteristics; medium to low shear strength.	Slopes of more than 15 percent in places; shale at a depth of 20 to 40 inches.	Slow intake rate; slopes of more than 15 percent in places.
Poor: more than 35 percent coarse fragments.	Poor: more than 15 percent coarse fragments.	Unsuited for sand. Fair for dirty gravel.	Good	Good	Slopes of 4 to 15 percent.	Slow permeability; slopes of 4 to 15 percent.	Medium to low shear strength.	Slopes of 4 to 15 percent; coarse fragments in subsoil.	Slow intake rate; slopes of 4 to 15 percent.

Soil series and map symbols	Degree and kind of limitation for—						
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings without basements	Local roads and streets	Trench type sanitary landfill[1]	Area type sanitary landfill
Osage:							
Og	Severe: very slow permeability; subject to occasional flooding.	Severe: subject to occasional flooding.	Severe: subject to occasional flooding; poorly drained; clay material.	Severe: poorly drained; subject to occasional flooding; high shrink-swell potential.	Severe: poorly drained; high shrink-swell potential; flooded more than once every 5 years.	Severe: poorly drained; subject to occasional flooding; clay material.	Severe: subject to occasional flooding.
Os	Severe: very slow permeability.	Severe: subject to occasional flooding.	Severe: poorly drained; silty clay material.	Severe: poorly drained; subject to occasional flooding; high shrink-swell potential.	Severe: poorly drained; high shrink-swell potential.	Severe: poorly drained; silty clay material.	Moderate: subject to occasional flooding.
*Ringo: Rc, Rd For Sogn part of Rd, see Sogn series.	Severe: very slow permeability.	Moderate: slopes of 4 to 7 percent; shale at a depth of 40 to 60 inches.	Severe: silty clay material.	Severe: high shrink-swell potential.	Severe: high shrink-swell potential.	Severe: silty clay material.	Moderate: slopes of 4 to 15 percent.
Sogn Mapped only in complex with Clareson and Ringo soils.	Severe: bedrock at a depth of less than 20 inches.	Severe: bedrock at a depth of less than 20 inches; rocks in surface layer.	Severe: limestone at a depth of less than 20 inches; rocks in surface layer.	Severe: limestone at a depth of less than 20 inches; rocks in surface layer.	Severe: limestone at a depth of less than 20 inches; rocks in surface layer.	Severe: limestone at a depth of less than 20 inches; rocks in surface layer.	Slight
Stephenville: Sa	Severe: bedrock at a depth of 20 to 40 inches.	Severe: bedrock at a depth of 20 to 40 inches.	Moderate: bedrock at a depth of 20 to 40 inches.	Moderate: rippable bedrock at a depth of 20 to 40 inches.	Slight: sandstone at a depth of 20 to 40 inches.	Moderate: rippable bedrock at a depth of 20 to 40 inches.	Slight
Summit: Sd, Se	Severe: slow permeability.	Moderate: slopes of 1 to 7 percent.	Severe: somewhat poorly drained; silty clay material.	Severe: high shrink-swell potential.	Severe: somewhat poorly drained; high shrink-swell potential.	Severe: silty clay material.	Moderate: somewhat poorly drained.
Verdigris: Va, Vc	Severe: subject to occasional flooding.	Severe: subject to occasional flooding.	Severe: subject to occasional flooding.	Severe: subject to occasional flooding.	Severe: flooded more than once every 5 years.	Severe: subject to occasional flooding.	Severe: subject to occasional flooding.
Woodson: Wa	Severe: very slow permeability.	Slight	Severe: somewhat poorly drained; silty clay material below a depth of 8 inches.	Severe: high shrink-swell potential; low strength.	Severe: high shrink-swell potential; low strength.	Severe: silty clay material below a depth of 8 inches.	Moderate: somewhat poorly drained.

[1] Onsite deep studies of the underlying strata, water tables, and hazards of aquifer pollution and drainage into ground water need to

Suitability as source of—					Soil features affecting—				
Sanitary landfill cover material	Topsoil	Sand and gravel	Road subgrade	Road fill	Highway location	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation
Poor: poorly drained; silty clay material.	Poor: poorly drained; silty clay material.	Unsuited	Poor: high plasticity; low load-supporting capacity.	Fair: fair shear strength.	Subject to occasional flooding; nearly level.	Subject to occasional flooding; nearly level; very slow permeability.	Fair to poor compaction characteristics; medium to low shear strength.	Nearly level; subject to occasional flooding.	Very slow intake rate; poorly drained; subject to occasional flooding.
Poor: poorly drained; silty clay material.	Poor: poorly drained.	Unsuited	Poor: high plasticity; low load-supporting capacity.	Fair: fair shear strength.	Subject to occasional flooding; nearly level.	Nearly level; subject to occasional flooding; very slow permeability.	Fair to poor compaction characteristics; medium to low shear strength.	Nearly level; subject to occasional flooding.	Very slow intake rate; poorly drained; subject to occasional flooding.
Poor: silty clay material.	Poor: silty clay surface layer.	Unsuited	Poor: poor shear strength; high plasticity.	Poor: high plasticity; low load-supporting capacity.	Shale at a depth of 40 to 60 inches; seeps; slopes of 4 to 15 percent.	Shale at a depth of 40 to 60 inches; very slow permeability.	Fair to poor compaction characteristics; medium to low shear strength.	Likely exposure of clayey subsoil.	Very slow intake rate; slopes of 4 to 7 percent.
Poor: less than 20 inches of material; rocks in surface layer.	Poor: more than 15 percent coarse fragments.	Unsuited	Poor: low load-supporting capacity.	Poor: thickness of material.	Limestone at a depth of less than 20 inches.	Bedrock at a depth of less than 20 inches; gently sloping; rocks in surface layer.	Rocks in surface layer; medium to low shear strength.	Rocks in surface layer; bedrock at a depth of less than 20 inches.	Very low available water capacity; shallow root zone; rocks in surface layer.
Fair: bedrock at a depth of 20 to 40 inches.	Fair: 8 to 16 inches of material.	Unsuited	Fair: medium load-supporting capacity.	Good	Rippable sandstone at a depth of 20 to 40 inches.	Bedrock at a depth of 20 to 40 inches; subject to seepage.	Good to fair compaction characteristics; medium to low shear strength.	Bedrock at a depth of 20 to 40 inches.	Bedrock at a depth of 20 to 40 inches; low available water capacity; slopes of 1 to 4 percent.
Poor: silty clay material.	Fair: silty clay loam surface layer.	Unsuited	Poor: low load-supporting capacity; high plasticity.	Fair: fair shear strength.	Poor workability; seeps; slow internal drainage.	All features favorable.	Fair to poor compaction characteristics; medium to low shear strength.	All features favorable.	Slow intake rate; slopes of 1 to 7 percent.
Good	Fair: silty clay loam below a depth of 6 inches.	Unsuited	Fair: medium load-supporting capacity.	Good	Subject to occasional flooding; nearly level.	Subject to occasional flooding; nearly level.	Fair compaction characteristics; medium to low shear strength.	Subject to occasional flooding; nearly level.	Subject to occasional flooding.
Poor: silty clay material below a depth of 8 inches.	Poor: silty clay material below a depth of 8 inches.	Unsuited	Poor: low load-supporting capacity.	Fair: fair shear strength.	Nearly level to gently sloping; poor workability; slow internal drainage; difficult to revegetate.	Nearly level to gently sloping.	Fair to poor compaction characteristics; medium to low shear strength.	Likely exposure of clayey subsoil.	Very slow intake rate.

