SOIL SURVEY OF

Anderson 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. In line with Department of Agriculture policies, benefits of this program are available to all, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in the period 1965–73. Soil names and descriptions were approved in 1973. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1973. 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 Anderson County Conservation District.

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

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

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

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

Finding and Using Information

The "Guide to Mapping Units" can be used to find information in this publication. 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 range site to which the soil has been assigned.

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

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the descriptions of the range sites and woodland groups.

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

Wildlife managers 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 the choice of sites for recreation areas in the section "Recreation."

Engineers and builders can find, under "Engineering," 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 Anderson 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 "Environmental Factors Affecting Soil Use."

Cover: **Soybeans planted on the contour on Kenoma siit loam, 1 to 4 percent slopes.**

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Issued December 1977

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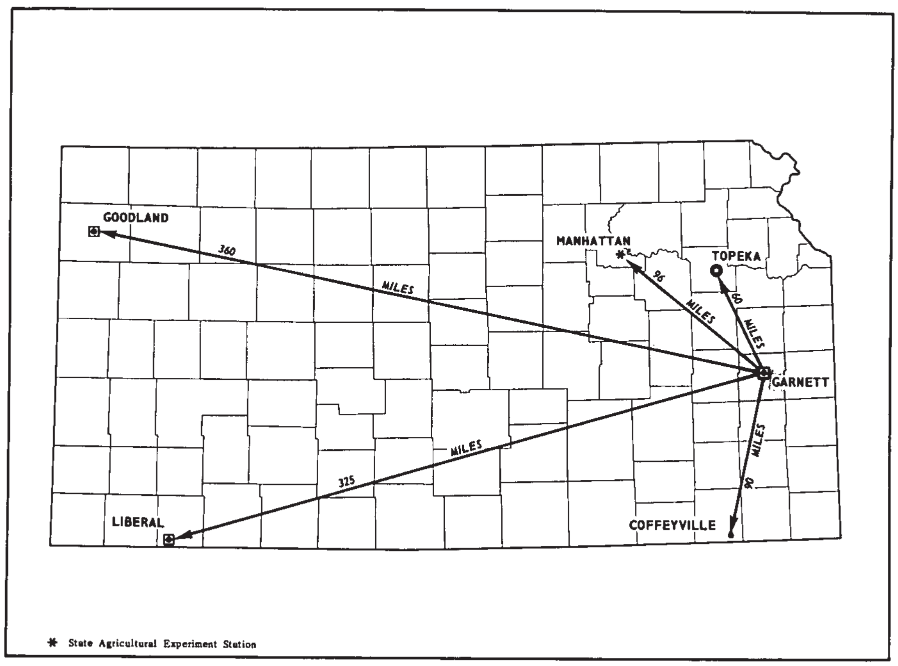

Location of Anderson County in Kansas.

SOIL SURVEY OF ANDERSON COUNTY, KANSAS

By Kenneth H. Sallee, Soil Conservation Service[1]

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

ANDERSON COUNTY, in the east-central part of Kansas (see facing page), covers a total area of 577 square miles, or about 369,024 acres. Garnett, in the north-central part of the county, is the county seat. The elevation is about 1,090 feet. In 1970, the population of Anderson County was 8,501. About 60 percent was rural.

Farming is an important enterprise in the county. Soybeans, grain sorghum, corn, wheat, and alfalfa are the main crops. Beef cattle are the main livestock. Some milk cows are kept for dairy products. Raising swine, sheep, and poultry is also important.

Anderson County is in the Osage Plain section of the Central Lowlands physiographic province. The landscape is one of gently rolling prairies, low hills, and well defined drainage patterns. Along the northwest edge of the county are rolling hills of Eram and Summit soils. These hills are capped by limestone bedrock and underlain by interbedded sandstone and shale. To the east of these hills, from along the northern border of the county to the southwest corner, is a nearly level and gently sloping old alluvial plain that is dissected by upland streams. Woodson and Kenoma soils are the main soils. Isolated low hills are common. The south-central part of the county is gently undulating uplands of old alluvium overlying limestone and shale. Kenoma soils are the main soils. Gravelly knolls occupied by Olpe soils are common.

The northeastern and eastern parts of the county are gently sloping to rolling uplands. Steep and broken slopes along drainageways and ridges are common throughout these areas. Catoosa and Clareson soils are in the higher areas and are underlain by limestone bedrock. Outcrops of limestone are common. Eram and Talihina soils are in the steeper areas and Summit and Dennis soils are on the gentle side slopes. The valleys of the major drainageways are occupied by Lanton, Verdigris, and Mason soils.

The main streams in the county are Pottawatomie Creek, Deer Creek, Sugar Creek, and Indian Creek. A number of smaller streams empty into Pottawatomie Creek, which flows eastward, turns to the north at Greeley, and intercepts the Marais des Cygnes River (Miami County). Pottawatomie Creek and its tributaries drain about 65 percent of the county in the north, west-central, and central parts. These tributaries are Crystal, Kenoma, Iantha, Sac, Thomas, Cedar, Fish, and South Fork Pottawatomie Creeks.

Deer Creek, which drains the south-central part, and Indian Creek, which drains the southwest corner, flow south into Allen County to join the Neosho River. Sugar Creek and its tributaries drain the eastern part of the county and flow east into Linn County. The Little Osage River drains the southeastern corner of the county.

The lowest point in the county, about 860 feet above sea level, is where Pottawatomie Creek leaves the county north of Greeley. The highest points, about 1,210 feet, are in the gravelly area north and west of Kincaid and between Garnett and Bush City. Most of the county is at an elevation between 1,000 and 1,100 feet. The greatest difference in local relief, about 200 to 300 feet, is along Cedar Creek and Pottawatomie Creek, near Garnett. Here the valley floors are bounded by steep bluffs that have rock escarpments in many places.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Anderson 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 many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

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

Soils that have profiles 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 that series was first observed and mapped. Summit and Woodson, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differ-

[1] DONALD A. GIER and PAUL R. KUTNINK, soil scientists, Soil Conservation Service, assisted in the surveying.

ences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Eram silty clay loam, 1 to 4 percent slopes, is one of several phases within the Eram 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 woodland, 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 other kind that have been seen within an area that is dominantly of a recognized soil phase.

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

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Eram-Clareson complex, 1 to 15 percent slopes, is an example.

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

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

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

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

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in the survey area. A soil association is a landscape that has a distinctive pattern of soils in defined proportions. It typically consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in an association can occur in other associations, but in different patterns.

A map showing soil associations is useful to people who want to have a general idea of the soils in a survey area, who want to compare different parts of that area, or who want to locate large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide for broad planning on a watershed, a wooded tract, or a wildlife area or for broad planning of recreational facilities, community developments, and such engineering works as transportation corridors. It is not a suitable map for detailed planning for management of a farm or field or for selecting the exact location of a road or building or other structure, because the soils within an association ordinarily vary in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The five soil associations in this survey area are described on the pages that follow.

1. Woodson-Kenoma association

Deep, nearly level to gently sloping, somewhat poorly drained and moderately well drained soils of the uplands

The landscape of this soil association is one of gently undulating uplands and low ridges dissected by slightly entrenched drainageways. The soils are dominantly nearly level to gently sloping (fig. 1).

This association makes up about 30 percent of the county. It is about 55 percent Woodson soils, 25 percent Kenoma soils, and 20 percent minor soils.

Woodson soils, in broad continuous areas, are nearly level to gently sloping. They are deep, are somewhat poorly drained, and have very slow permeability. The surface layer typically is black silt loam about 8 inches thick. The subsoil is black and very dark gray silty clay in the upper part and dark grayish brown and gray silty clay in the lower part. It extends to a depth of 60 inches or more.

Kenoma soils, on low ridges, are gently sloping. They are deep, moderately well drained, and very slowly permeable. The surface layer typically is very dark grayish brown silt loam about 7 inches thick. The subsoil is very dark grayish brown to dark yellowish brown silty clay about 31 inches thick. The substratum is mottled brown and reddish brown silty clay and silty clay loam. Limestone is at a depth of about 61 inches.

Minor in this association are Dennis, Eram, and Summit soils on the steeper slopes and Leanna, Mason, and Verdigris soils along and in drainageways.

A large part of this association is used for crops, and some large areas are in native range. Soybeans, grain sorghum, corn, and wheat are the main crops. Water erosion is the dominant hazard on the gently sloping soils. Droughty soil conditions exist during periods of low rainfall. Terraces, water-

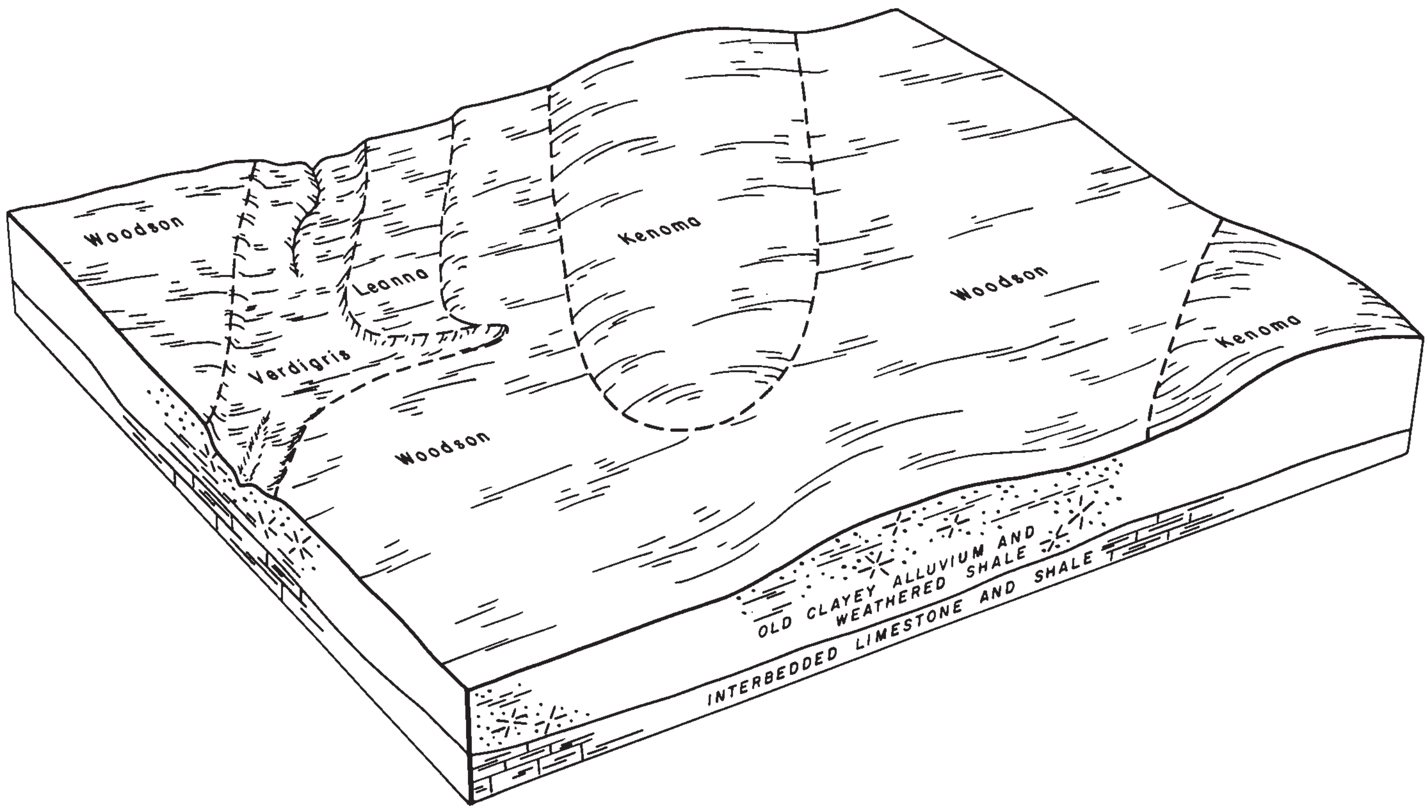

***Figure 1.*—Pattern of soils in association 1.**

ways, contour farming, and close-sown crops help control erosion. Proper range use is necessary to maintain native grasses.

2. *Eram-Summit-Collinsville association*

Deep to shallow, gently sloping to strongly sloping, moderately well drained to somewhat excessively drained soils of the uplands

The landscape of this association is one of gently undulating to rolling uplands. The soils are dominantly gently sloping to strongly sloping. They are steep, however, in a few places along drainageways and on side slopes of ridges.

This association makes up about 10 percent of the county. It is about 25 percent Eram soils (fig. 2), 20 percent Summit soils, 15 percent Collinsville soils, and 40 percent minor soils.

Eram soils, on summits of ridges and on side slopes, are gently sloping to strongly sloping. They are moderately well drained, moderately deep over shale, and slowly permeable. The surface layer typically is very dark brown light silty clay loam about 9 inches thick. The subsoil is very dark grayish brown, brown, and gray silty clay loam and clay loam. It is underlain by dark grayish brown and yellowish brown silty and sandy shale at a depth of about 33 inches.

Summit soils, on the lower side slopes of ridges, are gently sloping and sloping. They are deep, moderately well drained, and slowly permeable. The surface layer typically is black silty clay loam about 8 inches thick. The subsoil is black, very dark grayish brown, and dark gray silty clay. It is underlain by gray silty clay at a depth of 47 inches.

Collinsville soils, on the summits and side slopes of ridges, are gently sloping to strongly sloping. They are shallow over sandstone and sandy shale, well drained to somewhat excessively drained, and moderately rapidly permeable. The surface layer typically is very dark grayish brown loam about 6 inches thick. The subsoil is dark brown channery loam. It is underlain by interbedded sandstone and sandy shale at a depth of about 11 inches.

Minor in this association are Catoosa, Lula, Clareson, Dennis, Okemah, Kenoma, Talihina, Mason, and Verdigris soils. Catoosa, Lula, and Clareson soils are on ridgetops and in gently undulating areas underlain by limestone. Dennis and Okemah soils are on gentle foot slopes. Kenoma soils are on some ridge summits. Talihina soils, which are shallow over shale, are on steep sides of ridges. Mason and Verdigris soils are along and in drainageways.

Most of the strongly sloping areas are used for native range and tame pasture. The gently sloping areas are in soybeans, wheat, and grain sorghum. Water erosion is the dominant hazard. Terraces, waterways, contour farming, and close sown crops help control erosion. Proper range use is necessary to maintain native grasses.

3. *Catoosa-Eram-Clareson association*

Moderately deep, nearly level to strongly sloping, well drained and moderately well drained soils of the uplands

The landscape of this association is one of gently undulating and rolling uplands dissected by deeply entrenched drainageways. The soils are nearly level to strongly sloping.

This association makes up about 32 percent of the county. It is about 16 percent Catoosa soils, 12 percent Eram soils, 12 percent Clareson soils, and 60 percent minor soils.

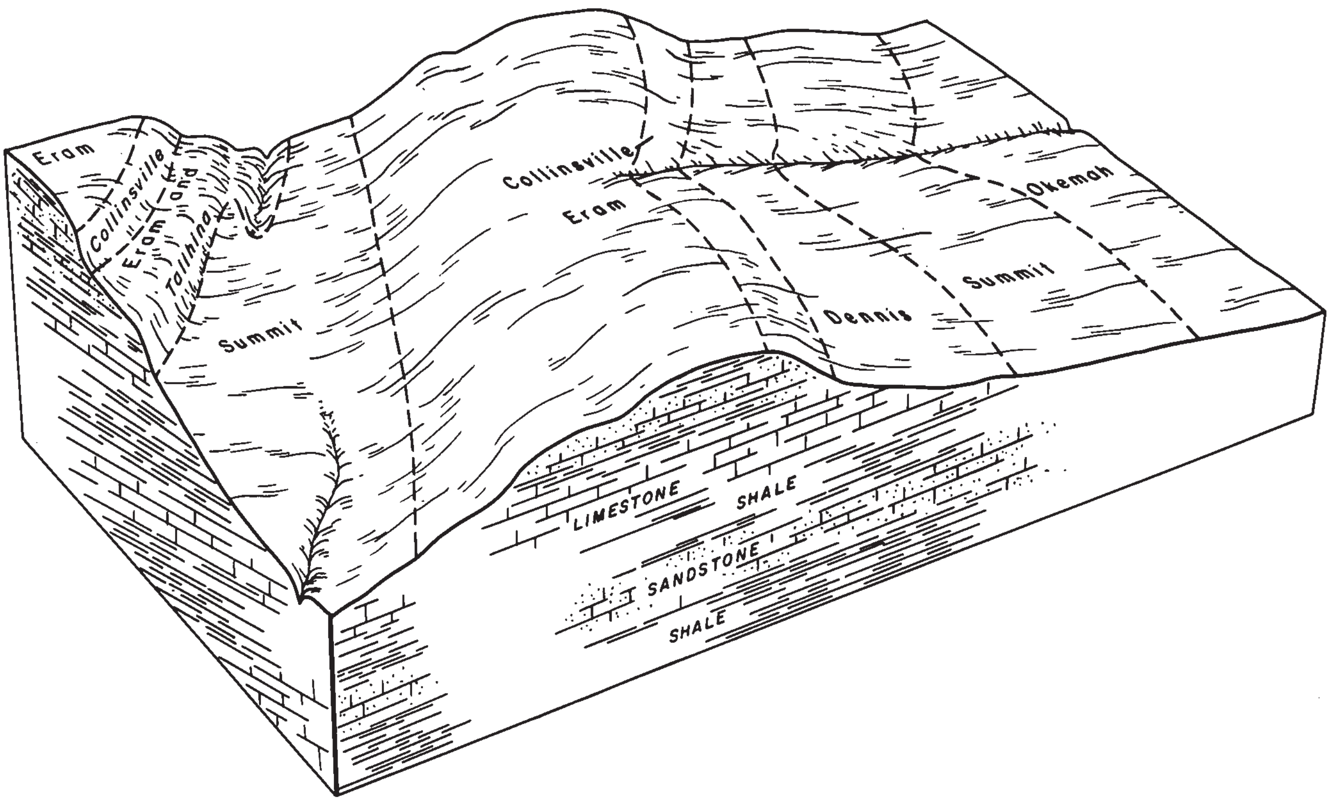

Figure 2.—**Pattern of soils in association 2.**

Catoosa soils, on gently undulating uplands, are nearly level and gently sloping. They are well drained, moderately deep over interbedded limestone, and moderately permeable. The surface layer typically is very dark brown silt loam about 8 inches thick. The subsoil is dark reddish brown and very dusky red silty clay loam. It is underlain by jointed limestone at a depth of about 28 inches.

Eram soils, on ridge summits and side slopes, are gently sloping to strongly sloping. They are moderately well drained, moderately deep over shale, and slowly permeable. The surface layer typically is very dark brown light silty clay loam about 9 inches thick. The subsoil is very dark grayish brown, brown, and gray silty clay loam and clay loam. It is underlain by dark grayish brown and yellowish brown silty and sandy shale at a depth of about 33 inches.

Clareson soils, on ridge summits and the outer edges of slopes along drainageways, are gently sloping. They are moderately deep over limestone, well drained, and moderately slowly to slowly permeable. The surface layer typically is very dark brown flaggy silty clay loam about 7 inches thick. The subsoil is dark reddish brown very flaggy silty clay. It is underlain by jointed limestone at a depth of about 24 inches.

Minor in this association are Summit, Lula, Kenoma, Dennis, Okemah, Woodson, Mason, and Verdigris soils and soils similar to Clareson but less than 20 inches deep over limestone. Lula and Kenoma soils are on higher sloping uplands and ridge summits. Summit, Dennis, Okemah, and Woodson soils are on the sides of ridges and on foot slopes. Mason and Verdigris soils are at the bottoms of drainageways. Vertical walls and deep canyons are along drainageways, and vertical walls are on some of the upper sides of ridges.

Most of the strongly sloping areas are used for native range and tame pasture. The gently sloping areas are in soybeans, wheat, and grain sorghum. Water erosion is the dominant hazard. Terraces, waterways, contour farming, residue management, and close-sown crops help control erosion. Proper range use is necessary to maintain native grasses.

4. *Kenoma-Olpe-Woodson association*

Deep, nearly level to strongly sloping, well drained to somewhat poorly drained soils of the uplands

The landscape of this association is one of gently undulating to rolling uplands that have gravelly knolls. The area is dissected by entrenched drainageways. The soils are nearly level to strongly sloping.