be made for landfills deeper than 5 or 6 feet.

TABLE 8.—*Engineering*

[Tests performed by Kansas State Highway Commission in accordance with standard procedures

Soil name and location	Parent material	Report no. Kans S71—	Depth	Moisture-density[1]		Modulus of deformation
				Maximum dry density	Optimum moisture	
			In	*Lbs per cu ft*	*Pct*	*Psi*
Bates loam:						
600 feet north and 110 feet west of southeast corner of sec. 16, T. 26 S., R. 16 E. (Modal)	Residuum weathered from acid sandstone and silty shale.	104-6-1	0-10	95	21	1,685
		104-6-2	16-27	108	17	1,910
		104-6-3	27-33	107	17	2,125
Dennis silt loam:						
600 feet south and 1,220 feet west of center of sec. 5, T. 26 S., R. 16 E. (Modal)	Residuum or colluvium weathered from noncalcareous, weakly laminated shaly clay loam or clay.	104-4-1	0-10	95	20	1,370
		104-4-2	15-28	95	24	2,210
		104-4-3	62-74	106	18	1,245
Hepler silt loam:						
420 feet west and 150 feet north of southeast corner of southwest quarter of sec. 16, T. 25 S., R. 16 E. (Modal)	Alluvium.	104-5-1	0-7	95	20	1,945
		104-5-2	18-30	109	14	3,385
		104-5-3	30-37	107	15	2,010
		104-5-4	60-80	101	19	1,295
Kenoma silt loam:						
320 feet east and 330 feet north of southwest corner of southeast quarter of sec. 15, T. 26 S., R. 17 E. (Modal)	Old alluvium and residuum weathered from shale and interbedded limestone.	104-3-1	0-6	93	20	1,465
		104-3-2	11-20	95	20	2,255
		104-3-3	46-62	97	23	1,515
Woodson silt loam:						
165 feet east and 600 feet north of southwest corner of northwest quarter of sec. 16, T. 24 S., R. 17 E. (Modal)	Old alluvium.	104-2-1	0-8	95	20	1,830
		104-2-2	8-22	92	25	1,450
		104-2-3	47-65	103	20	1,435

[1] Based on the moisture-density relations of soils using 5.5-lb rammer and 12-in. drop, AASHTO Designation T99-61, Method A, with the following variations: (1) All material is oven dried at 230°F.; (2) all material is crushed in a laboratory after drying; and (3) no time is allowed for dispersion of moisture after mixing with the soil material.

[2] Required thickness of bituminous mat having a modulus of deformation of 15,000 pounds per square foot.

[3] Mechanical analyses according to the AASHTO Designation T88-57 with the following variations: (1) All material is oven dried at 230°F and crushed in a laboratory crusher; (2) the sample is not soaked prior to dispersion; (3) sodium silicate is used as the dispersing agent; and (4) dispersing time, in minutes, is established by dividing the plasticity index value by 2; the maximum time is 15 minutes, and

delineated areas of a given mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have special meanings to soil scientists but are not known to all engineers. The Glossary defines many terms commonly used in soil science.

Engineering soil classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (*17*), used by Soil Conservation Service engineers, the Department of Defense, and others, and the AASHTO system (*1*), adopted by the American Association of State Highway and Transportation Officials.

The Unified system is used to classify soils according to engineering uses for building material or for the support of structures other than highways (*17*). Soils are classified according to particle-size distribution, plasticity index, liquid limit, and organic-matter content. Soils are grouped into 15 classes. There are eight classes of coarse-grained soils, subdivided on the basis of gravel and sand content. These are identified as GW, GP, GM, GC, SW, SP, SM, and SC. Six classes of fine-grained soils are subdivided on the basis of the plasticity index. Nonplastic classes are ML, MH, OL, and OH; plastic classes are CL and CH. Organic soils are identified as Pt.

The AASHTO system is used to classify soils according to those properties that affect use in highway construction and maintenance. 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 (foundation). At the other extreme, in group A-7, are clay soils that have low strength when wet, the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A-1, A-2, and A-7 groups are divided as follows: A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, and A-7-6. As an additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHTO classification for tested soils, with group index numbers in parentheses, is shown in

test data

of the American Association of State Highway and Transportation Officials (AASHTO) (*1*)]

Mat thickness[2]	Mechanical analysis[3]									Liquid limit	Plasticity index	Classification	
	Percentage less than 3 inches passing sieve[4]—					Percentage smaller than—							
	No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 60 (0.25 mm)	No. 200 (0.074 mm)	0.05 mm	0.02 mm	0.005 mm	0.002 mm			AASHTO	Unified
In										*Pct*			
8.3	--------	100	98	97	76	66	43	20	11	40	12	A–6(9)	ML
7.3	--------	100	92	89	69	57	43	29	23	35	14	A–6(8)	CL
6.3	--------	100	94	90	63	53	40	27	20	35	11	A–6(6)	ML–CL
10.4	--------	100	99	98	87	77	49	26	18	41	14	A–7–(10)	ML–CL
6.0	--------	100	100	100	93	86	68	55	49	57	32	A–7–6(19)	CH
11.3	--------	100	100	100	96	90	71	47	38	45	27	A–7–6(16)	CL
7.1	--------	100	99	99	87	75	48	21	12	41	11	A–7–5(9)	ML
2.7	--------	100	100	100	88	69	36	15	12	27	6	A–4(8)	ML–CL
6.9	--------	100	100	100	96	89	60	26	18	29	8	A–4(8)	ML–CL
10.9	--------	100	100	100	99	97	86	52	37	44	23	A–7–6(14)	CL
9.8	--------	100	97	96	89	81	51	20	11	41	13	A–7–6(9)	ML
5.9	--------	100	99	99	96	91	76	54	46	55	29	A–7–6(19)	CH
9.3	100	98	97	96	91	85	69	49	39	61	35	A–7–6(20)	CH
7.6	--------	100	99	98	95	89	62	23	13	38	11	A–6(8)	ML
9.8	--------	100	100	100	99	96	82	55	46	61	32	A–7–6(20)	MH–CH
9.9	--------	100	100	99	97	93	70	43	36	50	28	A–7–6(17)	CL

the minimum time is 1 minute. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conseravtion Service (SCS). In the AASHTO 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.

[4] Based on AASHTO Designation M 145–49 (*1*).

table 8; the estimated classification, without group index numbers, is given in table 6, for all soils mapped in the survey area.

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 (*14*). "Sand," "silt," "clay," and some of their other terms used in the USDA textural classification are defined in the Glossary. Stones, cobblestones, and gravel are used as textural modifiers where present in the soil.

Soil properties significant to engineering

Several estimated soil properties significant to engineering are given in table 6. These estimates are made through layers of representative soil profiles having significantly different properties. The estimates are based on field observations made in the course of mappping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties. Following are explanations of some of the columns in table 6.

Depth to bedrock is the distance from the surface of the soil to a rock layer within the depth of observation.

Depth to seasonal high water table is the distance from the surface of the soil to the highest level that ground water reaches in the soil in most years.

Soil texture is described in table 6 in the standard terms used by the Department of Agriculture. These terms are based on the percentages of sand, silt, and clay in the less-than-2-millimeter fraction of the soil. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, "gravelly sand." "Sand," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary.

Liquid limit and plasticity index are measures of water content obtained by specified operations. As the water content of a clayey soil from which the particles coarser than 0.5 millimeter have been removed, is increased, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material changes from a semisolid to a plastic state; and the liquid limit, from

a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of water content within which a soil material is plastic. Liquid limit and plasticity index are estimated in table 6, but in table 8 the data on liquid limit and plasticity index are based on tests of soil samples.

Permeability, as used here, is an estimate of the rate at which saturated soil would transmit water in a vertical direction under a unit head of pressure. It is estimated on the basis of soil characteristics observed in the field, particularly structure, porosity, and texture. Lateral seepage or such transient soil features as plowpans and surface crusts are not considered.

Available water capacity is an estimate of the capacity of soils to hold water for use by most plants. It is defined here as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most plants.

Reaction refers to the acidity or alkalinity of a soil, expressed in pH values for a stated soil-solution mixture. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential refers to the relative change in volume to be expected of soil material with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. The extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils may damage building foundations, roads, and other structures. Soils having a high shrink-swell potential are the most hazardous. Shrink-swell potential is not indicated for organic soils or certain soils that shrink markedly on drying but do not swell quickly when rewetted.

Corrosivity, as used in table 6, pertains to potential soil-induced chemical action that dissolves or weakens steel or concrete. The rate of corrosion of steel is related to soil properties such as drainage, texture, total acidity, and electrical conductivity of the soil material. Installations of steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely in one kind of soil or in one soil horizon. Corrosivity of concrete is influenced mainly by the content of sodium or magnesium sulfate, but also by soil texture and acidity. A corrosivity rating of low means that there is a low probability of soil-induced corrosion damage. A rating of high means that there is a high probability of damage, so protective measures for steel and more resistant concrete should be used to reduce damage.

Engineering interpretations of soils

The interpretations in table 7 are based on the estimated engineering properties of soils shown in table 6, on test data for soils in this survey area and in others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of Woodson County. In table 7, ratings are used to summarize limitations or suitability of the soils for all listed purposes other than for highway location, pond reservoir areas; embankments, dikes, and levees; terraces, diversions, and waterways; and irrigation. For these particular uses, table 7 lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are indicated by the ratings *slight, moderate,* and *severe. Slight* means that soil properties are generally favorable for the rated use, or, in other words, limitations are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means that soil properties are so unfavorable and so difficult to correct or overcome that major soil reclamation, special designs, or intensive maintenance are required.

Soil suitability is rated by the terms *good, fair,* and *poor,* which have, respectively, meanings approximately parallel to the terms slight, moderate, and severe.

Following are explanations of some of the columns in table 7.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material between depths of 18 inches and 6 feet is elevated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope affects difficulty of layout and construction and also the risk of erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor and sides, or embankments, of compacted soil material. The assumption is made that the embankment is compacted to medium density and the pond is protected from flooding. Properties are considered that affect the pond floor and the embankment. Those that affect the pond floor are permeability, organic-matter content, and slope; if the floor needs to be leveled, depth to bedrock is important. The soil properties that affect the embankment are the engineering properties of the embankment material as interpreted from the Unified Soil Classification and the amount of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Shallow excavations are those that require digging or trenching to a depth of less than 6 feet; for example, excavations for pipelines, sewer lines, telephone and power transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or big stones, lack of a high water table, and freedom from flooding.