This association makes up about 21 percent of the county. It is about 32 percent Kenoma soils, 9 percent Olpe soils, 9 percent Woodson soils, and 50 percent minor soils.

Kenoma soils, in gently undulating areas, are gently sloping. They are deep, moderately well drained, and very slowly permeable. The surface layer typically is very dark grayish brown silt loam about 7 inches thick. The subsoil is very dark grayish brown to dark yellowish brown silty clay about 31 inches thick. The substratum is mottled brown and reddish brown silty clay and silty clay loam. Limestone is at a depth of about 61 inches.

Olpe soils, in rolling areas and on knolls, are gently sloping to strongly sloping. They are deep, well drained, and slowly or very slowly permeable. The surface layer typically is dark brown gravelly silt loam about 10 inches thick. The subsoil is dark brown to reddish brown gravelly silty clay loam, clay loam, and silty clay that extends to a depth of 60 inches or more.

Woodson soils, in lower areas, are nearly level and gently sloping. They are deep, somewhat poorly drained, and very slowly permeable. The surface layer typically is black silt loam about 8 inches thick. The subsoil is black and very dark gray silty clay in the upper part and dark grayish brown and gray silty clay in the lower part. It extends to a depth of 60 inches or more.

Minor in this association are Eram, Catoosa, Lula, Clareson, and Summit soils. Eram and Summit soils are in sloping areas along drainageways. Catoosa, Lula, and Clareson soils are on ridgetops and in gently undulating areas underlain by limestone bedrock.

A large part of this association is used for crops and some large areas are in native range. Soybeans, sorghum, wheat, alfalfa, and corn are the main crops. Water erosion is the dominant hazard on the gently sloping and sloping soils. Droughty soil conditions exist during periods of low rainfall. Terraces, waterways, contour farming, residue management, and close-sown crops help control erosion. Proper range use is necessary to maintain native grasses.

5. *Verdigris-Lanton-Leanna association*

Deep, nearly level, moderately well drained to poorly drained soils of the bottom land

This soil association is in the valleys of the larger streams. Slopes are dominantly less than 2 percent, but they are steep along the stream channel and in some places along the adjoining uplands.

This association makes up about 7 percent of the county. It is about 30 percent Verdigris soils (fig. 3), 25 percent Lanton soils, 20 percent Leanna soils, and 25 percent minor soils.

Verdigris soils, on flood plains, have slopes of less than 2 percent. They are moderately well drained and moderately permeable. The surface layer typically is very dark grayish brown silt loam and silty clay loam about 29 inches thick. The next layer is very dark grayish brown silty clay loam about 9 inches thick. The substratum is dark grayish brown silt loam and loam.

Lanton soils, on flood plains, have slopes of less than 1 percent. They are poorly drained, having a water table that fluctuates to within 20 inches of the surface, and have moderately slow permeability. The surface layer typically is very dark grayish brown silty clay loam about 17 inches thick. The subsoil is very dark gray silty clay loam that extends to a depth of more than 60 inches.

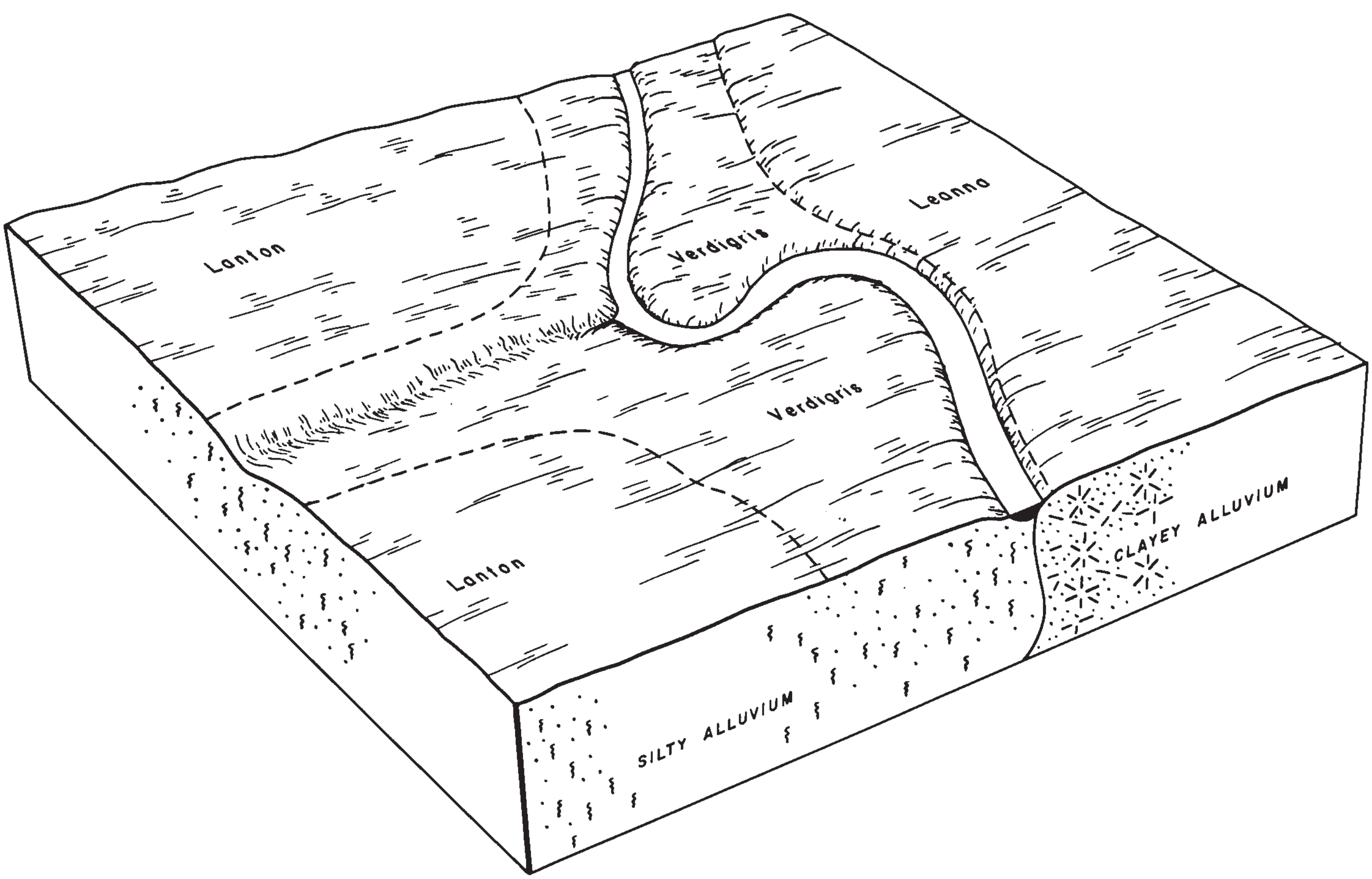

Figure 3.—**Pattern of soils in association 5.**

Leanna soils, on low stream terraces, have slopes of less than 1 percent. They are somewhat poorly drained and very slowly permeable. The surface layer typically is very dark gray silty loam about 11 inches thick. The subsurface layer is dark grayish brown silt loam about 6 inches thick. The subsoil is very dark gray and dark gray silty clay. The substratum, at a depth of 56 inches, is gray silty clay.

Minor in this association are Mason, Osage, Welda, Summit, and Woodson soils. Mason and Welda soils are on high, seldom flooded stream terraces. Osage soils are on low, wet bottom land. Adjoining the bottom land soils in places are the gently sloping Summit and nearly level and gently sloping Woodson soils on foot slopes of the uplands.

This association is used for both crops and native range. The soils are well suited to crops. Corn, grain sorghum, soybeans, wheat, and alfalfa are the main crops. Hardwood trees grow along the stream channels.

Descriptions of the Soils

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

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. Color terms are for moist soil unless otherwise stated. The profile described in the soil series is representative of mapping units in that series. If a given mapping unit has a profile in some ways different from the one described in the series, these differences are stated in the description of the mapping unit, or they are apparent in the name of the mapping unit. The description of each mapping unit contains suggestions on how the soil can be managed. The general management of soils in this county is discussed in the section, "Use and Management of the Soils."

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

Preceding the name of each mapping unit is a symbol. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit, range site, and woodland group in which the mapping unit has been placed. The page for the description of each mapping unit and range site can be learned 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," and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*15*).[2]

Catoosa Series

The Catoosa series consists of moderately deep, nearly level and gently sloping, well drained soils of the uplands. These soils formed in material weathered from limestone. They commonly are on convex ridgetops and gently undulating uplands. Native vegetation is tall prairie grasses.

In a representative profile the surface layer is very dark brown silt loam about 8 inches thick. The subsoil is about 20 inches thick. The upper 15 inches is dark reddish brown, friable silty clay loam, and the lower 5 inches very dusky red silty clay loam. Fractured limestone bedrock is at a depth of 28 inches.

Catoosa soils have moderate permeability, low available water capacity, and medium fertility. Crops respond well to additions of lime and fertilizer.

Catoosa soils are used for crops, range, tame pasture, and woodland.

Representative profile of Catoosa silt loam, 0 to 3 percent slopes, in a cultivated field; 1,400 feet west and 120 feet south of the northeast corner of sec. 11, T. 23 S., R. 19 E.

Ap—0 to 8 inches; very dark brown (7.5YR 2/2) silt loam, dark brown (7.5YR 3/2) when dry; weak very fine granular structure; hard when dry, friable when moist; many roots; slightly acid; gradual smooth boundary.

B1—8 to 12 inches; dark reddish brown (5YR 2/2) light silty clay loam, dark reddish brown (5YR 3/2) when dry; weak fine granular structure; hard when dry, friable when moist; many roots; many pores; medium acid; gradual smooth boundary.

B21t—12 to 23 inches; dark reddish brown (5YR 3/3) silty clay loam, dark reddish brown (5YR 3/3) when dry; few fine faint very dusky red (2.5YR 2/2) mottles; moderate very fine subangular blocky structure; hard when dry, friable when moist; many roots; few pores; clay films on surface of peds; few fine black concretions; medium acid; gradual smooth boundary.

B22t—23 to 28 inches; very dusky red (2.5YR 2/2) silty clay loam, dark reddish brown (2.5YR 2/4) when dry; moderate very fine subangular blocky structure; hard when dry, friable when moist; few roots; clay films on ped surface; few fine black concretions; slightly acid; abrupt wavy boundary.

R—28 inches; hard fractured limestone bedrock.

Depth to hard fractured limestone bedrock ranges from 20 to 40 inches. The A horizon is 6 to 12 inches thick. In places the B2t horizon has a few chert or limestone fragments.

Catoosa soils are near Lula and Clareson soils. They are not so deep over limestone as Lula soils. They lack the high content of limestone fragments typical of Clareson soils.

Cb—Catoosa silt loam, 0 to 3 percent slopes. This soil occurs as convex, nearly level and gently sloping areas. The areas are between 10 and 600 acres in size. They are mainly long and narrow. Some are irregular in shape.

Included with this soil in mapping are a few small tracts of Lula and Kenoma soils in the slightly higher parts of the mapped areas, tracts of Clareson soils along the outer edges, and Eram and Summit soils in the lower parts. In some areas large limestone stones are on the surface and in the surface layer. Also included are small depressional areas and eroded spots that are identified on the soil map by spot symbols (fig. 4).

More than half the acreage is cultivated. The rest is in native range and native and tame meadow. This soil is well

[2] Italic numbers in parentheses refer to Literature Cited, p. 56.

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

Soil	Area	Extent	Soil	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Catoosa silt loam, 0 to 3 percent slopes	28,090	7.6	Mayes silty clay loam	4,260	1.1
Clareson complex, 1 to 4 percent slopes	22,060	6.0	Okemah silt loam, 0 to 2 percent slopes	3,510	1.0
Collinsville complex, 2 to 15 percent slopes	3,290	.9	Olpe gravelly silt loam, 3 to 15 percent slopes	7,020	1.9
Dennis silt loam, 1 to 4 percent slopes	5,820	1.6	Osage silty clay loam	4,830	1.3
Dennis silty clay loam, 1 to 4 percent slopes, eroded	1,180	.3	Stony land-Talihina complex, steep	7,470	2.0
Eram silty clay loam, 1 to 4 percent slopes	5,040	1.4	Summit silty clay loam, 1 to 4 percent slopes	13,940	3.8
Eram silty clay loam, 4 to 7 percent slopes	3,230	.9	Summit silty clay loam, 4 to 7 percent slopes	5,320	1.4
Eram soils, 1 to 4 percent slopes, eroded	1,620	.4	Summit soils, 1 to 4 percent slopes, eroded	2,310	1.0
Eram soils, 4 to 7 percent slopes, eroded	2,520	.7	Summit-Eram complex, 4 to 7 percent slopes, eroded	2,230	1.0
Eram-Clareson complex, 1 to 15 percent slopes	13,070	3.5	Verdigris silt loam, occasionally flooded	9,060	2.4
Eram-Gullied land complex, 3 to 7 percent slopes	780	.2	Verdigris soils, frequently flooded	12,030	3.2
Eram-Talihina silty clay loams, 5 to 20 percent slopes	13,260	3.6	Welda silt loam, 0 to 2 percent slopes	300	(1)
Eram-Verdigris complex, 0 to 8 percent slopes	11,180	3.0	Welda silt loam, 2 to 6 percent slopes	250	(1)
Kenoma silt loam, 1 to 4 percent slopes	45,420	12.3	Woodson silt loam, 0 to 1 percent slopes	34,330	9.2
Kenoma soils, 1 to 4 percent slopes, eroded	3,660	1.0	Woodson silt loam, 1 to 3 percent slopes	53,894	14.6
Kenoma-Olpe complex, 2 to 7 percent slopes	7,030	1.9	Woodson soils, 1 to 3 percent slopes, eroded	3,850	1.0
Lanton silty clay loam	5,080	1.4	Borrow pits	310	(1)
Leanna silt loam	8,880	2.4	Limestone quarry	200	(1)
Lula silt loam, 0 to 3 percent slopes	17,830	4.8	Gravel pits	110	(1)
Mason silt loam	4,530	1.2	Major streams	230	(1)
			Total	369,024	100.0

[1] Less than 0.05 percent.

suited to wheat and soybeans. Yields of other crops are somewhat limited because the available water capacity is low.

Runoff is slow to medium. Water erosion is a hazard in the gently sloping areas.

A cropping system, residue management, minimum tillage, and terracing help to control erosion. Capability unit IIe-2; Loamy Upland range site; not assigned to a woodland suitability group.

Clareson Series

The Clareson series consists of gently sloping, well drained soils of the uplands that are moderately deep over limestone bedrock. These soils formed in material weathered from limestone. The native vegetation is tall prairie grasses.

***Figure 4.*—Erosion has exposed the limestone in this area of Catoosa silt loam.**

In a representative profile the surface layer is very dark brown flaggy silty clay loam about 7 inches thick. The subsoil is dark reddish brown friable very flaggy silty clay about 17 inches thick. Fractured limestone bedrock is at a depth of about 24 inches.

Clareson soils have moderately slow to slow permeability, low available water capacity, and medium fertility.

Clareson soils are used for range, native meadow, and woodland.

Representative profile of Clareson flaggy silty clay loam in an area of Clareson complex, 1 to 4 percent slopes, in native grass; 2,600 feet east and 950 feet north of the southwest corner of sec. 19, T. 21 S., R. 20 E.

A1—0 to 7 inches; very dark brown (7.5YR 2/2) flaggy light silty clay loam, dark brown (7.5YR 3/2) when dry; moderate very fine granular structure; hard when dry, friable when moist; many roots; many pores; many worm casts; about 20 percent flaggy limestone; neutral; gradual wavy boundary.

B21t—7 to 16 inches; dark reddish brown (5YR 2/2) very flaggy light silty clay, dark reddish brown (5YR 3/2) when dry; strong fine granular and subangular blocky structure; hard when dry, friable when moist; many roots; many fine pores; few worm casts; about 60 percent flaggy limestone; neutral; gradual wavy boundary.

B22t—16 to 24 inches; dark reddish brown (5YR 3/3) very flaggy silty clay, dark reddish brown (5YR 3/3) when dry; weak very fine subangular blocky structure; hard when dry, friable when moist; few roots; few pores; few worm casts; about 80 percent flaggy limestone; neutral; abrupt broken boundary.

R—24 inches; fractured very pale brown limestone.

Depth to limestone bedrock ranges from 20 to 40 inches. The A horizon is very dark brown, dark brown, or very dark grayish brown and is 5 to 60 percent flaggy limestone fragments. The texture of the B2t horizon is silty clay loam to silty clay. It is 35 to 90 percent flaggy limestone fragments. A B3 horizon is present in some profiles.

Clareson soils are near Catoosa and Lula soils. They contain a high percentage of flaggy limestone fragments, whereas Catoosa and Lula soils have none to few of these fragments.

Cc—Clareson complex, 1 to 4 percent slopes. This mapping unit is mainly on the crests of ridgetops and on outer edges of limestone areas. It is about 60 percent Clareson soils, 10 percent Catoosa soils, 10 percent outcrops of limestone, 5 percent soils very shallow over limestone, 5 percent soils that are similar to Catoosa soils but have limestone at a depth of between 10 and 20 inches, and 10 percent sloping Talihina soils. The areas are 5 to 400 acres in size and irregular in shape. The Clareson soil has a surface layer that is dominantly flaggy silty clay loam. Included in mapping and shown by a spot symbol are small depressions.

Nearly all the acreage is used as range and meadow. Some areas are covered with trees and brush. The depth to limestone bedrock and the high content of limestone fragments in and on the soil make this soil generally unsuitable for crops. Runoff is medium. This complex is well suited to native range and meadow.

Proper range use and control of trees and brush help to maintain a stand of desirable grasses. Capability unit VIs–1; Shallow Flats range site; not assigned to a woodland suitability group.

Collinsville Series

The Collinsville series consists of gently sloping to strongly sloping, well drained to somewhat excessively drained soils. These soils are very shallow to shallow over sandstone and sandy shale. The native vegetation is tall prairie grasses.

In a representative profile the surface layer is very dark grayish brown loam about 6 inches thick. This layer contains some fragments of sandstone. The subsoil is dark brown, friable channery loam that contains many fragments of sandstone. Strong brown thinly bedded sandstone and interbedded sandy shale are at a depth of 11 inches.

Collinsville soils have moderately rapid permeability, medium to rapid surface runoff, and medium fertility. They have very low available water capacity and are somewhat droughty.

Most of the acreage of Collinsville soils is in native prairie grasses that are used for hay or grazing. These soils are not suitable for cultivation, but a few small areas are cultivated. These soils support a good stand of prairie grasses under proper management.

Representative profile of Collinsville loam in an area of Collinsville complex, 2 to 15 percent slopes, in native grass; 2,300 feet west and 100 feet south of the northeast corner of sec. 15, T. 23 S., R. 21 E.

A1—0 to 6 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) when dry; weak fine granular structure in upper part and weak thin platy structure in lower part; hard when dry, friable when moist; less than 15 percent coarse fragments; medium acid; gradual wavy boundary.

B—6 to 11 inches; dark brown (10YR 3/3) channery loam, brown (10YR 5/3) when dry; weak fine granular and weak very fine subangular blocky structure; hard when dry, friable when moist; about 20 percent coarse fragments; medium acid; gradual wavy boundary.

R—11 inches; strong brown thinly bedded sandstone and interbedded sandy shale.

Depth to sandstone and interbedded sandy shale ranges from 4 to 20 inches. The texture is sandy loam or loam throughout the profile. Fragments of sandstone are on the soil surface and throughout the soil, but average less than 35 percent by volume. In some places, there is a C horizon instead of a B horizon. The C horizon is very dark grayish brown to dark brownish yellow.

Collinsville soils are near Dennis, Eram, and Talihina soils. They are underlain by sandstone and sandy shale, whereas Talihina soils are underlain by silty and clayey shales. They are not so deep as Dennis and Eram soils.

Cd—Collinsville complex, 2 to 15 percent slopes. This mapping unit is on the summit and upper slopes of ridges and high knolls. It is about 65 percent Collinsville soils, 20 percent a soil that is similar to Collinsville soils but is 20 to 26 inches deep over sandstone, and 15 percent mostly Talihina, Eram, Dennis, and Summit soils.