Dwellings without basements, as rated in table 7, are not more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load, and those that relate to ease of excavation. Soil properties that

affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Local roads and streets, as rated in table 7, have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base consisting of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep. Soil properties that most affect design and construction of roads and streets are load-supporting capacity, stability of the subgrade, and the workability and quantity of available cut and fill material. The AASHO and Unified classifications of the soil material, as well as the shrink-swell potential, indicate traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to rock, content of stones and rocks, and wetness affect ease of excavation and the amount of cut and fill needed to reach an even grade. See also ratings for *road subgrade* in this table.

Sanitary landfill is a method of disposing of refuse in dug trenches (trench) or on the present soil surface (area). The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period (cover material). Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the ratings in table 7 apply only to a depth of about 6 feet, and therefore limitation ratings of *slight* or *moderate* may not be valid if trenches are to be much deeper than that. For some soils, reliable predictions can be made to a depth of 10 or 15 feet, but every site should be investigated before it is selected.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as for preparing a seedbed; natural fertility of the material, or the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments are characteristics that affect suitability, but also considered in the ratings is damage that will result to the area from which topsoil is taken.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 7 provide guidance about where to look for probable sources. A soil rated as a *good* or *fair* source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials, and neither do they indicate quality of the deposit.

Road fill is soil material used in embankments for roads. The suitability ratings reflect (1) the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and (2) the relative ease of excavating the material at borrow areas.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility. Stones and organic matter in the soil are considered to be unfavorable factors.

Terraces and diversions are embankments or ridges constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock or other unfavorable material; presence of stones; permeability; and resistance to water erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff and is easily vegetated.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, water erosion, or soil blowing; soil texture; content of stones; accumulations of salts and alkali; depth of root zone; rate of water intake at the surface; permeability of soil layers below the surface layer and in fragipans or other layers that restrict movement of water; amount of water available to plants; and need for drainage or depth to water table or bedrock.

Engineering test data

Table 8 contains the results of engineering tests performed by the State Highway Commission of Kansas in accordance with standard procedures of the American Association of State Highway and Transportation Officials (AASHTO) (*1*). These tests were performed on several soils in Woodson County. The table shows the specific location where the sample was taken, the depth to which sampling was done, and the results of tests to determine particle-size distribution and other properties significant to engineering. Some of the columns require explanation or are explained elsewhere in the engineering section.

Compaction (or moisture-density) data are important in earthwork. If a soil material is compacted at successively higher levels of moisture content, assuming that the compactive effort 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, maximum strength is obtained if the soil is compacted to the maximum dry density.

Tests to determine liquid limit and plastic limit measure the effect of water on the consistence of soil

material, as was explained for table 6.

The mechanical analyses were made by combined sieve and hydrometer methods.

Formation and Classification of Soils

This section has two main parts. The first part tells how the factors of soil formation have affected the development of soils in Woodson County. The second part explains the system of soil classification currently used and places each soil series in the classes of that system.

Factors of Soil Formation

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

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate also affect the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation of soil horizons. Usually a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are poorly understood.

Parent material

Parent material is the disintegrated or partly weathered rock from which the soils formed. Weathering takes place through physical, chemical, and biological processes interacting with the rocks.

Pennsylvanina Limestone, Sandstone, and Shale.—Soils on the uplands of Woodson County formed in material weathered from Pennsylvanian rocks, except for those formed in peridotite and igneous rock mentioned in this section (*10, 11*). Limestone, sandstone, and shale of the Shawnee Group alternate throughout the northwestern third of the county. Bates, Dennis, Eram, Ringo, Summit, and Sogn soils formed in residuum from these rocks. Rolling hills and a few moderately steep escarpments intermingled with gently sloping ridgetops typify this area. Also intermingled are a few broad, nearly level or gently sloping areas of Kenoma and Woodson soils. Toronto Limestone crops out between Toronto and Yates Center and extends north to the county line. It marks the base of the Shawnee Group.

The Chautauqua Hills escarpment is formed by the Ireland and Tonganoxie Sandstones and extends northeast by southwest through Yates Center. This is the lower part of the Douglas Group (fig. 26). Bates, Dennis, Eram, Niotaze, Stephenville, and Darnell soils formed in residuum from these rocks. Rolling hills with a few short, steep escarpments and intermingled, gently sloping ridgetops typify this area. Peridotite, of late Cretaceous age, occurs in this group in a small area known locally as Silver City. Rose Dome, another local name for an igneous rock intrusion also of late Cretaceous age, is in the southern part of this area.

The Pedee Group separates the Douglas Group from the Lansing Group. It extends in a strip about 2 to 4 miles wide and is composed mainly of limestone and shale. It is nearly masked by the other groups in Woodson County.

The Stanton Limestone, in the Lansing Group, forms an escarpment in southeast Woodson County. This limestone has stabilized the area north and south of a line from Yates Center to Piqua so that the landscapes are nearly level or gently sloping. Dennis, Kenoma, and Woodson soils are the principal soils in this area. Near the Stanton Limestone outcrop are Lula, Sogn, and Summit soils that are on short slopes of escarpments and on gently sloping ridgetops.

Smooth chert gravel is in the Olpe soils in the extreme southeast corner and in the southwest corner of the county. Its origin is believed to be from ancient alluvium with an admixture of loess. Smooth, rolling hills typify the landscapes in these areas.

Recent alluvium.—Soils of the flood plains and stream terraces of Woodson County formed in recent alluvium. The largest areas of recent alluvium are along the Neosho River, Verdigris River, and Owl Creek. Minor areas extend along Big Sandy Creek and Turkey Creek. Osage soils, which formed in clayey sediment, are mainly on the flood plains of the Neosho River, the Verdigris River, and Turkey Creek. Cleora soils, which formed in loamy sediment, are mainly on the flood plain along Big Sandy Creek. Hepler soils, which formed in loamy sediment, and Leanna soils, which formed in clayey sediment, are mainly on the flood plains and stream terraces of Owl Creek.

Climate

The weathering of rocks is the first step in providing a medium in which plants can grow. Climatic factors such as moisture, temperature, wind, and air play a vital part in the weathering process and the formation of soils. When climatic conditions are favorable for plant growth, as they are in Woodson County, the processes of soil development continue more rapidly.

The soil mantle that has formed over the bedrock in this county continues to be affected by factors of climate. Moisture falls in cycles, with wet periods followed by dry periods. Precipitation is sufficient to leach the fine clay particles from the surface layer of some soils and deposit them in a thick clayey layer a

Figure 26.—**Shale and interbedded sandstone of the Douglas Group. Collinsville and Eram soils formed in this material.**

few inches below the surface. Some soils have slowly or very slowly permeable subsoils with mottles that suggest seasonal wetness. Excess precipitation causes flooding, which affects the development of alluvial soils. Geological and accelerated erosion have contributed to the development of some upland soils. Some soils of the county crack during periods of drought.

Prevailing temperatures favor the growth of plants and animals, replenishing the organic matter of the soil. Temperature fluctuation during the winter causes freezing and thawing, which alters the soil structure.

A thin layer of windblown deposits (loess) probably sifted over this area during soil development. Soil blowing presently affects a few soils locally, but it plays a minor role in soil development in the county.

The color of the soils of the county reflects their interaction with air that enters the soil. Iron oxidation causes some well-drained soils to be red, whereas iron reduction may cause poorly drained soils to be gray.

Plant and animal life

Environmental conditions hasten the growth and development of plant and animal life in this county. The tall grasses have produced a dark-colored surface layer in the soils of the county.

Annual and perennial plants contribute to the organic matter of the soil. Microscopic and macroscopic animals feed on living and decaying plants that aid in decomposition. These animals in turn reproduce, live their life cycle, and die, further adding to the organic matter in the soil. The most visible signs of animal workings are worm holes and casts, crayfish burrows, and rodent runs and burrows. The greatest influence on the soil comes from organisms that are not visible without a microscope.

Blackjack oak and post oak have influenced the soils in areas of the county where they grow. A leached subsurface layer above the subsoil and a more acid soil has resulted.

Relief

Relief influences the formation of soils through its effect upon drainage, runoff, erosion, and soil temperature. Slowed drainage and runoff from nearly level and gently sloping areas result in soils that have strongly developed profiles. Rapid runoff and somewhat excessive drainage due to steep slopes result in less strongly developed profiles and less thickness over rock. Geological and accelerated erosion has thinned some soils and thickened others. Soils with south- and west-facing slopes warm faster than soils with north- and east-facing slopes.

Time

Soils require time for development. Some develop faster than others, but the rate of development depends on the other factors of soil formation. Verdigris soils, for example, lack horizon development and are considered young soils. Woodson soils, which have contrasting soil horizons, are in an advanced stage of development.

Classification of 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 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 woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas such as countries and continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965 (*12, 15*). Because this system is under continual study, readers interested in developments of the current system should search the latest available literature.

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 the soils of similar genesis, or mode of origin, are grouped. The same property or subdivision of this property may be used in several different categories. In table 9, the soil series of Woodson County are placed in higher 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 soil orders are those that tend to give broad climatic groupings of soils. Three exceptions to this are the Entisols, Histosols, and Vertisols, which occur in many different climates. Each order is named with a word of three or four syllables ending in *sol* (Moll-i-sol).

Table 9 lists the three soil orders represented in Woodson County—Alfisols, Inceptisols, and Mollisols.

Alfisols are mineral soils that contain horizons of accumulated clay. Unlike the Mollisols, they lack the dark-colored surface horizon dominated by bivalent cations. However, the base saturation of the lower horizons is moderate to high.

Inceptisols are mineral soils that have weakly expressed genetic horizons. The surface layer is generally lighter in color than in the Mollisols. Inceptisols do not have features that reflect soil mixing caused by shrinking and swelling.

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

TABLE 9.—*Soils classified according to the current system*

Soil Series	Family	Subgroup	Order
Bates	Fine-loamy, siliceous, thermic	Typic Argiudolls	Mollisols.
Clareson	Clayey-skeletal, mixed, thermic	Typic Argiudolls	Mollisols.
Cleora	Coarse-loamy, mixed, thermic	Fluventic Hapludolls	Mollisols.
Collinsville	Loamy, siliceous, thermic	Lithic Hapludolls	Mollisols.
Darnell	Loamy, siliceous, thermic, shallow	Udic Ustochrepts	Inceptisols.
Dennis	Fine, mixed, thermic	Aquic Paleudolls	Mollisols.
Dwight	Fine, montmorillontic, mesic	Typic Natrustolls	Mollisols.
Eram	Fine, mixed, thermic	Aquic Argiudolls	Mollisols.
Hepler[1]	Fine-silty, mixed, thermic	Udollic Ochraqualfs	Alfisols.
Kenoma	Fine, montmorillonitic, thermic	Vertic Argiudolls	Mollisols.
Leanna	Fine, mixed, thermic	Argiaquic Argialbolls	Mollisols.
Lula	Fine-silty, mixed, thermic	Typic Argiudolls	Mollisols.
Mason	Fine-silty, mixed, thermic	Typic Argiudolls	Mollisols.
Niotaze	Fine, montmorillonitic, thermic	Aquic Paleustalfs	Alfisols.
Olpe	Clayey-skeletal, montmorillonitic, thermic	Typic Paleudolls	Mollisols.
Osage	Fine, montmorillonitic, thermic	Vertic Haplaquolls	Mollisols.
Ringo[2]	Fine, mixed, thermic	Typic Hapludolls	Mollisols.
Sogn	Loamy, mixed, mesic	Lithic Haplustolls	Mollisols.
Stephenville	Fine-loamy, siliceous, thermic	Ultic Haplustalfs	Alfisols.
Summit	Fine, montmorillonitic, thermic	Vertic Argiudolls	Mollisols.
Verdigris	Fine-silty, mixed, thermic	Cumulic Hapludolls	Mollisols.
Woodson	Fine, mixed, thermic	Abruptic Argiaquolls	Mollisols.