Most of this unit is used for native range and meadow. Runoff is medium to rapid. Because of the slope and the hazard of erosion, the soils generally are not suited to cultivated crops. They are better suited to native grasses. A few areas are wooded.

Careful management of grazing is essential. Proper range use and deferment of grazing are needed. Capability unit VIe–2; Shallow Sandstone range site; not assigned to a woodland suitability group.

Dennis Series

The Dennis series consists of deep, gently sloping, moderately well drained soils of the uplands. These soils formed in old clayey sediment or in material weathered from shale. They commonly are on the gentle foot slopes in the steep upland areas and on crests of ridges in the undulating upland areas. The native vegetation is tall prairie grasses.

In a representative profile the surface layer is very dark brown silt loam about 10 inches thick. The subsoil is about 37 inches thick. The upper 11 inches is very dark grayish brown and mottled dark brown, friable silty clay loam, and the lower 26 inches is mottled dark brown and strong brown, firm silty clay. The substratum is coarsely mottled yellowish brown, firm silty clay loam to a depth of 56 inches. Below this is yellowish brown and light gray, mildly alkaline shale.

Dennis soils have slow permeability, high available water capacity, and medium to high fertility. Crops respond well to additions of lime and fertilizer.

Dennis soils are used for cultivated crops, range, tame pasture, and woodland.

Representative profile of Dennis silt loam, 1 to 4 percent slopes, in native range; 1,700 feet west and 150 feet south of the northeast corner of sec. 28, T. 19 S., R. 18 E.

A1—0 to 10 inches; very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) when dry; weak fine granular structure; hard when dry, friable when moist; many roots; many pores; few worm casts; medium acid; gradual smooth boundary.

B1—10 to 14 inches; very dark grayish brown (10YR 3/2) light silty clay loam, grayish brown (10YR 5/2) when dry; few fine faint dark yellowish brown (10YR 4/4) krotovinas; moderate medium subangular blocky and weak fine granular structure; hard when dry, friable when moist; few roots; many pores; few worm casts; few fine shale fragments; strongly acid; gradual smooth boundary.

B21t—14 to 21 inches; dark brown (10YR 3/3) silty clay loam, dark brown (10YR 4/3) crushed, brown (10YR 5/3) when dry; common medium prominent yellowish red (5YR 4/6) mottles; very dark grayish brown (10YR 3/2) filling vertical cracks; moderate fine subangular blocky structure; hard when dry, friable when moist; few roots; few pores; few worm casts; few fine black concretions; few fine shale fragments; strongly acid; gradual smooth boundary.

B22t—21 to 34 inches; dark brown (10YR 4/3) light silty clay, brown (10YR 5/3) when dry; many medium distinct strong brown (7.5YR 5/8) mottles; common medium prominent reddish brown (5YR 4/4) mottles; weak fine subangular blocky structure; very hard when dry, firm when moist; few roots; few pores; few fine and medium black concretions; few fine shale fragments; medium acid; gradual smooth boundary.

B23t—34 to 47 inches; coarsely mottled strong brown (7.5YR 5/6) and grayish brown (10YR 5/2) light silty clay, reddish yellow (7.5YR 6/6) and light brownish gray (10YR 6/2) when dry; weak fine subangular blocky structure; very hard when dry, firm when moist; few roots; few pores; few fine and medium black concretions; shale fragments 1/8 to 1/2 inch thick; medium acid; diffuse boundary.

C1—47 to 56 inches; coarsely mottled yellowish brown (10YR 5/6) and gray (10YR 6/1) silty clay loam, yellow (10YR 7/6) and light gray (10YR 7/1) when dry; weak fine subangular blocky structure; very hard when dry, firm when moist; few pores; few medium black concretions; thin platy shale fragments; neutral; diffuse boundary.

C2—56 to 60 inches; thin bedded, yellowish brown and light gray mildly alkaline shale.

The A horizon is 8 to 16 inches thick and is very dark brown to dark brown. It is silt loam, loam, or silty clay loam. A thin A2 horizon occurs in some places. The texture of the B2t horizon is silty clay loam, clay loam, or silty clay. Thickness of the solum ranges from 40 to more than 60 inches.

In most of the Dennis soils in Anderson County, thickness of the solum is less than the 60 inch limit defined for the series. This difference, however, does not alter use and management.

Dennis soils are near the Collinsville, Eram, Kenoma, Okemah, and Summit soils. They are less clayey in the upper part of the profile than Summit soils and are deeper than Collinsville and Eram soils. Their B2t horizon is brownish, whereas that of Okemah soils is grayish. They do not have the abrupt textural change between the A1 and B21t horizons that is characteristic of Kenoma soils.

Db—Dennis silt loam, 1 to 4 percent slopes. This gently sloping soil has the profile described as representative of the Dennis series. Areas are between 10 and 200 acres in size and are mostly narrow and irregular. Included with this soil in mapping are areas of Eram and Talihina soils in higher sloping areas, areas of Kenoma soils on ridge tops, and areas of Okemah soils on lower, smoother slopes.

About half the acreage is cultivated, and the rest is in native range. This soil is well suited to all crops commonly grown in the county. Runoff is medium. Water erosion is a hazard.

A cropping system that conserves soil and water, residue management, minimum tillage, terracing, and contour farming help to control erosion. Proper range use and controlling brush and trees are essential to good range management. Capability unit IIe-1; Loamy Upland range site; not assigned to a woodland suitability group.

De—Dennis silty clay loam, 1 to 4 percent slopes, eroded. Areas of this gently sloping soil are between 10 and 60 acres in size and are narrow and irregular in shape. In about 50 percent of a mapped area the surface layer is silty clay loam, in about 40 percent it is silt loam, and in the rest it is silty clay. In most places material from the subsoil has been mixed into the plow layer. Otherwise, the profile of this soil is similar to the one described as representative of the series. Included with this soil in mapping are small areas of gently sloping Eram and Kenoma soils.

Almost all areas have been cultivated. Some are now under cultivation, but many are in tame pasture. This soil is suited to the commonly grown crops if intensive protective measures are used. Runoff is medium. Water erosion is a severe hazard.

A cropping system that conserves soil and water, residue management, minimum tillage, terracing, and contour farming help to control erosion. Because of erosion, this soil has low fertility. Lime and fertilizer are needed to provide an adequate vegetative cover. Fertilizer used properly is beneficial to tame grasses. Capability unit IIIe-3; Clay Upland range site; not assigned to a woodland suitability group.

Eram Series

The Eram series consists of gently sloping to strongly sloping, moderately well drained soils that are moderately deep over shale. These soils of the upland formed in material weathered from shale. They generally are on convex sides of hills below outcrops of limestone and on convex side slopes in gently rolling uplands. The native vegetation is tall prairie grasses.

In a representative profile the surface layer is very dark brown light silty clay loam about 9 inches thick. The subsoil is about 24 inches thick. It is very dark grayish brown, friable silty clay loam in the upper 6 inches; very dark grayish brown, firm clay loam in the next 5 inches; brown, firm silty clay loam in the next 8 inches; and coarsely mottled gray, firm silty clay loam in the lower 5 inches. Dark grayish brown, light yellowish brown, and yellowish brown shale is at a depth of 33 inches.

Eram soils have slow permeability, moderate available water capacity, and medium fertility. Crops respond well to additions of lime and fertilizer.

Eram soils are used for cultivated crops, range, tame pasture, and woodland.

Representative profile of Eram silty clay loam, 1 to 4 percent slopes, in native range; 2,100 feet north and 550 feet west of the southeast corner of sec. 13, T. 23 S., R. 19 E.

A1—0 to 9 inches; very dark brown (10YR 2/2) light silty clay loam, dark grayish brown (10YR 4/2) when dry; weak fine granular structure; hard when dry, friable when moist; medium acid; gradual boundary.

B1—9 to 15 inches; very dark grayish brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) when dry; few fine faint brown (7.5YR 4/4) mottles; weak fine granular and subangular blocky structure; hard when dry, friable when moist; few fine black concretions; few fine sandstone fragments; slightly acid; clear wavy boundary.

B21t—15 to 20 inches; very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) heavy clay loam, grayish brown (10YR 5/2) when dry; very dark grayish brown (10YR 3/2) when crushed; few fine distinct dark reddish brown (2.5YR 3/4) mottles; moderate fine subangular blocky structure; very hard when dry, firm when moist; few fine black concretions; many fine dark reddish brown sandstone fragments; slightly acid; clear wavy boundary.

B22t—20 to 28 inches; brown (10YR 4/3) heavy silty clay loam to clay loam, pale brown (10YR 6/3) when dry; many fine prominent dark reddish brown (5YR 3/4) mottles; moderate fine and medium subangular blocky structure; very hard when dry, firm when moist; few fine black concretions; few fine sandstone fragments; slightly acid; gradual boundary.

B3—28 to 33 inches; coarsely mottled gray (10YR 5/1), red (2.5YR 4/6), and red (10R 4/8) heavy silty clay loam; weak fine subangular blocky structure; very hard when dry, firm when moist; thin yellowish brown platy shale; slightly acid; abrupt boundary.

C—33 to 35 inches; dark grayish brown, light yellowish brown, and yellowish brown shale; neutral.

Depth to bedded shale is 20 to 40 inches. The A horizon is 6 to 14 inches thick and is silt loam, silty clay loam, or clay loam. The B2t horizon is clay loam, silty clay loam, or silty clay.

Eram soils are near the Collinsville, Dennis, Okemah, Summit, and Talihina soils. They are not so deep as Dennis, Okemah, and Summit soils. They are deeper than Collinsville and Talihina soils and have more profile development.

Eb—Eram silty clay loam, 1 to 4 percent slopes. This gently sloping soil has the profile described as representative of the series. Areas are between 10 and 300 acres in size and are mostly narrow and long.

Included with this soil in mapping are small areas of Talihina and Collinsville soils on ridges, Catoosa soils in areas of limestone bedrock, and Summit and Dennis soils on lower slopes.

About half the acreage has been cultivated, of which part is tame pasture. The other half is native range. This soil is suited to all crops commonly grown in the county. Runoff is medium. Water erosion is a hazard.

A cropping system that conserves soil and water, residue management, minimum tillage, terracing, and contour farming help to control erosion. Proper range use and control of weeds and brush are essential to good range management. Fertilizer, used properly, is beneficial to tame grasses. Capability unit IIIe-5; Clay Upland range site; not assigned to a woodland suitability group.

Ec—Eram silty clay loam, 4 to 7 percent slopes. This sloping soil is on uplands, generally below areas of soils containing limestone fragments. Areas are long and narrow in shape and between 10 and 200 acres in size. About 30 percent of this mapping unit is Eram soils that have a surface layer of silt loam.

Included with this soil in mapping are small areas of Talihina and Collinsville soils on higher steeper slopes, Dennis and Summit soils on less steep slopes, and Catoosa and Clareson soils that are underlain by limestone bedrock.

This soil is used for native range, tame pasture, and cultivated crops. A few areas are in timber or brush. This soil is well suited to native range and tame pasture. It is suited to crops if intensive conservation practices are used to control erosion. Runoff is rapid. Water erosion is a severe hazard.

A combination of cultural and structural practices are needed to maintain good tilth and keep soil loss to a minimum. These practices include a cropping system that conserves soil and water, crop-residue management, minimum tillage, terracing, contour farming, and fertilization. Fertilizer, used properly, is beneficial to tame grasses. Regulation of grazing and control of weeds, trees, and brush are needed to maintain a stand of desirable native grasses. Capability unit IVe-2; Clay Upland range site; not assigned to a woodland suitability group.

Ed—Eram soils, 1 to 4 percent slopes, eroded. This gently sloping unit has short, convex slopes. Areas are between 10 and 60 acres in size and are long and narrow in shape. In most places material from the subsoil has been mixed into the surface layer; the texture of the surface layer in these areas is silty clay loam, clay loam, or silty clay. In some of the more severely eroded areas shale material is exposed at the surface.

Included with this unit in mapping are small areas of Talihina and Collinsville soils on higher positions, Dennis soils in similar positions, and soils, mainly in the more eroded areas, that are similar to Eram soils but are more clayey throughout.

Almost all the acreage has been cultivated. Most areas are in tame pasture, but some remain under cultivation. These soils are not well suited to crops. Runoff is medium. Water erosion is a severe hazard.

A cropping system that conserves soil and water, close-grown crops, residue management, minimum tillage, terracing, and contour farming help to control erosion. Because of erosion, this unit is low in fertility. Lime and fertilizer are needed to provide adequate vegetative cover. Capability unit IVe-3; Clay Upland range site; not assigned to a woodland suitability group.

Eh—Eram soils, 4 to 7 percent slopes, eroded. These soils are on the sides of ridges and hills. Areas are mostly long and narrow in shape and between 10 and 60 acres in size. So much of the original surface layer has been removed by erosion that ordinary tillage has mixed subsoil material with the remaining surface layer. The texture of the surface layer is silty clay loam, clay loam, or silty clay. In most areas a few shallow gullies and gully scars are evident. In some of the more severely eroded areas shale material is exposed at the surface.

Included with this unit in mapping are small areas of Talihina and Collinsville soils on higher steeper slopes, Dennis soils in lower less steep areas, and areas of soils that are similar to Eram soils but have a lighter colored surface layer.

Almost all the acreage has been cultivated. Most areas are in tame pasture, but some remain under cultivation. These soils are best suited to native grasses or tame pasture. Runoff is rapid. Because of past erosion and the continuing severe hazard of erosion, these soils are generally not suitable for cultivated crops.

Good management requires practices that control runoff and erosion and that establish and maintain adequate stands of perennial grasses or tame pasture grasses. Grazing at proper intensity and deferring grazing help to maintain a stand of desirable grasses. Lime and fertilizer are needed to establish and maintain an adequate vegetative cover of tame pasture grasses. Capability unit VIe-1; Clay Upland range site; not assigned to a woodland suitability group.

Ek—Eram-Clareson complex, 1 to 15 percent slopes. This mapping unit is along the upper edge of steep ridges. It is about 60 percent Eram soils, 20 percent Clareson soils, 5 percent Talihina soils, and 5 percent outcrops of limestone. In parts of the county, where the high limestone uplands break to lower lying areas and drainageways, some areas of these soils extend for long distances. The crest and upper parts of the ridges are Clareson soils that have outcrops of limestone. Narrow bands of Talihina soils and wider bands of Eram soils are below. Most areas have alternating areas of Clareson soils, Talihina soils, and Eram soils. The Eram soils in this unit have a profile similar to the one described as representative of the series, but they are dark colored to a lesser depth. The Clareson soils have a profile similar to the one described as representative of the Clareson series.

Included in mapping are small areas of Dennis, Summit, and Catoosa soils; soils that are shallow over limestone; and soils that have variable characteristics and are along drainageways.

Nearly all the acreage is used as range. Some areas are covered with trees and brush. Runoff is rapid. Because of the slope and the hazard of erosion, the soils in the mapping unit are generally not suited to cultivated crops. They are better suited to native grasses.

Proper grazing intensity, deferred grazing, and rotation grazing are practices needed to maintain a vegetative cover that is adequate in controlling erosion. Controlling brush and trees will help maintain a stand of desirable grasses. Capability unit VIe-2; Eram soils in Clay Upland range site, Clareson soils in Shallow Flats range site; neither soil assigned to a woodland suitability group.

Eo—Eram-Gullied land complex, 3 to 7 percent slopes. This mapping unit is on side slopes of ridges and hills on the uplands. It is about 40 percent Eram soils, 40 percent Gullied land, 10 percent Dennis soils, and 10 percent Talihina, Collinsville, Summit, and Kenoma soils and areas of exposed shale. About 40 percent of the Eram and Dennis soils is moderately eroded and 20 percent is severely eroded. Most areas are alternating gullies and areas of identifiable soils. The gullies range from a few feet to 15 feet in width and from a few feet to 10 feet in depth. A few areas are broad, gently sloping, and severely eroded, but have only a few gullies.

Areas of this mapping unit are so severely eroded that they no longer are suitable for cultivation. Gullied and severely eroded areas support little or no vegetation. Droughtiness and restricted root depth limit plant growth. Runoff is rapid in some areas and very rapid in the steeper areas and in areas of exposed shale.

Establishing and maintaining perennial grasses is a practical way to protect these soils from continued erosion. Constructing diversion terraces and land smoothing are practices needed to help establish perennial grasses. Additions of lime and fertilizer encourage growth of a vigorous stand of tame grasses. Capability unit VIe–1; Clay Upland range site; not assigned to a woodland suitability group.

Ep—Eram-Talihina silty clay loams, 5 to 20 percent slopes. This mapping unit consists of soils that are very shallow to moderately deep over shale. It is about 45 percent Eram silty clay loam, 25 percent Talihina silty clay loam, 10 percent Dennis soils, 10 percent Summit soils, and 10 percent Collinsville and Clareson soils and soils in drainageways. The soils are on ridgetops and the sides of ridges and hills. The shallow Talihina soil is on ridgetops and on the higher slopes above the moderately deep Eram soil that is on lower less steep slopes. The Eram soil of this mapping unit is dark colored to a lesser depth than is described in the representative profile. The Talihina soil has the profile described as representative of the Talihina series.

These soils are used as native range and tame pasture. A few small areas are cultivated with the surrounding soils. Some areas are covered with timber, most of which is low in quality for marketable logs. Runoff is rapid. Water erosion is a severe hazard. These soils are best suited to native grasses and tame pasture grasses.

Good management needs are practices that control runoff and that maintain and establish adequate stands of perennial grasses or tame pasture grasses. Proper grazing intensity, deferred grazing, and rotation grazing help to maintain a stand of desirable grasses. Practices for controlling brush and weeds are also needed. Lime and fertilizer are needed to establish and maintain an adequate vegetative cover of tame grasses. Capability unit VIe–2; Clay Upland range site; not assigned to a woodland suitability group.

Ev—Eram-Verdigris complex, 0 to 8 percent slopes. This mapping unit consists of soils along narrow drainageways of the uplands. It is about 50 percent Eram soils having slopes of 2 to 8 percent, 15 percent Verdigris soils having slopes of 0 to 2 percent, and 10 percent Mason and Osage soils that are on the bottoms of drainageways; the rest is Dennis, Kenoma, Summit, Woodson, and Talihina soils. Mapped areas consist of a narrow area of alluvial soils on the bottoms of the drainageways and soils on both sides of the drainageways. Areas are commonly between 250 and 1,000 feet in width and ½ mile to more than 2 miles in length. Where cultivated, the Eram soils have lost their original surface layer.

Most of the acreage is in tame or native grass. Many areas are used as natural waterways for terrace outlets. Some are farmed, but water erosion is a severe hazard. A few remain wooded. Runoff is medium to rapid. Because of the slope and added run-in water from surrounding sloping soils, these soils are not well suited to crops. These areas are well suited to wildlife habitat.

The main management needs are practices that control runoff and erosion and maintain or improve tilth and fertility. A cropping system that conserves soil and water and uses close-sown crops is necessary for controlling erosion. Minimum tillage and crop-residue management are helpful practices. Wood crops can be increased by thinning stands, selective cutting, and preventing fires. Regulation of grazing and control of weeds and brush are needed to maintain a desirable stand of native grasses. Capability unit IVe–4; Eram soil in Clay Upland range site, Verdigris soil in Loamy Lowland range site; Eram soil not assigned to a woodland suitability group, Verdigris soil in woodland suitability group 3o.

Kenoma Series

The Kenoma series consists of deep, gently sloping, moderately well drained soils of the uplands. These soils formed in sediment high in silt and clay. The native vegetation is tall and mid prairie grasses.

In a representative profile the surface layer is very dark grayish brown silt loam about 7 inches thick. The subsoil is very firm and firm silty clay about 31 inches thick. The upper 10 inches is mottled very dark grayish brown and dark brown and the lower 21 inches is mottled brown and dark yellowish brown. The substratum is mottled brown and reddish brown silty clay and silty clay loam. Limestone is at a depth of about 61 inches.

Kenoma soils have very slow permeability, moderate available water capacity, and medium fertility. Crops respond well to additions of lime and fertilizer.

Kenoma soils are used mainly for crops, but some large areas are in native range.

Representative profile of Kenoma silt loam, 1 to 4 percent slopes, in native grass; 1,750 feet east and 550 feet north of the southwest corner of sec. 32, T. 22 S., R. 20 E.