[1] The Hepler soils in this county are taxadjuncts to the Hepler series because they are less acid in the B2 horizon than is defined as the range for the Hepler series.

[2] The Ringo soils in this county are taxadjuncts to the Ringo series because they have a thicker solum and lack paralithic contact with shale bedrock within a depth of 40 inches, as defined for the Ringo series.

SUBORDER. Each order is subdivided into suborders using those soil characteristics that seem to produce classes that have the greatest genetic similarity. The suborders are more narrowly defined than are the orders. 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 solum; cracking of soils caused by a decrease in soil moisture; and fine stratification. The names of suborders have two syllables. The last syllable indicates the order. An example is *Udoll* (*Ud*, meaning humid or moist, and *oll*, from Mollisol).

GREAT GROUP. Soil suborders are separated int 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 constituents have accumulated or have been removed; and those that have pans that interfere with growth of roots, movement of water, or both. Some soil features used for comparison are acidity, climate, 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 Hapludoll (*Hapl*, meaning simple horizons, *ud* for moist or humid, and *oll*, from Mollisols).

SUBGROUP. Great groups are subdivided into subgroups, one representing the central (typic) segment of the group, and others called intergrades that have properties of the group and also one or more properties of another great group, suborder, or order. Other subgroups may have soil properties unlike those of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Hapludoll (a typical Hapludoll).

FAMILY. Soil families are separated within a subgroup 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, 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 differentiae (see table 9). An example is the fine, mixed, thermic family of Typic Hapludolls.

Additional Facts About the County

Woodson County was established in 1855 by the Territorial County Legislature as one of the original Kansas counties. These counties all lie south of the Kansas River. The boundary was later changed, and by 1868 the boundary was fixed as at present.

Relief

The relief of Woodson County is typified by several east-facing escarpments with rolling or hilly landscapes that generally trend in a northeasterly-southwesterly direction. Between these escarpment landscapes are broad areas that are nearly level or gently sloping. The southwestern part, approximately one-third of the county, drains south and west to the Verdigris River. The remaining two-thirds drains east to the Neosho River. Elevation above sea level ranges from about 1,250 feet in the northwest corner to about 980 feet in the southeast corner.

Water

The local water supply comes from ground water, surface impoundments, and streams. Ground water for livestock and domestic use is usually not reliable. Wells yield an estimated 1 to 10 gallons per minute, except in stream valleys, where they yield an average of about 10 to 100 gallons per minute (*6*).

Ponds built for stockwater and domestic uses are more dependable. Many such ponds have been built throughout the county. The larger streams are a reliable source of water, but smaller streams dry up during droughts. Rural water districts are supplying water to farmers in some areas of the county.

There are three large lakes in the county. Toronto Reservoir, a U.S. Army Corps of Engineers project, is the largest. It has 2,800 surface acres, mostly in Woodson County. It is used mainly for flood control and recreation. Lake Fegan, a state lake, has about 130 surface areas. It is used mainly for recreation. Yates Center Reservoir has about 100 surface acres and is used mainly for supplying water to the city of Yates Center, as well as for recreation.

Climate[8]

The climate of Woodson County is typically continental, as would be expected from its location in the interior of a large land mass in the middle latitudes. Such climates are characterized by large diurnal and annual variations in temperature. This feature of the climate applies to all of Kansas and to much of the area between the Rocky Mountains and the Applachian Mountains.

Woodson County lies on the border between the humid and subhumid climates, according to Thornthwaite (*13*). In this classification, the term implies that precipitation exceeds evapotranspiration and the surplus goes into runoff and ground-water recharge. A moist subsoil is present in these regions. Woodson County is far enough east to be out of the rain shadow of the Rocky Mountains. Moisture-laden air currents from the Gulf of Mexico frequent southeast Kansas, making it the wettest part of the state (*3*).

Climatological records have been kept at Toronto and Yates Center since the 1890's. Since these records are not on the tapes of the Weather Data Library of the Kansas Agricultural Experiment Station, the data in table 10 are from nearby Iola in Allen County. These data adequately represent the climate of Woodson County.

[8] By L. DEAN BARK, climatologist, Kansas Agricultural Experiment Station, Manhattan, Kansas.

TABLE 10.—*Temperature and precipitation*

[Data from Iola, Kansas]

Month	Temperature				Precipitation		
	Average daily maximum[1]	Average daily minimum[1]	Two years in 10 will have about 4 days with—[2]		Average monthly total[1]	One year in 10 will have[3]—	
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Totals less than—	Totals greater than—
	°F	°F	°F	°F	Inches	Inches	Inches
January	42.7	22.1	62.8	4.3	1.16	0.23	2.24
February	48.1	26.5	67.3	9.3	1.18	0.13	2.51
March	56.6	33.2	77.3	15.8	2.24	0.91	4.52
April	70.0	46.1	83.5	31.4	3.94	1.95	7.30
May	78.0	55.6	88.5	42.7	4.86	1.98	7.91
June	86.2	64.6	98.2	54.1	5.59	1.66	8.46
July	91.4	68.5	103.6	59.7	4.78	0.66	7.74
August	91.3	67.2	102.8	57.4	3.28	0.77	6.73
September	82.9	58.7	97.6	45.1	5.24	1.23	9.25
October	72.8	48.4	87.7	33.8	2.85	0.65	6.39
November	57.2	35.2	73.1	19.1	1.63	0.15	4.68
December	45.6	26.2	63.4	10.7	1.32	0.27	2.64
Year	68.7	46.1	104.0	−3.0	38.07	27.11	51.14

[1] Period of record: 1941–70.
[2] Period of record: 1931–60.
[3] Period of record: 1911–70.

Precipitation totals for the year in Woodson County average 37 to 38 inches, among the highest in the state. Over 70 percent of this annual total occurs in the growing season, April through September. Measurable amounts of precipitation occur on about 90 days of the year. Precipitation is fairly evenly distributed through the April-September period with the exception of August, which is the driest month of that season. Although the normal precipitation totals are adequate for crop production almost every year, the distribution can sometimes be erratic. It is not uncommon to have two and three weeks of dry weather between showers. These dry spells produce stress conditions in cultivated crops, native pastures, and meadows.