A1—0 to 7 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; upper 4 inches moderate thin platy structure parting to weak fine granular; lower 3 inches weak fine subangular blocky structure parting to weak fine granular; slightly hard when dry, friable when moist; many fine roots; many worm casts; few fine chert fragments; slightly acid; abrupt wavy boundary.

B21t—7 to 11 inches; very dark grayish brown (10YR 3/2) silty clay, grayish brown (10YR 5/2) when dry; light gray (10YR 7/1) silt coatings on peds in upper 1½ inches; many vertical streaks of very dark brown (10YR 2/2) and dark yellowish brown (10YR 4/4); weak fine prismatic structure parting to weak very fine angular blocky; extremely hard when dry, very firm when moist; common fine roots; few fine pores; few worm casts; thin discontinuous clay films; black concretions (oxides); few fine chert fragments; medium acid; clear irregular boundary.

B22t—11 to 17 inches; dark brown (10YR 3/3) silty clay; faces of peds very dark grayish brown (10YR 3/2), brown (10YR 4/3) when dry; few fine vertical streaks of very dark brown (10YR 2/2) silt loam; common fine faint dark yellowish brown (10YR 4/4) mottles; weak very fine subangular blocky structure; extremely hard when dry, very firm when moist; common fine roots; few fine pores; thin distinct clay films; black concretions (oxides); few fine chert fragments; slightly acid; clear irregular boundary.

B23t—17 to 26 inches; brown (10YR 4/3) silty clay, brown (10YR 5/3) when dry; few fine vertical streaks of very dark brown (10YR 2/2) silt loam; common very fine faint yellowish brown (10YR 5/4 and 5/6) mottles; weak very fine subangular blocky structure; extremely hard when dry, very firm when moist; few fine roots; few very fine pores; thin distinct clay films; black concretions (oxides); few fine chert fragments; neutral; gradual irregular boundary.

B3—26 to 38 inches; dark yellowish brown (10YR 4/4) silty clay, yellowish brown (10YR 5/6) when dry; common very fine faint yellowish brown (10YR 5/4) mottles; weak very fine subangular blocky structure; very hard when dry, firm when moist; few fine roots; black concretions; moderately alkaline; diffuse boundary.

C1—38 to 56 inches; brown (7.5YR 4/4) silty clay; common fine faint yellowish brown (10YR 5/4) mottles; massive; very hard when dry, firm when moist; common black concretions (oxides); few fine chert fragments; few lime concretions as much as 1½ inches in diameter; moderately alkaline; diffuse boundary.

C2—56 to 61 inches; mottled reddish brown (5YR 4/4), light brownish gray (2.5Y 6/2), pale olive (5Y 6/3), and yellowish brown (10YR 5/6) silty clay loam; massive; very hard when dry, firm when moist; many black films and stains; few small lime concretions; small fragments of decomposed shale; moderately alkaline; abrupt boundary.

R—61 inches; hard limestone bedrock.

The A1 horizon is 5 to 13 inches thick and is silt loam or light silty clay loam. The transition between the A1 horizon and B21t horizon is less than 3 inches. The upper part of the B2t horizon is very dark grayish brown or dark brown clay or silty clay. The chert content of the B horizon may be as high as 30 percent.

Kenoma soils are near Dennis, Olpe, Summit, and Woodson soils. They have a browner B horizon than Woodson soils. They do not have the transitional B1 horizon of Summit and Dennis soils and the high gravel content of Olpe soils.

Kb—Kenoma silt loam, 1 to 4 percent slopes. This gently sloping soil is on ridges and in broad undulating areas. It has the profile described as representative of the series. Areas are between 10 and 800 acres in size.

Included with this soil in mapping are a few areas of Woodson and Dennis soils on similar slopes, Summit soils in lower areas, Olpe soils on knolls, Catoosa and Clareson soils in areas underlain by limestone, and areas of soils that are similar to Kenoma soils but have a gray subsurface layer. Also included are very small saline spots from oil waste that are shown by spot symbols on the soil map.

A large part of the acreage is cultivated, and this soil is well suited to the commonly grown crops. Some large areas are in native range and tame pasture. Runoff is medium. Water erosion is a hazard in cultivated areas.

A cropping system that conserves soil and water, crop-residue management, minimum tillage, terracing, and contour farming help to control erosion. Capability unit IIIe-1; Clay Upland range site; not assigned to a woodland suitability group.

Kd—Kenoma soils, 1 to 4 percent slopes, eroded. These gently sloping soils are on ridges. They have profiles similar to the one described as representative of the series, but the texture of the surface layer varies from place to place. The proportions are about 50 percent silty clay loam, 25 percent silt loam, and 25 percent silty clay. In most places material from the underlying horizons has been mixed into the plow layer, and in some severely eroded areas mottled clay and waterworn chert pebbles are exposed at the surface. Small gullies make up as much as 10 percent of some areas (fig. 5). Areas are 10 to 60 acres in size.

Included with this soil in mapping are small areas of Olpe, Woodson, and Summit soils. Also included are small areas of saline spots and alkali spots that are shown by spot symbols on the soil map.

Nearly all the acreage is cultivated or has been cultivated. Some areas have been seeded to tame pasture. Runoff is medium. Water erosion is a severe hazard.

A cropping system that conserves soil and water, crop-residue management, minimum tillage, terracing, and contour farming help to control erosion. Controlled grazing is needed to provide adequate vegetative cover on grass areas. Because of erosion, this soil is low in fertility. Lime and fertilizer are needed. Capability unit IVe-4; Clay Upland range site; not assigned to a woodland suitability group.

***Figure 5.*—Gully in an area of Kenoma soils, 1 to 4 percent slopes, eroded. No conservation structures were used to control erosion on this sloping soil.**

Kh—Kenoma-Olpe complex, 2 to 7 percent slopes. This mapping unit is on undulating uplands with low knolls. It is about 40 percent Kenoma soils, 35 percent Olpe soils, 15 percent Dennis, Summit, Eram, and Woodson soils, and 10 percent Catoosa soils. Kenoma soils are in smoother gently sloping areas. Olpe soils are on knolls and in steeper areas.

This unit is used for crops, native range, meadow, and tame pasture. It is suited to the commonly grown cultivated crops if managed properly. Runoff is medium to rapid. Erosion is a severe hazard.

A cropping system that conserves soil and water, crop-residue management, minimum tillage, terracing, contour farming, and fertilization help to control erosion. Proper use of fertilizer and lime benefits tame grasses. Regulation of grazing and control of weeds and brush are needed to maintain a stand of desirable native grasses. Capability unit IVe-1; Kenoma soil in Clay Upland range site, Olpe soil in Loamy Upland range site; not assigned to a woodland suitability group.

Lanton Series

The Lanton series consists of deep, nearly level, poorly drained soils of the flood plains. These soils formed in silty alluvial sediment along the major streams of the county. The native vegetation is tall grasses and hardwood trees.

In a representative profile the surface layer is very dark grayish brown silty clay loam about 17 inches thick. The subsoil extends to a depth greater than 60 inches. It is mottled, very dark gray silty clay loam. It is friable to a depth of 31 inches and firm below.

Lanton soils have moderately slow permeability, high available water capacity, and high natural fertility. Crops respond to additions of fertilizer and in some areas to additions of lime.

Lanton soils are used mainly for crops. Corn, grain sorghum, and soybeans are the main crops. A few areas are used for range and tame pasture, and a few areas remain wooded with deciduous trees.

Representative profile of Lanton silty clay loam in cropland; 2,800 feet east and 650 feet south of the northwest corner of sec. 5, T. 20 S., R. 20 E.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) when dry; weak fine and moderate medium granular structure; hard when dry, friable when moist; few roots; neutral; clear boundary.

A12—9 to 17 inches; very dark grayish brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) when dry; moderate medium subangular blocky structure; hard when dry, friable when moist; few fine roots; many fine pores; few worm casts; neutral; clear wavy boundary.

B21g—17 to 31 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) when dry; few fine faint dark grayish brown (10YR 4/2) and brown (10YR 4/3) mottles; moderate medium subangular blocky structure; hard when dry, friable when moist; few roots; few fine pores; few worm casts; neutral; diffuse boundary.

B22g—31 to 45 inches; very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) when dry; common medium distinct dark yellowish brown (10YR 4/4) mottles and few fine and medium prominent dark reddish brown (5YR 3/3) mottles; very dark grayish brown (10YR 3/2) when rubbed; moderate medium subangular blocky structure, parting to weak fine granular; hard when dry, firm when moist; few fine roots; many fine pores; few fine black iron concretions; neutral; diffuse boundary.

B31g—45 to 63 inches; very dark gray (N 3/0) silty clay loam, gray (10YR 5/1) when dry; few fine and medium distinct brown (10YR 4/3) and dark yellowish brown (10YR 3/4) mottles and few very fine prominent dark reddish brown (5YR 3/3) mottles, very dark gray (10YR 3/1) when rubbed; weak medium subangular blocky structure; hard when dry, firm when moist; few fine roots; many pores; few fine black and brown iron concretions; neutral; diffuse boundary.

B32g—63 to 80 inches; very dark gray (N 3/0) silty clay loam, gray (10YR 5/1) when dry; many medium and coarse distinct yellowish brown (10YR 5/8) and dark brown (7.5YR 3/2) mottles; weak medium subangular blocky structure; hard when dry, firm when moist; few pores; few black stains and fine concretions; neutral.

The A horizon is 14 to 34 inches thick and is silt loam or silty clay loam. A Cg horizon is present in some profiles.

Lanton soils are near Mason, Osage, and Verdigris soils. They have a less clayey B horizon than Osage soils. They lack the Bt horizon of Mason soils. Unlike Verdigris soils, they have distinct mottling above a depth of 40 inches.

La—Lanton silty clay loam. This soil is on nearly level flood plains of streams. Areas are generally long and continuous. Slopes are 0 to 2 percent. Included with this soil in mapping are small tracts of Osage soils in lower areas, Verdigris soils along stream channels, and Mason soils on higher terraces.

Most of the acreage is cultivated, but a few areas remain wooded with hardwood trees. This soil is well suited to most commonly grown crops. Flooding is a hazard, and the water table fluctuates to near the surface in some years. Runoff is slow. Surface drainage is needed in some areas.

Managing crop residue and maintaining fertility and tilth are main management requirements. Surface and subsurface drainage is practical in some local areas. Fertilization is beneficial in areas of tame grasses. Wood crop yields can be increased by thinning stands, selective cutting, controlling grazing, and preventing fires. Capability unit IIw-1; Loamy Lowland range site; woodland suitability group 3w.

Leanna Series

The Leanna series consists of deep, nearly level, somewhat poorly drained soils. These soils formed in clayey alluvium. They are on low stream terraces and are subject to occasional flooding. The native vegetation is tall prairie grasses interspersed with hardwood trees.

In a representative profile the surface layer is very dark gray silt loam about 11 inches thick. The subsurface layer is dark grayish brown silt loam about 6 inches thick. The subsoil is very firm silty clay about 39 inches thick. It is very dark gray in the upper part and dark gray in the lower part. The substratum is gray silty clay.

Leanna soils have very slow permeability, moderate available water capacity, and medium to high fertility.

Leanna soils are used mainly for crops, but some large areas are in native range, and a few areas are wooded.

Representative profile of Leanna silt loam in native grass; 700 feet south and 100 feet east of the northwest corner of sec. 2, T. 23 S., R. 18 E.

A1—0 to 11 inches; very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) when dry; few fine faint yellowish brown (10YR 5/8) mottles; weak very fine granular structure; hard when dry, friable when moist; strongly acid; abrupt smooth boundary.

A2—11 to 17 inches; dark grayish brown (10YR 4/2) silt loam, light gray (10YR 7/1) when dry; few fine distinct dark yellowish brown (10YR 4/4) mottles; weak fine granular structure; hard when dry, friable when moist; strongly acid; abrupt smooth boundary.

B21t—17 to 29 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) when dry; few fine prominent dark red (2.5YR 3/6) mottles; moderate fine and medium subangular blocky structure; very hard when dry, very firm when moist; medium acid; diffuse boundary.

B22t—29 to 37 inches; dark gray (10YR 4/1) silty clay, gray (10YR 5/1) when dry; common medium distinct dark yellowish brown (10YR 4/4) mottles; moderate fine and medium subangular blocky structure; very hard when dry, very firm when moist; neutral; diffuse boundary.

B3—37 to 56 inches; dark gray (10YR 4/1) silty clay, gray (10YR 5/1) when dry; many medium distinct yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; very hard when dry, very firm when moist; neutral; gradual boundary.

C—56 to 64 inches; gray (10YR 5/1) silty clay, light gray (10YR 6/1) when dry; common medium distinct yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure; very hard when dry, very firm when moist; neutral.

The thickness of the solum ranges from 30 to 70 inches. The A1 horizon is 6 to 14 inches thick. The texture of the B2t horizon is heavy silty clay loam or silty clay.

Leanna soils are near Woodson, Mayes, and Osage soils. In contrast with those soils, they have an A2 horizon.

Le—Leanna silt loam. This nearly level soil is on stream terraces. The areas are mostly long and narrow, but broad areas do occur. Slopes are 0 to 1 percent. Included with this soil in mapping are small areas of Osage soils in depressions, Lanton and Verdigris soils on lower flood plains, Woodson soils in higher areas, and areas of slick spots shown by a spot symbol on the soil map.

Most of the acreage is cultivated. Some areas are in native range and woodland. This soil is well suited to the commonly grown crops. Flooding is a hazard. Runoff is slow.

Managing residue and maintaining fertility and tilth are the main management requirements. Regulation of grazing and control of weeds and brush are needed to maintain a desirable stand of grasses. Wood crops can be increased by thinning stands, selective cutting, controlling grazing, and preventing fires. Capability unit IIw-2; Clay Lowland range site; woodland suitability group 3w.

Lula Series

The Lula series consists of deep, nearly level and gently sloping, well drained soils of the uplands. These soils formed in material weathered from limestone. They are on ridgetops and on high gently undulating areas underlain by limestone. The native vegetation is mainly tall prairie grasses.

In a representative profile the surface layer is dark brown silt loam about 8 inches thick. The subsoil is about 41 inches thick. The upper 5 inches is very dark brown, friable silt loam; the next 16 inches is dark reddish brown friable silty clay loam; and the lower 20 inches is dark reddish brown, firm silty clay loam. Hard fractured limestone bedrock is at a depth of about 49 inches.

Lula soils have moderate permeability, moderate available water capacity, and medium fertility. Crops respond well to additions of lime and fertilizer.

Lula soils are used mainly for crops, but some areas are in native range, and some are in tame pasture.

Representative profile of Lula silt loam, 0 to 3 percent slopes, in crops; 1,200 feet west and 150 feet north of the southeast corner of sec. 33, T. 22 S., R. 20 E.

Ap—0 to 8 inches; dark brown (7.5YR 3/2) silt loam, brown (7.5YR 4/2) when dry; weak very fine granular structure; hard when dry, friable when moist; slightly acid; gradual smooth boundary.

AB—8 to 13 inches; very dark brown (7.5YR 2/2) silt loam, brown (7.5YR 4/2) when dry; few fine prominent dark reddish brown (5YR 3/3) mottles; krotovinas; moderate fine and very fine granular structure; hard when dry, friable when moist; many roots; many pores; many worm casts; medium acid; gradual smooth boundary.

B21t—13 to 18 inches; dark reddish brown (5YR 3/3) light silty clay loam, reddish brown (5YR 4/3) when dry; many very fine faint dark reddish brown (5YR 3/2) mottles; moderate very fine subangular blocky structure parting to weak fine granular; hard when dry, friable when moist; many roots; many pores; few thin discontinuous clay films; many worm casts; few fine black concretions; strongly acid; gradual smooth boundary.

B22t—18 to 29 inches; dark reddish brown (5YR 3/4) silty clay loam, reddish brown (5YR 4/4) when dry; many very fine faint dark reddish brown (5YR 3/3) mottles; moderate very fine subangular blocky structure; hard when dry, friable when moist; many roots; few pores; clay films on ped surfaces; few worm casts; few fine black concretions; strongly acid; gradual smooth boundary.

B23t—29 to 49 inches; dark reddish brown (2.5YR 3/4) heavy silty clay loam, dark reddish brown (2.5YR 3/4) when dry; common medium faint dark red (2.5YR 3/6) mottles; dark reddish brown (5YR 3/2) stains in vertical streaks; fine subangular blocky structure; very hard when dry, firm when moist; few roots; clay films on ped surfaces; many medium black concretions and stains; few very fine limestone fragments; medium acid; abrupt wavy boundary.

R—49 inches; hard fractured limestone bedrock.

The thickness of the soil over limestone bedrock ranges from 40 to 60 inches. The A1 horizon is 6 to 12 inches thick.

Lula soils are near Catoosa and Clareson soils. They are deeper over limestone bedrock than those soils.

Lh—Lula silt loam, 0 to 3 percent slopes. This nearly level to gently sloping soil is on ridgetops and in the broad, high, gently undulating upland areas underlain by limestone. Areas are between 20 and 600 acres in size and are irregular in shape.

Included with this soil in mapping are small areas of Catoosa and Clareson soils on similar positions but mainly near the outer edge of the areas, Kenoma soils in slightly higher areas, and soils that are similar to Lula soils but deeper than 60 inches over limestone bedrock. Large limestone fragments called floaters are in some areas.

Much of the acreage is cultivated, but some areas are in native range, meadow, and tame pasture. This soil is well suited to the commonly grown crops. Runoff is medium. Water erosion is a hazard. The moderate available water capacity limits yields in summer crops during years of below average summer rainfall.

A cropping system that conserves soil and water, crop-residue management, minimum tillage, and terracing help to control erosion. Capability unit IIe-1; Loamy Upland range site; not assigned to a woodland suitability group.

Mason Series

The Mason series consists of deep, nearly level, well drained soils on benches and stream terraces. These soils formed in silty alluvial sediments. The native vegetation is tall prairie grasses.

In a representative profile the surface layer is very dark grayish brown silt loam about 13 inches thick. The subsoil extends to a depth greater than 60 inches. It is very dark grayish brown, friable light silty clay loam in the upper 4 inches; very dark grayish brown and dark brown, friable silty clay loam in the next 9 inches; mottled dark brown, firm silty clay loam in the next 28 inches; and mottled brown, firm silty clay loam in the lower 11 inches.

Mason soils have moderately slow permeability, high available water capacity, and high natural fertility. Crops respond to additions of lime and fertilizer.

Mason soils are used mainly for crops. They are well suited to all crops commonly grown in the county. A few areas are used for range and tame pasture.

Representative profile of Mason silt loam in crops; 2,550 feet north and 200 feet east of the southwest corner of sec. 6, T. 21 S., R. 19 E.

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) heavy silt loam, dark grayish brown (10YR 4/2) when dry; massive; slightly hard when dry, friable when moist; few roots; many pores; slightly acid; clear smooth boundary.

A12—7 to 13 inches; very dark grayish brown (10YR 3/2) heavy silt loam, dark grayish brown (10YR 4/2) when dry; weak very fine granular structure; hard when dry, friable when moist; few roots; many pores; few worm casts; medium acid; clear smooth boundary.

B1—13 to 17 inches; very dark grayish brown (10YR 3/2) light silty clay loam, dark grayish brown (10YR 4/2) when dry; moderate fine and medium granular structure; hard when dry, friable when moist; few roots; few pores; few worm casts; strongly acid; gradual smooth boundary.

B21t—17 to 26 inches; very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) silty clay loam, dark grayish brown (10YR 4/2) and brown (10 YR 5/3) when dry; weak fine granular and subangular blocky structure; hard when dry, friable when moist; few roots; many pores; few worm casts; medium acid, diffuse boundary.

B22t—26 to 38 inches; dark brown (10YR 3/3) and very dark grayish brown (10YR 3/2) silty clay loam, brown (10YR 5/3) and dark grayish brown (10YR 4/2) when dry; few fine faint yellowish brown (10YR 5/4) mottles; weak fine granular and subangular blocky structure; hard when dry, firm when moist; few roots; many pores; few worm casts; medium acid; diffuse boundary.

B31—38 to 54 inches; dark brown (10YR 3/3) silty clay loam, brown (10YR 5/3) when dry; many fine distinct strong brown (7.5YR 5/6) mottles; very dark brown staining along pore channels; weak medium prismatic structure parting to weak fine and medium granular; very hard when dry, firm when moist; few roots; many pores; few worm casts; slightly acid; diffuse boundary.