Most of the annual precipitation totals come from convective shower activity. Huge thunderstorms move across the county, usually in the evening or during the night, accounting for most of the summer precipitation. Rain from these storms is generally intense and of short duration. The intensity is great enough that runoff is a regular occurrence. Measures must be taken to slow down the runoff and conserve moisture. Twelve percent of the rains each year are more than 1 inch, and several are more than 3 inches. Fifty-five percent of the rains are less than 0.25 inch and contribute little to the moisture budget (*4*).

Snowfall is light in southern Kansas. Woodson County averages about 12 to 14 inches of snow per year. Snows are most frequent in January and February, but March and December also have snow frequently. In general, snow seldom remains on the ground more than 1 or 2 days from a particular storm. On the average, less than 20 days of the year have snow cover. Blizzards are infrequent and of short duration.

Temperature ranges are large in a continental climate. Annual extremes generally range from near zero to above 100 degrees. These extremes are of short duration and are not of great importance to the overall climate. The average temperature shown in table 10 illustrates the rather short transition seasons of spring and fall that occur in Kansas. Winter is from December through February, and winter temperatures average in the 30's. Summer conditions with warm temperatures necessary for plant growth continue from late April into early October. The average growing season (the period between freezes in spring and fall) is 195 days in Woodson County. At Toronto, in southwest Woodson County, March 15, 1910, is the earliest date of the last freeze in the spring, and May 15, 1907, is the latest the temperature reached 32° F. September 26, 1912, is the ealiest date in the fall the temperature reached 32° F, and November 11, 1946, is the latest it reached 32° F. Truck garden and orchard crops are occasionally damaged by late spring freezes. Corn is frozen back occasionally. The probabilities of freezes in the spring and fall are given in table 11 (*2*).

The prevailing wind direction is southerly except in January and February, when northerly winds are more frequent. Winds in southeast Kansas are generally lighter than those in the western part of the state. Winds are strongest in spring.

Tornadoes and severe windstorms occur occasionally in Woodson County. This area of Kanas is nearest the region of maximum tornado occurrence, located in east-central Oklahoma. These storms are usually local in extent and of short duration, so that risk is small. Hail occurs during the warmest part of the year, but it is infrequent and also of local extent. Woodson County is in the part of Kansas that has a risk of hail.

TABLE 11.—*Probabilities of last freezing temperatures in spring and first in fall*

[Data for central Woodson County (2)]

Probability	Dates for stated 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	March 24	April 1	April 6	April 15	April 27
2 years in 10 later than	March 18	March 26	April 1	April 10	April 22
5 years in 10 later than	March 6	March 16	March 23	March 31	April 12
Fall:					
1 year in 10 earlier than	November 18	November 8	October 26	October 17	October 10
2 years in 10 earlier than	November 24	November 13	October 31	October 22	October 14
5 years in 10 earlier than	December 5	November 24	November 9	October 31	October 24

Droughts are not uncommon in southeastern Kansas. For the period 1931 through 1968, droughts, classified as mild, moderate, severe, or extreme, were recorded during 175 months (*5*). Severe or extreme drought periods occurred in 71 months, or 16 percent of the total period. This figure is undoubtedly high, since the period for the study cited above was selected in order to compare the well-known droughts of the 1930's and 1950's. A longer period of study would reduce this percentage. The drought period from 1952 to 1957 had severe and extreme ratings for 44 months, making it the worst on record from a meteorological point of view.

Farming

Tall prairie grasses orginally covered most of Woodson County. Deciduous trees grow on the bottom lands of the larger streams. Farming has developed through the raising of livestock, mainly beef cattle, and the growing of cash crops. In 1967, about 116,000 acres were in cropland, and 142,500 acres were in native grasses (*16*).

Cropping trends have changed during the past 40 to 50 years. In the period 1921 through 1930, the average acreage planted to sorghum was about 10,000 acres; corn, about 3200 acres; wheat, about 9,000 acres; oats, about 10,000 acres; and soybeans, negligible. In 1970, sorghum acreage increased to about 24,000 acres, corn decreased to about 5,000 acres, wheat increased to about 11,000 acres, oats decreased to about 2,000 acres, and soybeans increased to about 20,000 acres (*7, 8*).

Beef cattle outnumber all other livestock. In 1970, there were about 54,000 beef cattle in the county (*7, 8*). There is one large feedlot and several small feedlots. Hog production is increasing. Sheep and chicken production fluctuates from year to year.

Natural Resources

Small oil fields are scattered over the county. The largest is in the northwest corner. Vermiculite is mined in the south-central part of the county. Limestone is crushed for agricultural lime and for road-surfacing material at several places in the county. Small areas of gravel are mined in the southeast and southwest parts of the county.

Transportation

Two major highways transect the county. U.S. Highway 75 extends north-south and U.S. Highway 54 east-west through the center of the county. State Highway 15 passes through Toronto. Most county roads have gravel surfacing, and a few are paved.

The Missouri Pacific Railroad passes north-south and east-west through the county. It follows the same general route as the two U.S. highways. It services the town of Toronto, Yates Center, and Piqua. A spur track also runs south from Piqua.

The chief grain-handling and storage facilities are in Yates Center, Piqua, and Toronto. These towns and Neosho Falls provide general trading facilities.

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Glossary

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

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 the soil aggregate. Synonyms: clay coat, clay skin.

Cobblestone. A rounded or partly rounded fragment of rock, 3 to 10 inches in diameter.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Effluent. The outflow of water from a subterranean storage space. The term is also used in reference to gases and other liquids.

Gravelly soil material. From 15 to 50 percent of material, by volume, consists of rounded or angular rock fragments that are not prominently flattened and are up to 3 inches in diameter.

Gleyed soil. A soil in which waterlogging and lack of oxygen have caused the material in one or more horizons to be neutral gray in color. The term "gleyed" is applied to soil horizons with yellow and gray mottling caused by intermittent waterlogging.

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.

Igneous rock. Rock that has been formed by the cooling of molten mineral material. Examples: Granite, syenite, diorite, and gabbro.

Loess. Fine-grained material, dominantly of silt-sized particles, that has been deposited by wind.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Organic matter. A general term for plant and animal material, in or on the soil, in all stages of decomposition. Readily decomposed organic matter is often distinguished from the more stable forms that are past the stage of rapid decomposition.

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; and alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH
Extremely acid	Below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

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.

Slickspots. Small areas in a field that are slick when wet because they contain excess exchangeable sodium, or alkali.

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 grained* (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 soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

GUIDE TO MAPPING UNITS

For a complete description of a mapping unit, read both the description of the mapping unit and the description of the soil series to which the mapping unit belongs. Management of the soils for crops is given in the section "Descriptions of the Soils." Dashes indicate that the mapping unit was not assigned to a woodland suitability group. Other information is given in tables as follows:

Acreage and extent, table 1, page 9.
Predicted yields, table 2, page 34.
Use of soils for wildlife, table 4, page 42.
Use of soils for recreation, table 5, page 45.
Engineering uses of the soils, tables 6, 7, and 8, pages 46 through 57.

Map symbol	Mapping unit	Page	Capability unit	Range site		Woodland suitability group	
			Symbol	Name	Page	Number	Page
Bb	Bates loam, 1 to 4 percent slopes	10	IIe-2	Loamy Upland	40	---	--
Bc	Bates loam, 4 to 7 percent slopes	10	IIIe-2	Loamy Upland	40	---	--
Ca	Clareson-Sogn complex, 1 to 8 percent slopes	11	VIe-2	---	--	---	--
	Clareson part	--	-------	Shallow Flats	41	---	--
	Sogn part	--	-------	Shallow Limy	41	---	--
Cd	Cleora fine sandy loam	12	IIw-1	Loamy Lowland	40	2o2	35
Da	Darnell-Niotaze complex, 25 to 45 percent slopes	13	VIIs-1	---	--	---	--
	Darnell part	--	-------	Shallow Savannah	41	5d2	37
	Niotaze part	--	-------	Savannah	41	5r2	37
Dd	Dennis silt loam, 1 to 3 percent slopes	14	IIe-1	Loamy Upland	40	---	--
De	Dennis silt loam, 3 to 6 percent slopes	15	IIIe-1	Loamy Upland	40	---	--
Df	Dennis silty clay loam, 1 to 3 percent slopes, eroded	15	IIIe-4	Clay Upland	40	---	--
Dg	Dennis and Eram soils, 3 to 7 percent slopes, eroded	15	IVe-1	Clay Upland	40	---	--
Dw	Dwight silt loam, 0 to 2 percent slopes	16	IVs-1	Claypan	40	---	--
Eb	Eram silty clay loam, 1 to 4 percent slopes	17	IIIe-5	Clay Upland	40	---	--
Ec	Eram silty clay loam, 4 to 7 percent slopes	17	IVe-1	Clay Upland	40	---	--
Ex	Eram-Collinsville complex, 4 to 25 percent slopes	17	VIe-2	---	--	---	--
	Eram part	--	-------	Clay Upland	40	---	--
	Collinsville part	--	-------	Shallow Sandstone	41	---	--
Ha	Hepler silt loam	18	IIw-3	Loamy Lowland	40	3w2	37
Ka	Kenoma silt loam, 1 to 2 percent slopes	19	IIIe-3	Clay Upland	40	---	--
Ko	Kenoma-Olpe complex, 2 to 7 percent slopes	20	IVe-1	---	--	---	--
	Kenoma part	--	-------	Clay Upland	40	---	--
	Olpe part	--	-------	Loamy Upland	40	---	--
Kw	Kenoma and Woodson soils, 1 to 3 percent slopes, eroded	20	IVe-2	Clay Upland	40	---	--
La	Leanna silt loam	21	IIw-2	Clay Lowland	39	3w2	37
Lb	Lula silt loam, 0 to 2 percent slopes	22	IIe-3	Loamy Upland	40	---	--
Ld	Lula-Dwight complex, 0 to 2 percent slopes	22	IIIe-6	---	--	---	--
	Lula part	--	-------	Loamy Upland	40	---	--
	Dwight part	--	-------	Claypan	40	---	--
Ma	Mason silt loam	23	I-1	Loamy Lowland	40	3o1	36
Ns	Niotaze-Stephenville complex, 4 to 25 percent slopes	24	VIe-1	Savannah	41	---	--
	Niotaze part	--	-------	---	--	5r2	37
	Stephenville part	--	-------	---	--	5d1	37

Map symbol	Mapping unit	Page	Capability unit	Range site		Woodland suitability group	
			Symbol	Name	Page	Number	Page
Od	Olpe soils, 4 to 15 percent slopes-------	25	VIe-2	Loamy Upland	40	---	--
Og	Osage silty clay------------------------	26	IIIw-1	Clay Lowland	39	5w3	37
Os	Osage silty clay loam--------------------	27	IIw-2	Loamy Lowland	40	4w2	37
Rc	Ringo silty clay loam, 4 to 7 percent slopes----------	27	IIIe-7	Clay Upland	40	---	--
Rd	Ringo-Sogn complex, 4 to 15 percent slopes----------	28	VIe-2	----------	--	---	--
	Ringo part----------	--	-------	Clay Upland	40	---	--
	Sogn part----------	--	-------	Shallow Limy	41	---	--
Sa	Stephenville fine sandy loam, 1 to 4 percent slopes----------	28	IIe-2	Savannah	41	5d1	37
Sd	Summit silty clay loam, 1 to 4 percent slopes----------	29	IIe-1	Loamy Upland	40	---	--
Se	Summit silty clay loam, 4 to 7 percent slopes----------	29	IIIe-1	Loamy Upland	40	---	--
Va	Verdigris silt loam----------	30	I-1	Loamy Lowland	40	3o2	36
Vc	Verdigris soils, channeled----------	30	VIw-1	Loamy Lowland	40	3o2	36
Wa	Woodson silt loam, 0 to 2 percent slopes-	32	IIs-1	Clay Upland	40	---	--

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