B32—54 to 65 inches; brown (10YR 4/3) silty clay loam, pale brown (10YR 6/3) when dry; common medium distinct yellowish brown (10YR 5/8) mottles; dark gray staining along pore channels; weak fine granular structure; very hard when dry, firm when moist; few roots; many pores; neutral.

The A horizon is 10 to 22 inches thick and is very dark brown to very dark grayish brown. The texture is loam or silty clay loam.

Mason soils are near Lanton, Verdigris, and Welda soils. They have a B2t horizon that is lacking in Lanton and Verdigris soils. They have a darker A horizon than Welda soils.

Me—Mason silt loam. This nearly level soil is on benches and terraces of major streams. Areas range from 10 to 200 acres in size. Slopes are 0 to 2 percent. Included with this soil in mapping are small areas of Dennis and Welda soils in higher sloping areas, Verdigris, Lanton, and Osage soils on lower flood plains, and areas of soils that are similar to Mason soils but have more clay in the subsoil.

Most of the acreage is cultivated, but some areas are native range or tame pasture and a few areas are wooded. This soil is well suited to all crops commonly grown. It is among the best in the county for farming. Runoff is slow to medium.

About the only management practices needed are those that maintain soil tilth and fertility. Diversion terraces are needed to divert run-in water from gently sloping soils. Flooding is rare. Proper range use and control of brush and trees are needed for good range management. Timber stand improvement is important in woodland management. Capability unit I–1; Loamy Lowland range site; woodland suitability group 3o.

Mayes Series

The Mayes series consists of deep, nearly level, somewhat poorly drained soils. These soils formed in old clayey alluvium on broad, nearly level, slightly depressional uplands. The native vegetation is tall prairie grasses.

In a representative profile the surface layer is black silty clay loam about 11 inches thick. The subsoil extends to a depth greater than 60 inches. It is very dark brown, mottled, very firm silty clay to a depth of 41 inches and black, mottled, extremely firm silty clay below.

Mayes soils have very slow permeability, moderate available water capacity, and medium to high fertility.

Mayes soils are used for crops and range. They are suitable for both.

Representative profile of Mayes silty clay loam in crops; 1,400 feet west and 120 feet north of the southeast corner of sec. 35, T. 20 S., R. 18 E.

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; massive in upper part and moderate medium blocky structure in lower part; very hard when dry, firm when moist; few roots; neutral; abrupt smooth boundary.

A12—7 to 11 inches; black (10YR 2/1) heavy silty clay loam, dark gray (10YR 4/1) when dry; few fine faint brown mottles; moderate medium and fine blocky structure; very hard when dry, firm when moist; few roots; neutral; gradual smooth boundary.

B2tg—11 to 41 inches; very dark brown (10YR 2/2) silty clay, very dark grayish brown (10YR 3/2) when dry; few very fine distinct brown (7.5YR 5/2) and reddish brown (5YR 5/3) mottles; moderate fine and very fine blocky structure; extremely hard when dry, very firm when moist; few roots; few fine black concretions; neutral to mildly alkaline; diffuse irregular boundary.

B3g—41 to 64 inches; black (5Y 2/1) silty clay, very dark gray (5Y 3/1) when dry; common fine distinct dark yellowish brown (10YR 4/4) mottles; black (10YR 2/1) vertical streaks; weak fine blocky structure; extremely hard when dry, extremely firm when moist; few very fine roots; few fine black and brown concretions; mildly alkaline.

The A horizon is 7 to 16 inches thick and is black to very dark brown. The texture is silt loam or silty clay loam. The texture of the B horizon ranges from silty clay loam to silty clay or clay. It is black, very dark gray, or very dark brown. Reaction ranges from medium acid to neutral in the upper 24 inches and from neutral to moderately alkaline below a depth of 24 inches.

Mayes soils are near Leanna, Osage, and Woodson soils. They lack the textural change between the A1 and B2t horizons that is in Woodson soils. Unlike Osage soils, Mayes soils have a B2t horizon. They lack the A2 horizon of Leanna soils.

Mf—Mayes silty clay loam. This nearly level soil is in depressional areas on uplands and in a few places on high terraces. Slopes are 0 to 1 percent. Included in mapping are small areas of Osage and Woodson soils and small depressions.

Much of the acreage is cultivated, but large areas are in native range. This soil is suited to crops. Runoff is very slow. Ponding is a problem in depressions.

Removing excess water and maintaining fertility and tilth are the main concerns in managing this soil. Shallow water covers the surface in some places during wet seasons. This soil is not easily worked. It is sticky and plastic when worked too wet and very hard when worked too dry. A bedding system and surface drainage ditches help to remove excess water. In some places it is necessary to construct diversion terraces to control water that runs in from adjacent slopes. This soil is also droughty during years of low rainfall. Regulation of grazing and control of weeds and brush help to maintain a desirable stand of native grasses. Capability unit IIw–3; Clay Lowland range site; not assigned to a woodland suitability group.

Okemah Series

The Okemah series consists of deep, nearly level, moderately well drained soils on low-lying uplands. These soils are on foot slopes. They formed in colluvial material weathered from shale and old clayey alluvium. The native vegetation is tall prairie grasses.

In a representative profile the surface layer is very dark gray silt loam and silty clay loam about 13 inches thick. The subsoil extends to a depth of 60 inches. It is mottled very dark gray, firm silty clay loam in the upper 9 inches; mottled dark grayish brown, firm silty clay in the next 17 inches; and coarsely mottled gray, firm silty clay in the lower 21 inches.

Okemah soils have slow permeability, high available water capacity, and high fertility. Crops respond to additions of lime and fertilizer.

Okemah soils are used mainly for crops. They are well suited to all crops commonly grown in the county. A few areas are used for range and tame pasture.

Representative profile of Okemah silt loam, 0 to 2 percent slopes, in native range; 1,425 feet north and 700 feet west of the southeast corner of sec. 13, T. 23 S., R. 19 E.

A1—0 to 9 inches; very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) when dry; weak fine granular structure; hard when dry, friable when moist; many roots; medium acid; gradual smooth boundary.

A3—9 to 13 inches; very dark gray (10YR 3/1) light silty clay loam, gray (10YR 5/1) when dry; weak fine granular structure; hard when dry, friable when moist; many roots; many fine pores; medium acid; gradual smooth boundary.

B21t—13 to 22 inches; very dark gray (10YR 3/1) heavy silty clay loam, dark gray (10YR 4/1) when dry; few fine distinct brown (10YR 5/3) and dark brown (10YR 3/3) mottles; moderate coarse subangular blocky structure parting to moderate medium blocky; very hard when dry, firm when moist; many roots; many fine pores; thin discontinuous clay films; few fine brown concretions; slightly acid; gradual smooth boundary.

B22t—22 to 31 inches; dark grayish brown (10YR 4/2) silty clay, grayish brown (10YR 5/2) when dry; common fine distinct dark yellowish brown (10YR 5/6) mottles and common medium prominent yellowish red (5YR 5/6) mottles; vertical fillings of very dark gray (10YR 3/1) silty clay loam; moderate medium subangular blocky and fine blocky structure; very hard when dry, firm when moist; many roots; few pores; continuous clay films; few fine black and brown concretions; neutral; gradual smoothy boundary.

B23t—31 to 39 inches; dark grayish brown (10YR 4/2) silty clay, grayish brown (10YR 5/2) when dry; many coarse strong brown (7.5YR 5/6) and yellowish brown (10YR 5/6) mottles; vertical fillings of very dark gray (10YR 3/1); moderate coarse subangular blocky structure; very hard when dry, firm when moist; few roots; thick continuous clay films; many black and brown concretions; mildly alkaline; gradual wavy boundary.

B31g—39 to 47 inches; coarsely mottled gray (10YR 5/1), dark gray (N 4/0), gray (N 5/0), grayish brown (10YR 5/2), and yellowish brown (10YR 5/6) silty clay; vertical fillings of very dark gray (10YR 3/1); moderate medium prismatic structure parting to moderate fine subangular blocky; very hard when dry, firm when moist; slickensides; calcium carbonate concretions; moderately alkaline; gradual wavy boundary.

B32g—47 to 60 inches; coarsely mottled gray (10YR 5/1), yellowish brown (10YR 5/6 and 5/8), and light gray (10YR 7/1) light silty clay; vertical fillings of very dark gray (10YR 3/1); massive; hard when dry, firm when moist; slickensides; calcium carbonate concretions; moderately alkaline.

The A horizon is 9 to 20 inches thick and is very dark gray, black, or very dark brown.

Okemah soils are near Dennis, Eram, Summit, and Woodson soils. They have a grayish B2t horizon, whereas Dennis soils have a brownish B2t horizon. They are deeper than Eram soils and less clayey above a depth of 10 inches than Summit soils. They do not have the change in texture between the A and B horizons of Woodson soils.

Ok—Okemah silt loam, 0 to 2 percent slopes. This soil is on foot slopes along drainageways in the uplands. Areas are between 10 and 150 acres in size. Included with this soil in mapping are about 30 percent Summit, Woodson, and Dennis soils and about 5 percent small areas of Eram, Lula, and Catoosa soils.

Some of the acreage is cultivated. Many areas in native range are included with larger areas of soils that are unsuited to cultivation. Runoff is slow to medium. This soil is well suited to all crops commonly grown and is among the best soils for farming in the county.

About the only conservation practices needed are those that maintain tilth and fertility. Diversion terraces are needed to divert run-in water from higher sloping soils. Although terraces may not be necessary, they will reduce runoff and possible erosion. Regulation of grazing and control of weeds and brush are needed to maintain a desirable stand of native grasses. Capability unit I-1; Loamy Upland range site; not assigned to a woodland suitability group.

Olpe Series

The Olpe series consists of deep, sloping to strongly sloping, well drained soils of the uplands. These soils are on the tops of ridges and knolls in the rolling and hummocky uplands. They formed in old loamy and clayey alluvial sediment that had a high content of waterworn (rounded) chert gravel (fig. 6). The native vegetation is tall prairie grasses.

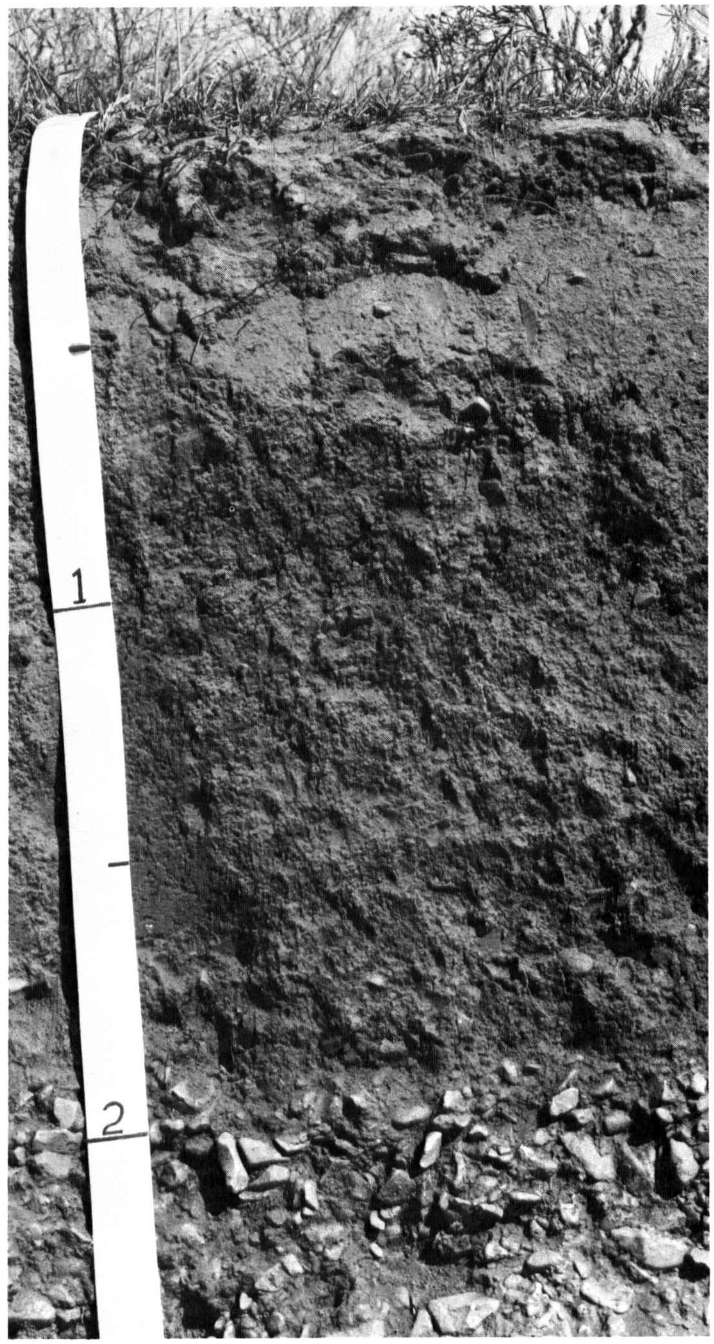

Figure 6.—**Profile of Olpe gravelly silt loam showing the very gravelly subsoil.**

In a representative profile the surface layer is dark brown gravelly silt loam about 10 inches thick. The subsoil extends to a depth of 70 inches. It is dark brown, friable gravelly silty clay loam in the upper 6 inches; dark reddish brown, friable very gravelly clay loam in the next 18 inches; mottled reddish brown, firm very gravelly silty clay in the next 26 inches; and red, very firm silty clay in the lower 10 inches.

Olpe soils have slow or very slow permeability, low available water capacity, and low fertility. Crops respond to additions of fertilizer and lime.

Olpe soils are used mainly for range and native meadow. Only a small part of the acreage is used for crops. Small areas of Olpe soils occur in fields with other soils. Many areas have been mined for road surfacing material.

Representative profile of Olpe gravelly silt loam, 3 to 15 percent slopes, in native meadow; 2,000 feet south and 90 feet east of the northwest corner of sec. 1, T. 21 S., R. 20 E.

A1—0 to 10 inches; dark brown (7.5YR 3.2) gravelly silt loam, brown (7.5YR 5/2) when dry; weak very fine granular structure; hard when dry, friable when moist; many roots; about 15 percent waterworn chert gravel; strongly acid; gradual smooth boundary.

B1—10 to 16 inches; dark brown (7.5YR 3/2) gravelly light silty clay loam, brown (7.5YR 5/2) when dry; weak very fine granular structure; hard when dry, friable when moist; many roots; about 15 percent waterworn chert gravel; strongly acid; gradual irregular boundary.

B21t—16 to 34 inches; dark reddish brown (5YR 3/4) very gravelly heavy clay loam, reddish brown (5YR 5/4) when dry; weak very fine subangular blocky structure; hard when dry, friable when moist; few roots; between 60 and 80 percent waterworn chert gravel; medium acid; gradual irregular boundary.

B22t—34 to 60 inches; reddish brown (2.5YR 4/4) very gravelly silty clay, reddish brown (2.5YR 5/4) when dry; many medium faint red (2.5YR 5/6) mottles; weak very fine blocky structure; very hard when dry, firm when moist; few roots; common medium black stains; between 60 and 80 percent waterworn chert gravel; medium acid; diffuse irregular boundary.

IIB—60 to 70 inches; red (2.5YR 4/5) silty clay, red (2.5YR 4/8) when dry; common medium faint light reddish brown (5YR 6/4) mottles; moderate fine and medium blocky structure; extremely hard when dry, very firm when moist; few roots; many medium black stains; few chert pebbles; medium acid.

The A horizon is 8 to 15 inches thick and is dark brown to very dark grayish brown. The texture is silt loam or gravelly silt loam. The texture of the B1 horizon is gravelly silt loam or gravelly silty clay loam. The B2t horizon is gravelly clay loam, gravelly silty clay loam, or gravelly silty clay. Content of gravel ranges from 35 to 90 percent.

Olpe soils are near Kenoma soils. They contain a high percentage of waterworn chert gravel, whereas Kenoma soils have no gravel or have only a low percentage of gravel.

Op—Olpe gravelly silt loam, 3 to 15 percent slopes. This soil is on narrow ridgetops and knolls of the hummocky and rolling uplands. It has the profile described as representative of the series.

About 30 percent of this mapping unit is included areas of soils that are similar to Olpe soils but contain less clay in the upper 20 inches of the subsoil and a few areas that have a grayish subsurface layer, and about 15 percent is areas of other soils. Kenoma soils occupy the higher and lower less sloping areas and Catoosa, Clareson, Dennis, and Eram soils the lower less sloping areas. In some places limestone crops out near the lower edge of mapped areas. Also included are small saline spots shown by a spot symbol on the soil map.

Nearly all the acreage is in range and native meadow. Native grasses are well suited. Runoff is medium to rapid. Erosion is a hazard. Some areas of this soil are good sources of gravel suitable for road surfacing.

The chief management need is to maintain a good stand of grasses that provides grazing and helps to control erosion. Capability unit VIe-2; Loamy Upland range site; not assigned to a woodland suitability group.

Osage Series

The Osage series consists of deep, nearly level, poorly drained soils on low flood plains. These soils formed in clayey alluvial sediment. The native vegetation is tall grasses and bottom land hardwoods.

In a representative profile the surface layer is very dark brown silty clay loam about 13 inches thick. The subsoil extends to a depth of 64 inches. It is mottled very dark gray, firm and very firm silty clay to a depth of 56 inches and mottled very dark grayish brown, very firm silty clay below that.

Osage soils have very slow permeability, moderate available water capacity, and medium to high fertility. Crops respond well to additions of fertilizer and to lime in some areas.

Osage soils are used mainly for crops, but flooding limits crop selection. A few areas are used for range and tame pasture, and some areas remain wooded with deciduous trees.

Representative profile of Osage silty clay loam in tame pasture; 1,600 feet north and 100 feet west of the center of sec. 33, T. 19 S., R. 20 E.

A1—0 to 13 inches; very dark brown (10YR 2/2) silty clay loam, dark grayish brown (10YR 4/2) when dry; moderate fine granular and subangular blocky structure; very hard when dry, friable when moist; many roots; few fine open pores; many worm casts; neutral; gradual smooth boundary.

B21g—13 to 37 inches; very dark gray (10YR 3/1) light silty clay, dark gray (10YR 4/1) when dry; many fine faint brown (10YR 4/3) mottles; weak very fine and fine subangular blocky structure; very hard when dry, firm when moist; many roots; few fine open pores; many worm casts and channels; few very fine black and brown concretions; slightly acid; gradual smooth boundary.

B22g—37 to 47 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) when dry; many very fine faint dark brown (10YR 3/3) mottles; weak fine subangular blocky structure; extremely hard when dry, very firm when moist; few roots; few pores; many very fine black and brown concretions; slightly acid; gradual smooth boundary.

B23g—47 to 56 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) when dry; many very fine distinct dark yellowish brown (10YR 4/4) mottles; moderate very fine blocky structure; extremely hard when dry, very firm when moist; few roots; few pores; common very fine black and brown concretions; mildly alkaline; diffuse broken boundary.

B3g—56 to 64 inches; very dark grayish brown (2.5Y 3/2) silty clay, grayish brown (2.5Y 5/2) when dry; many very fine distinct yellowish brown (10YR 5/6) mottles; vertical streaks of very dark gray (10YR 3/1); weak very fine blocky structure; extremely hard when dry, very firm when moist; few very fine black concretions; few fine lime concretions; moderately alkaline.

The A horizon is 13 to 18 inches thick and is very dark brown to black. The texture is silty clay loam or silty clay. The B horizon is very dark gray to dark gray. Thickness of the solum ranges from 50 to 60 inches or more. Reaction ranges from medium acid to neutral in the upper 48 inches and from slightly acid to moderately alkaline below a depth of 48 inches. Some profiles contain gypsum crystals below a depth of 40 inches.

Osage soils are near Lanton, Leanna, Mayes, and Verdigris soils. They are more clayey throughout the profile than Lanton and Verdigris soils. They have less profile development than Leanna and Mayes soils.

Os—Osage silty clay loam. This nearly level soil is on low flood plains of major streams. Areas are from 10 to 800 acres in size. Slopes are 0 to 1 percent.

Included with this soil in mapping are small areas of Verdigris and Lanton soils and areas of Osage soils, in depressions and old stream channels, that have a surface layer of silty clay.

Much of the acreage is cultivated. Some large areas are in tame grasses, and a few areas remain wooded with hardwood trees. This soil is not suited to all crops commonly grown in the county. Flooding is a hazard. Runoff is very slow. Surface water ponds in some local areas. In some areas the water table fluctuates to the surface during prolonged wet periods.

Diversion terraces are needed to control run-in water in areas near the uplands that stay wet from the runoff from the adjacent uplands. This soil is not easily worked. It is sticky and plastic if worked when too wet and is very hard if worked when too dry. If this soil is cultivated, adequate drainage is needed. Wetness is the main limitation. Managing crop residue and maintaining soil tilth and fertility are needed. Proper fertilization benefits tame grasses. Yields of wood crops can be increased by thinning stands, selective cutting, controlling grazing, and preventing fires. Capability unit IIw-2; Clay Lowland range site; woodland suitability group 4w.

Stony Land

Se—Stony land-Talihina complex, steep, is on uplands. Slopes are steep and broken. In places there are vertical rock ledges. This unit consists of very shallow soils intermingled with deeper soils and limestone outcrops. Slopes are 15 to 45 percent.

In this mapping unit Stony land makes up 60 percent of the acreage, shallow soils about 20 percent, and moderately deep and deep soils about 20 percent. Some of the soils that are very shallow over limestone are very dark grayish brown. The rest are similar to Talihina soils. The moderately deep and deep soils resemble Eram, Dennis, and Summit soils. The deeper soils are near the lower part of the slope. Limestone outcrops are prominent in the Stony land part of this mapping unit, especially in the upper part of mapped areas. Limestone fragments range from 3 to 30 inches in diameter. The larger ones are commonly flat. Included in mapping are small areas of Clareson, Eram, Dennis, Summit, and Talihina soils that have slopes of 6 to 15 percent.

The water intake rate ranges from rapid in the stony area to slow in the areas of deeper soils. Runoff ranges from medium to very rapid. The shallow soils have low available water capacity.

Much of the acreage is in hardwoods and brush timber. The rest is in mid and tall prairie grasses. The hardwoods are mostly oak, hickory, and ash. Grazing is the chief use. Because this unit has steep slopes, however, much of the acreage is not readily accessible to livestock. Water erosion is a serious limitation because of the slope. The shallow rooting zone is also a limitation.

Careful management of grazing is essential. Proper range use and deferment of grazing are needed. Capability unit VIIe-1; Stony land is in Breaks range site, and Talihina soil is in Clay Upland range site; not assigned to a woodland suitability group.

Summit Series

The Summit series consists of deep, gently sloping and sloping, moderately well drained soils of the uplands. These soils formed in material weathered from interbedded silty and clayey shale. They are on foot slopes, in most places below limestone outcrops. The native vegetation is tall prairie grasses.

In a representative profile the surface layer is black silty clay loam about 8 inches thick. The subsoil is about 39 inches thick. It is black, firm silty clay in the upper 16 inches; very dark grayish brown, very firm silty clay in the next 14 inches; and dark gray, firm silty clay in the lower 9 inches. The substratum is gray silty clay to a depth of 69 inches.

Summit soils have slow permeability, moderate available water capacity, and high fertility. Crops respond well to additions of lime and fertilizer.

About 60 percent of the acreage of Summit soils is cultivated, and most of the rest is in range or pasture. A few areas are wooded.

Representative profile of Summit silty clay loam, 1 to 4 percent slopes, in tame pasture; 2,400 feet south and 100 feet east of the northwest corner of sec. 24, T. 20 S., R. 20 E.

Ap—0 to 8 inches; black (10YR 2/1) heavy silt clay loam, dark gray (10YR 4/1) when dry; moderate medium subangular blocky structure; hard when dry, firm when moist; few roots; few pores; slightly acid; gradual smooth boundary.

B1—8 to 12 inches; black (10YR 2/1) light silty clay, very dark gray (10YR 3/1) when dry; moderate medium subangular blocky structure; very hard when dry, firm when moist; few roots; few pores; few worm casts; slightly acid; gradual smooth boundary.

B21t—12 to 24 inches; black (10YR 2/1) silty clay, very dark gray (10YR 3/1) when dry; moderate fine prismatic structure parting to moderate fine subangular blocky; extremely hard when dry, firm when moist; few roots; few pores; slightly acid; gradual wavy boundary.

B22t—24 to 38 inches; very dark grayish brown (2.5Y 3/2) silty clay, grayish brown (2.5Y 5/2) when dry; few very fine distinct yellowish brown (10YR 5/6) mottles; vertical cracks filled with black (10YR 2/1); weak very fine subangular blocky structure; extremely hard when dry, very firm when moist; few fine roots; few pores; few fine black concretions; slightly acid; gradual irregular boundary.

B23t—38 to 47 inches; dark gray (10YR 4/1) silty clay, gray (10YR 5/1) when dry; common fine distinct yellowish brown (10YR 5/6) mottles; vertical cracks filled with very dark gray (10YR 3/1); weak fine subangular blocky structure; extremely hard when dry, firm when moist; few roots; few pores; few fine black concretions; neutral; diffuse boundary.

C—47 to 69 inches; gray (10YR 5/1) light silty clay, light gray (10YR 6/1) when dry; many fine distinct strong brown (7.5YR 5/6) mottles; massive; extremely hard when dry, firm when moist; few pores; few fine and medium black concretions; neutral.

Thickness of the solum ranges from 30 to 50 inches. The A horizon is 8 to 12 inches thick and is very dark brown, black, or very dark gray. It is silty clay loam to silty clay. The B1 horizon has the same range in texture and color as the A horizon. The texture of the B2t horizon is silty clay or clay.

Summit soils are near Dennis, Eram, Kenoma, Okemah, and Woodson soils. They are less deep over the clayey B2t horizon than Dennis and Okemah soils and do not have the bright colored mottling of those soils. In contrast with Woodson and Kenoma soils, they have a transitional horizon between the A and B2t horizons. They are deeper over shale than Eram soils.

Sf—Summit silty clay loam, 1 to 4 percent slopes. This soil commonly is on lower side slopes. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Okemah and Woodson soils on lower smoother slopes, Kenoma soils on higher smoother slopes, and Eram and Dennis soils on higher slopes. Also included are a few small areas of Catoosa, Clareson, and Lula soils.

This soil is used for crops and native range. It is well suited to both. Runoff is medium. Water erosion is a hazard. A cropping system that conserves soil and water, crop-residue management, minimum tillage, and terracing help to control erosion. Yields of wood crops can be increased by thinning stands, selective cutting, controlling grazing, and preventing fires. Capability unit IIe-1; Loamy Upland range site; not assigned to a woodland suitability group.

Sh—Summit silty clay loam, 4 to 7 percent slopes. This soil is on convex hillsides. Included in mapping are small areas of Okemah, Dennis, and Eram soils and small areas of Clareson soils that have outcrops of limestone.

This soil is used for crops and native range. A few areas are wooded. This soil is suited to all uses. Runoff is rapid. Water erosion is a severe hazard.

A cropping system that conserves soil and water, crop-residue management, minimum tillage, terracing, and contour farming help to control erosion. Also needed are practices that improve tilth and fertility. Proper range use and control of trees and brush are essential for good range management. Proper fertilization is beneficial to tame grasses. Yields of wood crops can be increased by thinning stands, selective cutting, controlling grazing, and preventing fires. Capability unit IIIe-2; Loamy Upland range site; not assigned to a woodland suitability group.

Sk—Summit soils, 1 to 4 percent slopes, eroded. These soils commonly occur on lower side slopes. So much of the original surface soil has been removed by erosion that ordinary tillage has mixed subsoil material with the remaining surface layer. In most areas shallow gullies and gully scars are evident. About 30 percent of the acreage is moderately eroded, and about 20 percent is severely eroded. The surface layer of most areas is about 65 percent silty clay loam and 35 percent silty clay. Included with this soil in mapping are small areas of Dennis, Eram, and Woodson soils.

Nearly all the acreage has been cultivated. The soils are suited to all of the commonly grown crops. Runoff is medium. Erosion is a severe hazard.

Because these soils are susceptible to further damage by erosion, practices are needed to reduce the loss of soil. A cropping system that conserves soil and water, crop-residue management, minimum tillage, terracing, and contour farming help to control erosion. Also needed are practices that maintain or improve tilth and fertility. Areas seeded to tame grasses benefit from additions of lime and fertilizer. Capability unit IIIe-3; Clay Upland range site; not assigned to a woodland suitability group.

So—Summit-Eram complex, 4 to 7 percent slopes, eroded. This mapping unit is commonly on lower sides of high hills or ridges. It is about 55 percent Summit soils, 30 percent Eram soils, and 15 percent small areas of Dennis and Kenoma soils and Clareson soils with outcrops of limestone. The soils have been damaged by erosion to the extent that the present surface layer is a mixture of the original surface layer and the more clayey subsoil. Shallow gullies and gully scars are in most places. In about 60 percent of a mapped area, the surface layer is silty clay loam; in about 30 percent silty clay; and in 10 percent, clay loam.

Nearly all the acreage has been cultivated. The soils are suited to most of the commonly grown crops. Runoff is rapid. Erosion is a very severe hazard.

Because these soils are susceptible to further damage by erosion, practices are needed to reduce the loss of soil. A cropping system that conserves soil and water, crop-residue management, minimum tillage, terracing, and contour farming help to control erosion. Also needed are practices that maintain or improve tilth and fertility. Areas seeded to tame pasture grasses benefit from additions of lime and fertilizer. Capability unit IVe-3; Clay Upland range site; not assigned to a woodland suitability group.

Talihina Series

The Talihina series consists of sloping to steep, moderately well drained soils that are shallow over shale. These soils formed in material weathered from shale in the rolling and hilly uplands of the county. The native vegetation is tall prairie grasses.

In a representative profile the surface layer is very dark grayish brown silty clay loam about 7 inches thick. The subsoil is about 8 inches thick. It is dark grayish brown, friable silty clay loam containing many fragments of shale in the lower part. Mildly alkaline yellowish brown shale is at a depth of 15 inches.

Talihina soils have slow permeability, very low available water capacity, and low fertility.

Most of the acreage is in native prairie grass, range and meadow. A number of areas in tame grasses are used for hay or grazing. Part of the acreage is wooded.

Representative profile of Talihina silty clay loam in an area of Eram-Talihina silty clay loams, 5 to 20 percent slopes, in tame grass pasture; 1,700 feet north and 300 feet west of the southeast corner of sec. 17, T. 20 S., R. 21 E.

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) when dry; moderate fine and very fine granular structure; hard when dry, friable when moist; many roots; many pores; few worm casts; few thin shale fragments; mildly alkaline; gradual wavy boundary.

B21—7 to 12 inches; dark grayish brown (2.5Y 4/2) heavy silty clay loam, grayish brown (10YR 5/2) when dry; moderate fine and very fine granular structure; hard when dry, friable when moist; many roots; many pores; many worm casts; few thin shale fragments; neutral; gradual wavy boundary.

B22—12 to 15 inches; dark grayish brown (2.5Y 4/2) silty clay loam, grayish brown (10YR 5/2) when dry; few fine faint gray (10YR 5/1) and yellowish brown (10YR 5/4) mottles; moderate fine and very fine granular structure; hard when dry, friable when moist; many roots; many pores; few worm casts; many thin shale fragments; neutral; gradual wavy boundary.

C—15 to 17 inches; yellowish brown (10YR 5/4) fractured, bedded, mildly alkaline shale.

Depth to shale is between 10 and 20 inches. The texture throughout the profile is clay loam, silty clay loam, or silty clay. Reaction ranges from slightly acid through mildly alkaline.

Talihina soils are near Eram, Dennis, and Collinsville soils. They are shallower than Eram and Dennis soils. They are underlain by shale, whereas Collinsville soils are underlain by sandstone or sandy shale.

Verdigris Series

The Verdigris series consists of deep, nearly level, moderately well drained soils on flood plains. These soils formed in silty alluvial sediment along most streams in the county. The native vegetation was tall grasses and bottom land hardwoods.

In a representative profile the surface layer is very dark grayish brown silt loam and silty clay loam about 29 inches thick. The next layer is very dark grayish brown, friable silty clay loam about 9 inches thick. The substratum is dark grayish brown silt loam and loam.

Verdigris soils have moderate permeability, high available water capacity, and high natural fertility. Crops respond to additions of fertilizer, and in some areas to lime.

Verdigris soils are used mainly as cropland because they are suited to all crops commonly grown in the county. A few areas are used for range and tame pasture. Some remain wooded with deciduous trees.

Representative profile of Verdigris silt loam in an area of Verdigris silt loam, occasionally flooded, in cropland; 1,700 feet east and 80 feet south of the northwest corner of sec. 16, T. 23 S., R. 19 E.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) when dry; massive; hard when dry, friable when moist; few roots; few pores; few worm casts; slightly acid; gradual smooth boundary.

A12—9 to 18 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak fine granular structure; hard when dry, friable when moist; few roots; many pores; many worm casts; slightly acid; gradual smooth boundary.

A13—18 to 29 inches; very dark grayish brown (10YR 3/2) light silty clay loam, dark grayish brown (10YR 4/2) when dry; weak fine granular structure; hard when dry, friable when moist; few roots; many pores; few worm casts; slightly acid; clear wavy boundary.

AC—29 to 38 inches; very dark grayish brown (10YR 3/2) light silty clay loam, grayish brown (10YR 5/2) when dry; stratified with dark grayish brown (10YR 4/2) loam; weak fine granular structure; hard when dry, friable when moist; few roots; few pores; neutral; clear wavy boundary.

C1—38 to 50 inches; dark grayish brown (10YR 4/2) silt loam, grayish brown (10YR 5/2) when dry; distinctly stratified with thin layers of lighter color; massive; hard when dry, friable when moist; few roots; many pores; slightly acid; clear wavy boundary.

C2—50 to 65 inches; dark grayish brown (10YR 4/2) loam, grayish brown (10YR 5/2) when dry; distinctly stratified with thin layers of lighter color; massive; hard when dry, very friable when moist; few fine roots; many pores; neutral.

The A1 horizon is 20 to 32 inches thick. The AC horizon is very dark grayish brown, dark grayish brown, or dark brown. The texture is silt loam, loam, or silty clay loam throughout the profile. Colors of very dark grayish brown and very dark gray and darker extend to depths of 30 inches or more. Reaction ranges from medium acid to neutral.

Verdigris soils are near Lanton, Mason, Osage, and Welda soils. They lack the distinctly mottled Bg horizon that is typical of Lanton and Osage soils and the more clayey B2t horizon typical of Mason and Welda soils.

Vf—Verdigris silt loam, occasionally flooded. This nearly level soil is on flood plains. It has the profile described as representative of the series. Areas are long, and some along the major streams are broad. Slopes are 0 to 2 percent.

Included with this soil in mapping are areas of soils that are similar to this Verdigris soil but have an overwash of lighter colored material as thick as 10 inches and areas of soils that have lighter colored strata within 20 inches of the surface. Also included are small areas of Lanton soils on flood plains and of Mason soils on higher terraces.

Most areas are under cultivation. Some areas are in native range, and some remain wooded. This soil is well suited to all crops commonly grown in the county. Runoff is slow. Flooding is a hazard, but floods damaging to crops occur only about once every 3 years.

Maintaining fertility and tilth is the chief management need. Regulation of grazing and control of weeds and brush are needed to protect the soil and maintain a stand of desirable native grasses. Wooded areas need protection from grazing and fire. Yields of wood crops can be increased by thinning stands and selective cutting. Capability unit IIw–1; Loamy Lowland range site; woodland suitability group 3o.

Vx—Vertigris soils, frequently flooded. This mapping unit is mainly on the narrow flood plains of drainageways. It is about 45 percent Verdigris silt loam and silty clay loam, 15 percent Mason soils, 10 percent Lanton soils, 10 percent Osage and Leanna soils, 10 percent adjoining upland soils, and 10 percent stream channels. The narrow valley floors are cut by meandering stream channels. Slopes are irregular, but most are less than 2 percent. The adjoining slopes are short and steep. Included in mapping are small areas of gravelly sediment.

Native range is the main use because this unit is well suited to native grasses. Runoff is variable. Recurrent flooding, scouring, and deposition are hazards. Damaging floods occur 1 to 3 times a year. Cultivation is generally not practical because of the flooding. Also, many areas are small and inaccessible. Some areas are used for wood production, wildlife habitat, and native meadow.

Regulation of grazing and control of weeds and brush are needed to protect the soil and maintain a stand of desirable grasses. Wooded areas need protection from grazing and fire. Yields of wood crops can be increased by thinning stands, selective cutting, and preventing fire. Capability unit Vw–1; Loamy Lowland range site; woodland suitability group 3o.

Welda Series

The Welda series consists of deep, nearly level to sloping, well drained soils of the uplands. These soils formed in loess. They are on high stream terraces adjacent to the major streams. In Anderson County these soils are mostly along the South Fork of Pottawatomie Creek. The native vegetation is mainly tall grasses, oak, hickory, and ash.

In a representative profile the surface layer is dark grayish brown silt loam about 7 inches thick. The subsurface layer is grayish brown silt loam about 5 inches thick. The subsoil is dark brown, friable and firm silty clay loam that extends to a depth of 60 inches.

Welda soils have moderately slow permeability, high available water capacity, and medium fertility. Crops respond well to additions of lime and fertilizer.

Welda soils are used mostly for crops and range. A few areas remain wooded.

Representative profile of Welda silt loam, 0 to 2 percent slopes, in a cultivated field; 2,300 feet north and 1,050 feet west of the southeast corner of sec. 19, T. 21 S., R. 20 E.

Ap—0 to 7 inches; dark grayish brown (10YR 4/2) silt loam; light brownish gray (10YR 6/2) when dry; weak fine granular structure; soft when dry, friable when moist; slightly acid; abrupt boundary.

A2—7 to 12 inches; grayish brown (10YR 5/2) silt loam; light gray (10YR 7/2) when dry; weak fine granular structure; soft when dry, very friable when moist; many fine open pores; strongly acid; abrupt broken boundary.

B1—12 to 15 inches; dark brown (7.5YR 4/4) light silty clay loam; pink (7.5YR 7/4) when dry; weak medium subangular blocky structure; light gray (10YR 7/2) bleached silt coatings on ped surfaces; hard when dry, friable when moist; many fine open pores; strongly acid; clear boundary.

B21t—15 to 21 inches; dark brown (7.5YR 4/4) silty clay loam; light brown (7.5YR 6/4) when dry; weak medium subangular blocky structure; bleached silt coatings on ped surfaces; thin discontinuous clay films; hard when dry, friable when moist; strongly acid; gradual boundary.

B22t—21 to 42 inches; dark brown (7.5YR 4/4) heavy silty clay loam; light brown (7.5YR 6/4) when dry; common faint fine pinkish gray (7.5YR 6/2) mottles; weak medium subangular blocky structure; hard when dry, slightly firm when moist; strongly acid; diffuse boundary.

B3—42 to 60 inches; dark brown (7.5YR 4/4) silty clay loam, brown (7.5YR 5/4) when dry; weak fine blocky and subangular blocky structure; hard when dry, firm when moist; few fine black concretions; slightly acid.

The A1 horizon is 3 to 7 inches thick and is grayish brown to dark grayish brown. The A2 horizon is 3 to 8 inches thick. The B2t horizon is medium acid or strongly acid.

Welda soils are near Mason and Verdigris soils. They have a lighter colored A horizon than either of those soils. They have more clay in the B horizon than Mason soils. In contrast with Verdigris soils, they have a Bt horizon.

Wb—Welda silt loam, 0 to 2 percent slopes. This soil is on high terraces or benches. It has the profile described as representative of the series. Included with this soil in mapping are small areas of Dennis and Mason soils.

Nearly all the acreage is cultivated. This soil is well suited to all cultivated crops. Crops respond to additions of lime and fertilizer. Runoff is slow to medium.

This soil has few management needs other than practices for maintaining fertility and tilth. Capability unit I–2; Loamy Upland range site; woodland suitability group 4o.

Wc—Welda silt loam, 2 to 6 percent slopes. This soil is adjacent to stream valleys. The surface and subsurface layers are 1 to 3 inches thinner than those in the profile described as representative of the series.

Included with this soil in mapping are small areas of soils that are similar to Welda soils but have shale between depths of 40 and 60 inches, and small areas of Dennis, Summit, and Eram soils.

About half the acreage is cultivated, and the rest is native range and woods. This soil is suited to cultivated crops. Runoff is medium to rapid.

Because erosion is a hazard, practices are needed to reduce runoff. Terraces, waterways, and contour farming help to control runoff. Returning all crop residue to the soil helps to maintain and increase organic-matter content and soil tilth. Careful management of grazing is essential on the native range and in wooded areas. Among the practices needed are proper range use and deferment of grazing. Capability unit IIIe–4; Loamy Upland range site; woodland suitability group 4o.

Woodson Series

The Woodson series consists of deep, nearly level and gently sloping, somewhat poorly drained soils of the uplands. These soils formed in old alluvium high in clay. They are in broad continuous areas of the nearly level to gently undulating uplands. The native vegetation is tall prairie grasses.

In a representative profile the surface layer is black silt loam about 8 inches thick. The subsoil extends to a depth of about 64 inches. It is black, very firm silty clay in the upper 8 inches; very dark gray, very firm silty clay in the next 13 inches; dark grayish brown, very firm silty clay in the next 9 inches; and gray, very firm silty clay in the lower 26 inches.

Woodson soils have very slow permeability, moderate available water capacity, and medium to high fertility. Crops respond well to additions of lime and fertilizer.

These soils are used mostly for crops. Some large areas are in native range.

Representative profile of Woodson silt loam, 1 to 3 percent slopes, in a cultivated field; 2,200 feet east and 150 feet south of the northwest corner of sec. 31, T. 19 S., R. 18 E.

Ap—0 to 8 inches; black (10YR 2/1) heavy silt loam, dark gray (10YR 4/1) when dry; weak very fine granular structure; slightly hard when dry, friable when moist; few roots; neutral; abrupt smooth boundary.

B21t—8 to 16 inches; black (10YR 2/1) silty clay, dark gray (10YR 4/1) when dry; common very fine distinct dark brown (7.5YR 4/4) mottles; moderate fine and very fine blocky structure; very hard when dry, very firm when moist; few roots; few very fine black concretions; medium acid; gradual smooth boundary.

B22t—16 to 29 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) when dry; common fine faint gray (10RY 5/1), brown (10YR 5/3), and dark grayish brown (10YR 4/2) mottles; black vertical streaks; moderate very fine blocky structure; extremely hard when dry, very firm when moist; few roots; common fine black concretions; slightly acid; gradual wavy boundary.

B31—29 to 38 inches; dark grayish brown (10YR 4/2) silty clay, grayish brown (10YR 5/2) when dry; common very fine faint brown (10YR 5/3) mottles; common thin black vertical streaks; weak very fine blocky structure; extremely hard when dry, very firm when moist; few roots; common fine black and brown concretions and stains; neutral; diffuse irregular boundary.

B32—38 to 64 inches; gray (10YR 5/1) silty clay, light gray (10YR 6/1) when dry; many fine distinct and prominent yellowish red (5YR 5/6) and reddish brown (2.5YR 4/4) mottles; few thin black vertical streaks; weak very fine blocky structure; extremely hard when dry, very firm when moist; common fine and medium black and brown concretions and stains; mildly alkaline.

The A horizon is 6 to 14 inches thick and is very dark gray or black. It is silt loam or silty clay loam. The B3 horizon is lacking in some profiles. A C horizon ranging in color from gray to grayish brown to olive brown is present in some profiles.

Woodson soils are near Kenoma, Leanna, Mayes, Okemah, and Summit soils. They have a grayer B horizon than Kenoma soils and have an abrupt textural change between the A1 and B2t horizons that is lacking in the Mayes, Summit, and Okemah soils. They lack the distinct A2 horizon typical of Leanna soils.

Wd—Woodson silt loam, 0 to 1 percent slopes. This nearly level soil is in broad areas of the uplands. Areas are as large as 2,000 acres in size.

Included with this soil in mapping are small areas of Kenoma, Okemah, and Summit soils. Also included are areas of soils that are similar to Woodson soils but have a gray subsurface layer, and some small saline and alkali spots that are shown by spot symbols on the soil map.

A large part of the acreage is cultivated. Some areas are used as range and native meadow. This soil is well suited to all crops commonly grown in the county. Runoff is slow, and wetness is a problem. Droughtiness reduces crop yields during years of low rainfall.

This soil has few management needs other than practices for maintaining fertility and tilth. In some fields land smoothing or drainage ditches are needed to keep water from standing in slight depressions. Diversion terraces are needed in some places to protect the soil from runoff from higher areas. Capability unit IIs–1; Clay Upland range site; not assigned to a woodland suitability group.

Wf—Woodson silt loam, 1 to 3 percent slopes. This gently sloping soil is on high terraces and in broad gently undulating areas of the uplands. It has the profile described as representative of the series. Areas are as large as 1,500 acres in size. Included with this soil in mapping are small areas of Kenoma, Summit, and Eram soils and saline and alkaline spots that are shown by spot symbols on the soil map.

A large part of the acreage is cultivated. Some areas are used as range, native meadow, and tame pasture. This soil is well suited to all crops commonly grown in the county. Runoff is medium, and wetness is a problem. Water erosion is a hazard. Droughtiness reduces crop yields during seasons of low rainfall.

A cropping system that conserves soil and water, crop-residue management, minimum tillage, terracing, contour farming, and waterways help to control erosion. Maintaining tilth and fertility is needed. Good grazing management is needed to maintain a cover of native and tame grasses. Proper use of fertilizer and lime benefit tame grasses. Capability unit IIIe-1; Clay Upland range site; not assigned to a woodland suitability group.

Wh—Woodson soils, 1 to 3 percent slopes, eroded. These gently sloping soils are on convex side slopes that extend from higher areas. Areas are between 10 and 70 acres in size. In about 50 percent of a mapped area the surface layer is silty clay loam; in about 30 percent, silt loam; and in 20 percent, silty clay. So much of the original surface soil has been removed by erosion that ordinary tillage has mixed subsoil material with the remaining surface soil. Otherwise these soils have a profile similar to the one described as representative of the series. In some areas a few shallow gullies or gully scars are evident. The soils that have a surface layer of silty clay are in the more severely eroded areas.

Included with these soils in mapping are small areas of Kenoma and Summit soils. Also included are saline and alkali spots that are shown by spot symbols on the soil map.

All of the acreage has been cultivated, and most is now in crops. The soils are suited to the commonly grown crops if protective measures are used. Runoff is medium.

The main management needed is control of runoff and erosion. Also needed are practices for improving fertility and tilth. Capability unit IVe-4; Clay Upland range site; not assigned to a woodland suitability group.

Use and Management of the Soils

The soils of Anderson County are used mostly for nonirrigated farming and for range. The pages that follow explain how the soils can be used for those purposes and for woodland, wildlife, and recreation. They also explain how the soils can be used in engineering structures.

This part of the survey defines the system of capability grouping. Readers who wish to know the capability classification of a given soil can refer to the Guide to Mapping Units at the back of this survey. Those who want detailed information on management of a given soil can refer to the section "Descriptions of the Soils." Table 2 lists for all arable soils in the county the average yields per acre of the commonly grown crops to be expected under defined levels of management.

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 their farm. These readers can make good use of the capability classification system, a grouping that shows, in a general way, the suitability of soils for most kinds of farming.

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 horticultural crops or to other crops that require special management.

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

In the capability system, all kinds of soil are grouped at

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

[Only the soils suitable for cultivation are listed]

Soil	Corn	Sorghum	Wheat	Soybeans	Alfalfa
	Bu	*Bu*	*Bu*	*Bu*	*Tons*
Catoosa silt loam, 0 to 3 percent slopes	55	51	35	28	3.5
Dennis silt loam, 1 to 4 percent slopes	67	75	40	35	4.0
Dennis silty clay loam, 1 to 4 percent slopes, eroded	55	60	30	22	3.5
Eram silty clay loam, 1 to 4 percent slopes	50	51	25	25	2.6
Eram silty clay loam, 4 to 7 percent slopes	40	39	22	18	2.2
Eram soils, 1 to 4 percent slopes, eroded	40	40	22	18	2.2
Eram-Verdigris complex, 0 to 8 percent slopes	45	46	22	18	2.0
Kenoma silt loam, 1 to 4 percent slopes	67	75	35	30	3.5
Kenoma-Olpe complex, 2 to 7 percent slopes	45	50	25	20	2.2
Kenoma soils, 1 to 4 percent slopes, eroded	50	55	25	20	2.5
Lanton silty clay loam	85	85	40	35	5.0
Leanna silt loam	70	75	35	30	3.8
Lula silt loam, 0 to 3 percent slopes	65	70	40	35	4.5
Mason silt loam	84	84	45	39	5.0
Mayes silty clay loam	45	55	25	25	3.0
Okemah silt loam, 0 to 2 percent slopes	68	79	45	39	4.7
Osage silty clay loam	70	75	31	31	2.8
Summit silty clay loam, 1 to 4 percent slopes	68	73	39	34	4.5
Summit silty clay loam, 4 to 7 percent slopes	60	65	34	28	3.5
Summit soils, 1 to 4 percent slopes, eroded	50	55	28	25	3.8
Summit-Eram complex, 4 to 7 percent slopes, eroded	45	45	24	17	2.5
Verdigris silt loam, occasionally flooded	79	79	40	39	5.0
Welda silt loam, 0 to 2 percent slopes	75	79	40	36	4.0
Welda silt loam, 2 to 6 percent slopes	73	74	37	35	4.0
Woodson silt loam, 0 to 1 percent slopes	73	80	35	31	3.5
Woodson silt loam, 1 to 3 percent slopes	73	80	35	31	3.5
Woodson soils, 1 to 3 percent slopes, eroded	55	60	25	20	2.5

three levels: the capability class, the subclass, and the unit. The broadest grouping, the capability class, is designated by Roman numerals I through 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 or range or wildlife.

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 IVe-1.

The eight classes in the capability system and the subclasses and units in Anderson County are described in the list that follows. The unit designation is given in the Guide to Mapping Units.

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

- Unit I-1. Deep, nearly level, well drained and moderately well drained silt loams on low uplands or stream terraces.
- Unit I-2. Deep, nearly level, well drained silt loams on low uplands or stream terraces.

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

- Subclass IIe. Soils subject to moderate erosion unless protected.
  - Unit IIe-1. Deep, nearly level and gently sloping, well drained and moderately well drained silt loams and silty clay loams on uplands.
  - Unit IIe-2. Moderately deep, nearly level and gently sloping, well drained silt loams on uplands.
- Subclass IIw. Soils moderately limited by excess water.
  - Unit IIw-1. Deep, nearly level, moderately well drained and poorly drained silt loams and silty clay loams on flood plains.
  - Unit IIw-2. Deep, nearly level, somewhat poorly drained and poorly drained silt loams and silty clay loams on flood plains of low and high stream terraces.
  - Unit IIw-3. Deep, nearly level, somewhat poorly drained silty clay loams on uplands.
- Subclass IIs. Soils moderately limited by a clayey subsoil.
  - Unit IIs-1. Deep, nearly level, somewhat poorly drained silt loams on uplands.

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

- Subclass IIIe. Soils subject to severe erosion if they are cultivated and not protected.
  - Unit IIIe-1. Deep, gently sloping, moderately well drained and somewhat poorly drained silt loams on uplands.
  - Unit IIIe-2. Deep, sloping, moderately well drained silty clay loams on uplands.
  - Unit IIIe-3. Deep, gently sloping, moderately well drained, eroded soils on uplands.
  - Unit IIIe-4. Deep, gently sloping and sloping, well drained silt loams on uplands.
  - Unit IIIe-5. Moderately deep, gently sloping, moderately well drained silty clay loams on uplands.

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, gently sloping and sloping, well drained and moderately well drained silt loams on uplands.
  - Unit IVe-2. Moderately deep, sloping, moderately well drained silty clay loams on uplands.
  - Unit IVe-3. Deep and moderately deep, gently sloping and sloping, moderately well drained, eroded soils on uplands.
  - Unit IVe-4. Deep and moderately deep, gently sloping and sloping, moderately well drained and somewhat poorly drained, eroded soils on uplands.

Class V soils are subject to little or no erosion, but have other limitations, impractical to remove, that limit their use largely to pasture or range, woodland, or wildlife habitat.

- Subclass Vw. Soils too wet for cultivation; drainage or protection not feasible.
  - Unit Vw-1. Deep, nearly level, moderately well drained silt loams and silty clay loams on low flood plains.

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

- Subclass VIe. Soils severely limited, chiefly by risk of erosion unless protective cover is maintained.
  - Unit VIe-1. Moderately deep, sloping, moderately well drained, eroded soils on uplands.
  - Unit VIe-2. Deep, moderately deep, shallow, and very shallow, gently sloping to steep, somewhat excessively drained to moderately well drained loams, silt loams, and silty clay loams on uplands.
- Subclass VIs. Soils severely limited by low available water capacity and stones.
  - Unit VIs-1. Moderately deep, gently sloping, well drained, stony soils on uplands.

Class VII soils have very severe limitations that make them unsuitable for cultivation and restrict their use largely to range, woodland, or wildlife food and cover.

- Subclass VIIe. Soils very severely limited, chiefly by

risk of erosion, unless protective cover is maintained.
Unit VII-1. Shallow to deep, steep soils and stony land.

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

General Management

Most of Anderson County was originally covered with grass and grass residue or a mixture of trees and grass. Geologic erosion took place at a slow rate and did little damage to the soil. In most areas the surface layer was friable and fertile and the organic-matter content was high. After a few years of cultivation, the organic-matter content decreased and a general deterioration of soil structure and physical condition occurred. This poorer physical condition, combined with management that left the soil bare and unprotected, resulted in accelerated soil erosion.

Soil erosion and the loss of fertile topsoil has been serious in some places in the county. In this survey over 27,000 acres was moderately eroded and about 800 acres was severely eroded. Many eroded areas less than 5 acres in size were not included in these figures.

In eroded areas the lighter colored clayey subsoil is tilled as part of the plow layer. Fertility is lower, and cost of crop production can be higher than on uneroded fertile soils. Tillage is more costly, and in places uncrossable gullies prevent the use of the soil for crops.

In addition to controlling erosion, fertility and good tilth of cultivated soils must be maintained. Many soils in this county, unless recently limed, are strongly acid or medium acid, and application of lime is commonly beneficial. Correcting or bringing the soil reaction to a desirable level aids in better plant growth and more efficient use of commercial fertilizer. Because many years of cultivation has lowered the fertility of the soils in the county, most soils show a good response to fertilizer.

The amount and kind of fertilizer needed for optimum crop production depends in part on the kind of soil. Soil tests help determine fertilizer needs. If there are two or more kinds of soil in a field, it is best to sample each one separately. There may be enough difference in fertilizer requirements to warrant separate rates of application or kinds of fertilizer.

A suitable cropping system, minimum tillage, and good use of fertilizer so that a large amount of crop residue is produced and returned to the soil are needed to conserve cultivated soil. Terracing, contour farming, and grassed waterways reduce runoff and erosion on sloping soils (fig. 7).

Maintaining the terraces and grassed waterways is important in extending the usefulness of these structures and in protecting the soils during periods of high rainfall. Farming on the contour reduces the rate of runoff and the silting of terrace channels. A good cropping system and terraces

***Figure 7.*—Soybeans planted on the contour on terraced Kenoma soils. Capability unit IIIe-1.**

and contour farming are needed on the sloping soils when cultivated crops are grown. Soil loss is high on slowly permeable soils if row crops are planted up and down the slope, especially if they are grown continuously year after year. In these fields the supply of organic matter is decreasing.

The crops commonly grown in Anderson County are soybeans, corn, grain sorghum, wheat, and alfalfa. Tame grasses, mostly brome and fescue, are used for grazing hay and as a plant cover in waterways (fig. 8). These crops and grasses respond well to commercial fertilizer, manure, and lime. The kind and amount of fertilizer to be used on each crop is determined by field trials and soil tests. Burning of residue should be eliminated.

Predicted Yields

The average yields per acre that can be expected for the principal crops grown on the soils suitable for cultivation in Anderson County are shown in table 2. The yields do not apply to any specific field in any particular year. They indicate what can be expected as an average yield over a long period under improved management. The estimates are based on information obtained from local farmers, various agricultural agencies, demonstrations and test plots, and research data.

Crop yields on the same field vary from year to year. They are influenced by management, crop varieties, weather, and damage caused by insects and plant disease. Management also varies from farm to farm. Alternating years of drought and high rainfall can cause great fluctuations in crop yields from year to year. Wind, hail, or heavy rains may cause heavy local crop damage.

The yields listed in table 2 can be expected under improved management. On sloping soils, erosion is controlled by terraces, contour farming, and crop residue management. Drainage is provided where needed. Adequate fertilizer is used, generally on the basis of a soil test or field trials. The more productive crop varieties are planted, commonly at rates heavier than in ordinary management. All tillage, seeding, harvesting, and control of weeds, diseases, and insects are timely.

The control of weeds by the use of chemicals in recent years has significantly increased yields. Good weed control is important in years of high rainfall as well as in years of low rainfall.

A local representative of the Soil Conservation Service or the County Agricultural Extension Agent should be consulted for more information on the conservation cropping systems and management needed on a specific tract of land.

Range [3]

Approximately 143,000 acres of Anderson County is range. This acreage represents about 31 percent of the total

[3] Prepared by LEONARD J. JURGENS, range conservationist, Emporia, Kans.

Figure 8.—**Bromegrass hay on Kenoma silt loam, 1 to 4 percent slopes.**

land area in the county. An additional 20,000 acres of native grassland is used for hay. The range provides the base for a livestock economy that produces about 30 percent of the farm income in the county.

Livestock that use the range consist mainly of cow-calf units, some yearlings, and a few stocker-feeders. The range is used to some extent in the dairying enterprise. Deer, prairie chicken, quail, and rabbits are a few of the more common wildlife species that depend to varying degrees on the range.

In Anderson County there are many differences in the soils and climate. For these reasons there are several different kinds of range, which are called range sites.

Range sites and range condition

Over the centuries, a mixture of plants best suited to each range site has developed. This group of plants is called the potential, or climax, plant community for the site. The climax plant community for a site varies slightly from year to year, but the kinds and amounts of plants remain about the same if the site is undisturbed. So consistent is the relationship between the plants and the climate and soils that the climax plant community can be accurately predicted even on severely disturbed sites if the soil is identified.

Repeated overuse by grazing animals, excessive burning, or plowing results in changes in the kinds, proportions, or amounts of climax plants in the plant community. Depending on the kind and degree of disturbance, some kinds of plants increase while others decrease. If the disturbance is severe, plants that are not part of the climax plant community invade. Plant response to grazing use depends on the kind of grazing animal, the season of use, and how closely the plant is grazed. If good management follows disturbances, the climax plant community is gradually reestablished unless the site is seriously eroded.

Range condition is an expression of how the present plant community compares with the climax plant community for the range site. The more nearly the present kinds and amounts of plants are like the climax mixture, the higher the range condition.

Range condition provides an index to changes that have taken place in the plant community. More important, range condition is a basis for predicting the kinds and number of changes in the present plant community that can be expected under specified management. A site is in *excellent* condition if 76 to 100 percent of the plant cover is the climax plant community, in *good* condition if the percentage is 51 to 75, in *fair* condition if the percentage is 26 to 50, and in *poor* condition if the percentage is less than 25.

Knowledge of the climax plant community of a range site and the present community as related to the potential is important in planning management. Such information is the basis for selecting management objectives, designing grazing systems, managing wildlife, determining potential for recreation, and rating watershed conditions.

Any management objective on rangeland must provide for a plant cover that will adequately protect or improve the soil and water resources and meet the needs of the operator. The management involves maintaining or increasing desirable plants and restoring the plant community to near climax conditions where it has been degraded. Occasionally a plant cover somewhat below climax will better meet specific grazing needs, provide better wildlife habitat, or furnish other benefits while still protecting the soil and water resources.

In the following section the range sites of Anderson County are described and the climax plants are listed for each site. Plant species most likely to invade are also shown. In addition, an estimate of the potential annual production of air-dry vegetation is indicated for each site. The soils in each range site may be determined by referring to the Guide to Mapping Units at the back of this survey.

BREAKS RANGE SITE

The following tabulation indicates the percentage of the major species in the approximate climax plant community on this site:

	Percent composition by weight
Big bluestem	20
Little bluestem	15
Indiangrass	10
Switchgrass	10
Side-oats grama	5
Tall dropseed	5
Forb decreasers	10
Woody decreasers	10
Woody increasers	15

This range site is the Stony land part of Stony land-Talihina complex, steep. Because this soil material is shallow to deep, the vegetation is variable. North- and east-facing slopes typically have a higher percentage of woody species than south- and west-facing slopes.

Production ranges from 5,500 pounds of air-dry forage per acre in favorable years to 3,500 pounds in unfavorable years. All species but the woody increasers are readily grazed by cattle.

Heavy grazing causes a decrease of big bluestem, little bluestem, indiangrass, and switchgrass and an increase in tall dropseed, side-oats grama, sumac, gray dogwood, and skunkbush. Under continued overuse and lack of brush control, the plant cover is dominantly woody increasers and invaders, such as buckbrush, eastern redcedar, elm, hackberry, hickory, oak, and grasses of low quality. Many areas now appear as wooded slopes.

Returning this range site to the climax plant community not only provides improved grazing for livestock, but also improves habitat for most wildlife species in the area. Brush control and controlled burning in addition to grazing management are required if the climax plant community is to be restored.

CLAY LOWLAND RANGE SITE

The following tabulation indicates the percentage of major species in the approximate climax plant community on this site:

	Percent composition by weight
Prairie cordgrass	30
Eastern gamagrass	20
Switchgrass	10
Big bluestem	10
Indiangrass	10
Tall dropseed	3
Canada wildrye	2
Virginia wildrye	2
Sedge species	2
Maximilian sunflower	5
Forb decreasers	3
Forb increasers	3

This range site is Leanna, Mayes, and Osage soils. If the plant community is in climax condition, prairie cordgrass and eastern gamagrass provide half or more of the total production.

Production ranges from 10,000 pounds of air-dry forage per acre in favorable years to 4,000 pounds in unfavorable years. In climax condition, all species provide forage for cattle.

Heavy grazing causes an increase in prairie cordgrass, tall dropseed, and ironweed and a decrease in eastern gamagrass, big bluestem, and indiangrass. If grazing pressure continues, prairie cordgrass and switchgrass also decline with a corresponding increase in tall dropseed and the invaders, sumpweed, annual ragweed, barnyardgrass and annual three-awn. Under continued overuse and lack of brush control, the canopy is osage-orange, green ash, and other trees and the understory is sedges, purpletop, tall dropseed, and annual invaders.

Grazed areas in poor to fair condition can be restored by controlling brush and deferring grazing during the growing season. Where feasible, this site should be fenced and managed separately from the other sites to obtain maximum productivity from the climax plant community.

CLAY UPLAND RANGE SITE

The following tabulation indicates the percentage of major species in the approximate climax plant community on this site:

	Percent composition by weight
Big bluestem	25
Little bluestem	20
Indiangrass	15
Switchgrass	15
Virginia wildrye	5
Tall dropseed	5
Side-oats grama	3
Rosette panicums	2
Leadplant amorpha	2
Sedge species	3
Forb decreasers	3
Forb increasers	2

This range site is Eram, Kenoma, Talihina, and Woodson soils and the eroded phases of Dennis and Summit soils.

Production ranges from 7,500 pounds of air-dry forage per acre in favorable years to 2,500 pounds in unfavorable years. In climax condition, all species provide forage for cattle.

Under heavy grazing, big bluestem, indiangrass, little bluestem, and the decreaser forbs are replaced by tall dropseed and heath aster. If grazing pressure continues, switchgrass also declines and annual three-awn, annual ragweed, and buckbrush invade this site. Tall dropseed, heath aster, annual three-awn, annual ragweed, annual bromes, and buckbrush dominate this range site when it is reduced to a fair or poor range condition by heavy grazing.

A planned grazing system is one of the best management techniques in restoring or maintaining the climax plant community on this range site. Abandoned crop fields can be restored by seeding the suitable native species.

LOAMY LOWLAND RANGE SITE

The following tabulation indicates the percentage of major species in the approximate climax plant community on this site:

	Percent composition by weight
Big bluestem	20
Eastern gamagrass	20
Indiangrass	15
Switchgrass	10
Prairie cordgrass	5
Tall dropseed	5
Virginia wildrye	3
Canada wildrye	2
Sedge species	5
Forb decreasers	5
Forb increasers	5
Woody increasers	5

This range site is Lanton, Mason, and Verdigris soils. If the plant community is in climax condition, it is the most productive range site in the county. Most of these soils are used for crops, introduced pasture, woodland, or native meadow.

Production from the climax plant community ranges from 10,000 pounds of air-dry forage per acre in favorable years to 6,000 pounds in unfavorable years. All species but the woody increasers are readily utilized by cattle. Most grazed areas are overgrazed because the site is easily accessible to livestock.

Heavy grazing reduces eastern gamagrass and the decreaser forbs. Big bluestem, indiangrass, switchgrass, and the wildryes also decrease under continued heavy grazing. These species are replaced by buckbrush, tall dropseed, ironweed, goldenrod, annual ragweed, and annual grasses. If excessive grazing continues, the canopy is hackberry, osage-orange, green ash, oak, and other trees and the understory is buckbrush, green muhly, sedges, annual grasses, and woody shrubs.

Restoring this range site to the climax plant community depends on the amount of departure from the climax and the length of time the site has been in poor condition. Brush control and reseeding are needed in many areas. Controlled burning helps where the amount of the desired species is adequate.

LOAMY UPLAND RANGE SITE

The following tabulation indicates the percentage of major species in the approximate climax plant community on this site:

	Percent composition by weight
Big bluestem	35
Little bluestem	20
Indiangrass	15
Switchgrass	10
Side-oats grama	3
Tall dropseed	3
Rosette panicums	2
Sedge species	2
Forb decreasers	5
Forb increasers	5

This range site is Catoosa, Dennis, Lula, Okemah, Olpe, Summit, and Welda soils. These soils have a substratum of shale, limestone, waterworn gravel, or loess. The differing kinds of substratum result in no significant differences in the climax plant community, but they do affect the kind of increasers and invaders that become significant in the plant community.

Production from the climax plant community ranges from 7,500 pounds of air-dry forage per acre in favorable years to 3,500 pounds in unfavorable years. All species in the climax community provide forage for cattle.

Heavy grazing causes a decrease in big bluestem, indiangrass, little bluestem, and switchgrass and an increase in tall dropseed, annual three-awn, and buckbrush. Side-oats grama is an increaser on Lula soils, and rosette panicums are increasers on Olpe soils. Blackberry and broomsedge are invaders on Dennis soils, and weed trees are invaders on Welda soils. If heavy grazing continues, tall dropseed, annual three-awn, buckbrush, annual broomweed, annual ragweed, blackberry, broomsedge, annual bromes, and weed trees become the major species on one or more soils of this range site when it is in poor to fair range condition.

A planned grazing system is most effective in restoring the climax plant community on this range site. Brush control and controlled burning are also helpful. Abandoned crop fields can be restored by seeding the suitable native species.

SHALLOW FLATS RANGE SITE

The following tabulation indicates the percentage of major species in the approximate climax plant community on this site:

	Percent composition by weight
Little bluestem	25
Big bluestem	20
Side-oats grama	15
Indiangrass	10
Switchgrass	5
Tall dropseed	5
Blue and hairy grama	5
Forb decreasers	5
Forb increasers	5
Woody increasers	5

This range site is Clareson soils.

Production of air-dry forage ranges from 5,000 pounds per acre in favorable years to 2,000 pounds in unfavorable years. All species but the woody increasers are utilized by cattle.

Excessive grazing causes a decrease in big bluestem, indiangrass, little bluestem, and switchgrass and an increase in side-oats grama, tall dropseed, woody increasers, and forb increasers. Invaders, such as annual grasses, broomweed, buckbrush, and silver bluestem, move in. Continued heavy grazing reduces the plant population to sumac, skunkbush, buckbrush, eastern redcedar, annual broomweed, silver bluestem, annual three-awn, and annual bromes.

Weed and brush control in combination with deferred grazing is quickest in restoring the climax plant community. Tillage is not feasible on this site because of the amount of rock at or near the surface. This range site is excellent winter range for livestock if grazing is deferred during the previous growing season.

SHALLOW SANDSTONE RANGE SITE

The following tabulation indicates the percentage of major species in the approximate climax plant community on this site:

	Percent composition by weight
Little bluestem	30
Big bluestem	25
Indiangrass	10
Switchgrass	10
Broomsedge	3
Rosette panicums	3
Purple lovegrass	2
Sedge species	2
Forb decreasers	5
Forb increasers	5
Woody increasers	5

This range site is Collinsville soils.

Production from the climax plant community ranges from 4,000 pounds of air-dry forage per acre in favorable years to 2,000 pounds in unfavorable years. All species but the woody increasers are readily grazed by cattle. Sheep and goats graze the woody species and forbs.

Heavy grazing causes a decrease in little bluestem, big bluestem, indiangrass, and switchgrass and an increase in blackberry, sumac, broomsedge, and purple lovegrass. If grazing continues, the plant community degenerates to woody shrubs, eastern redcedar, broomsedge, purpletop, annual grasses, and forb increasers. Under overgrazing by sheep and goats, the forbs and woody shrubs are eliminated and the chief remaining plant species are annual three-awn, broomsedge, purpletop, and annual bromes.

Brush control in combination with deferred grazing and controlled burning is most practical in restoring the climax plant community on this range site. Mechanical treatment generally is impractical because of the amount of sandstone rock at or near the surface and the severe hazard of erosion on these soils if the plant cover is destroyed.

Woodland

Approximately 23,000 acres of Anderson County is woodland, of which about 7,000 acres is wooded pasture. All is privately owned. Most of the wooded areas occur as small, irregularly shaped tracts along streams and on some of the steep slopes along drainageways.

Only a small part of the woodland is managed for timber production. Nearly all of the woodland is grazed by livestock. Woodland also provides food and cover for wildlife and natural areas for recreation. All woodland must be protected against fire and excessive grazing and cleared of cull trees. Weeding, thinning, pruning, intermediate cutting, and harvest cutting may be needed. Competition from weed trees and vines can prevent the establishment of desirable trees unless cultural measures are applied.

The bottom land soils have a good potential for production of black walnut and trees that grow to timber size, but most of these soils are used for row crops, small grain, and legumes. The upland soils have poor potential for the production of saw logs. Disease, lightning, and poor trunk growth limit the quality of timber on these soils.

Woodland suitability groups

The woodland suitability groups represented in Anderson County are described on the pages that follow. Only soils having a potential for producing merchantable saw logs are grouped. The soils in each group are suited to trees that produce similar kinds of wood crops. They require about the same kind of management and have about the same potential productivity. The soils in the county differ in their capacity to grow trees. They vary somewhat from place to place in texture, depth, and degree of wetness. This variation is reflected in tree growth and species suitability.

Each woodland group is identified by a two-part symbol, for example, 3o, 4w, or 4o. The first part of the symbol, always a number, indicates the relative potential productivity of the soils in the group. The number 1 indicates very high potential productivity; 2, high; 3, moderately high; 4, moderate; and 5, low. These ratings are based on field determinations of average site index. Site index is the height, in feet, that the dominant trees of a given species, on a specific kind of soil, reach in a natural, unmanaged stand in a specified number of years. For most merchantable hardwoods and softwoods in this county, the site index is the height reached in 50 years. For cottonwood, however, it is the height reached in 30 years.

The five foregoing ratings are based on field determination of average site index of an indicator forest type or species. Site indexes are grouped into site quality classes, and the classes are used to determine approximate expected yields per acre in cords and board feet. On basis of research studies, site index can be converted into approximate expected growth and yield per acre in cords and board feet.

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 the soils of the group for wood crops. The letter *c* indicates that the main limitation is the kind or amount of clay in the upper part of the soils in the group; *o*, that the soils have few limitations restricting their use for trees; *r*, that the main limitation is steep slopes; *s*, that the soils are sandy and dry, show little or no difference in texture between the surface layer and subsoil, have low available water capacity, and generally have a low supply of plant nutrients; and *w*, that water in or on the soil, either seasonally or year round, is the chief limitation.

Table 3 contains information on tree species, potential productivity, and management hazards and limitations. The hazards or limitations that affect management of soils for woodland are seedling mortality, erosion hazard, windthrow hazard, plant competition, and equipment limitations. They are expressed as *slight*, *moderate*, or *severe*. The following explanations of these ratings apply to all woodland suitability groups in Anderson County.

Potential productivity of a soil for growing trees is the height attained by the dominant and codominant species at the age of 50 years. For example, if a soil has a site index of 70, trees reach a height of 70 feet in 50 years.

Seedling mortality refers to the expected degree of mortality of naturally occurring or planted seedlings as influenced by soil texture, depth, drainage, flooding, height of the water table, and degree of erosion. Normal rainfall, good planting stock, and proper planting are assumed. Mortality is *slight* if the expected loss is less than 25 percent, *moderate* if 25 to 50 percent, and *severe* if more than 50 percent.

Erosion hazard is rated according to the risk of erosion on woodland where normal methods are used in managing and harvesting trees. The hazard is *slight* if erosion control is not an important concern, *moderate* if some attention is needed to check soil losses, and *severe* if special treatment or special methods are necessary.

Windthrow hazard depends on the growth of roots and the capacity of the soil to hold trees firmly. The hazard is *slight* if windthrow is no special concern; *moderate* if roots hold the trees firmly, except when the soil is excessively wet or the wind is strongest; and *severe* if many trees are blown over because their roots cannot provide enough stability.

Plant competition refers to the invasion or growth of unwanted trees, shrubs, vines, or other plants when openings are made in the canopy. Competition is *slight* if competing plants do not hinder the establishment of a desirable stand, *moderate* if they delay the establishment of a desirable stand, and *severe* if they prevent the establishment of a desirable stand unless intensive cultural measures are applied.

Equipment limitations are based on the degree that soils and topographic features restrict or prohibit the use of equipment normally employed in tending a crop of trees. The limitation is *slight* if there is little or no restriction on the type of equipment that can be used or the time of year that it can be used. It is *moderate* if the use of equipment is seasonally limited or if modified equipment or methods of harvesting are needed. The limitation is *severe* if special equipment is

TABLE 3.—*Wood crops and management*

Woodland suitability group and map symbols	Soil productivity		Management hazards or limitations					Species to be—	
	Tree species	Potential [1]	Seedling mortality	Erosion hazard	Windthrow hazard	Plant competition	Equipment limitations	Favored in existing stands	Planted
Group 3o: Ev, Me, Vf, Vx.	Bur oak Hackberry Black walnut Cottonwood Green ash Red oak	55 69 69 87 75 57	Slight	Slight	Slight	Slight	Slight	Hackberry, black walnut, cottonwood, red oak, green ash.	Hackberry, black walnut, cottonwood, sycamore, green ash.
Group 3w: La, Le.	Pecan Hackberry Cottonwood Green ash Pin oak	63 70 85 75 80	Moderate	Slight	Moderate	Severe	Severe	Cottonwood, hackberry, green ash, sycamore, pecan.	Cottonwood, green ash, pecan, sycamore.
Group 4o: Wb, Wc.	White oak Hackberry Green ash Black walnut	51 60 60 55	Slight	Slight	Slight	Slight	Slight	White oak, black walnut, hackberry, green ash.	Black walnut, green ash.
Group 4w: Os.	Pin oak Burr oak Green ash Hackberry Pecan	74 55 70 66 75	Severe	Slight	Moderate	Severe	Severe	Pin oak, burr oak, green ash, hackberry, pecan.	Pin oak, hackberry, pecan.

[1] Potential productivity, or site index: 40 to 55 is poor; 56 to 70 fair; and 71 to 85 good.

needed or if the use of such equipment is severely restricted by one or more unfavorable soil characteristics.

The species listed in the last two columns of table 3 are those to be favored in existing stands and those having productivity potential.

The following paragraphs describe the woodland groups in Anderson County.

Woodland group 3o consists of deep, well drained and moderately well drained soils. These soils have a surface layer of silt loam and a subsoil of silt loam and silty clay loam. They are on low terraces and flood plains. Flooding is occasional to frequent on the flood plains and rare on the terraces. Cottonwood, black walnut, and green ash are important species that produce well.

Woodland group 3w consists of deep, somewhat poorly drained and poorly drained soils. These soils have a surface layer of silt loam and silty clay loam and a subsoil of silty clay loam and silty clay. They are on flood plains and low terraces. Flooding is occasional to frequent. Cottonwood and pin oak are important species that produce well.

Woodland group 4o consists of deep, well drained soils that have a surface layer of silt loam and a subsoil of silty clay loam. These soils are on uplands and high terraces. Available water capacity is high. Upland oaks and black walnut are important species. Productivity is fair for all species.

Woodland group 4w consists of deep, poorly drained soils on flood plains. These soils have a surface layer and subsoil of silty clay loam and silty clay. These bottom land soils are wet for long periods after rains, and runoff is very slow. Flooding is common. Green ash, pecan, and pin oak are im-

TABLE 4.—*Wildlife*

Soil series and map symbols	Wildlife habitat elements				
	Grain and seed crops	Domestic grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants
Catoosa: Cb	Fair	Good	Good	Good	Good
Clareson: Cc	Poor	Good	Good	Fair	Fair
Collinsville: Cd	Poor	Poor	Fair	Poor	Poor
Dennis: Db, De	Good	Good	Good	Good	Good
Eram: Eb, Ec, Ed, Eh, Ek, Eo, Ep, Ev For Clareson part of Ek, see Clareson series; for Talihina part of Ep, see Talihina series; for Verdigris part of Ev, see Verdigris series. Gullied land part of Eo is too variable to be rated.	Good	Good	Fair	Good	Good
Kenoma: Kb, Kd, Kh For Olpe part of Kh, see Olpe series.	Good	Good	Fair	Fair	Fair
Lanton: La	Fair	Good	Good	Good	Good
Leanna: Le	Fair	Good	Fair	Good	Good
Lula: Lh	Good	Good	Good	Good	Good
Mason: Me	Good	Good	Good	Good	Good
Mayes: Mf	Fair	Good	Fair	Good	Good
Okemah: Ok	Good	Good	Good	Good	Good
Olpe: Op	Fair	Good	Good		
Osage: Os	Fair	Fair	Fair	Fair	Fair
Summit: Sf, Sh, Sk, So For Eram part of So, see Eram series.	Fair	Good	Fair	Good	Good
Stony land: Se. For Talihina part, see Talihina series. Stony land too variable to rate.					
Talihina Mapped only with Eram soils and Stony land.	Poor	Poor	Fair	Poor	Poor
Verdigris: Vf, Vx	Good	Good	Good	Good	Good
Welda: Wb, Wc	Good	Good	Good	Good	Good
Woodson: Wd, Wf, Wh	Fair	Good	Poor		

portant species. Productivity is good for pin oak, hackberry, and green ash.

Wildlife [4]

The kind and abundance of wildlife in Anderson County and elsewhere is mainly determined by land use and by the fertility, topography, permeability, and depth of the soils. If land use is changed, the wildlife in the area also is likely to change.

Soils directly affect the kind and amount of vegetation that is available to wildlife as food and cover, and they affect the development of water impoundments. The kind and abundance of wildlife that populates an area depend largely on the amount and distribution of food, cover, and water. If any one of these elements is missing, inadequate, or inaccessible, wildlife will either be scarce or will not inhabit the area.

If the soils have the potential, wildlife habitat can be created or improved by planting appropriate plant cover, by properly managing the existing plant cover, and by fostering the natural establishment of desirable plants.

In table 4 the soils in the survey area are rated according to their potential to support the main kinds of wildlife habitat in the area. This information can be used in—

1. Planning the use of parks, wildlife refuges, nature study areas, and other developments for wildlife.

[4] By Jack W. Walstrom, biologist, Soil Conservation Service.

habitat

Wildlife habitat elements—Continued			Kinds of wildlife			
Shrubs	Wetland plants	Shallow water areas	Openland	Woodland	Wetland	Rangeland
Good	Poor	Very poor	Good	Good	Very poor	Good.
Fair	Very poor	Very poor	Fair	Fair	Very poor	Fair.
Fair	Very poor	Very poor	Poor	Poor	Very poor	Fair.
Good	Poor	Poor	Good	Good	Poor	Good.
Good	Poor	Very poor	Fair	Good	Very poor	Good.
Fair	Poor	Fair	Good	Fair	Poor	Fair.
Good	Fair	Fair	Good	Good	Fair.	
Good	Fair	Good	Fair	Good	Fair.	
Good	Poor	Very poor	Good	Good	Very poor.	
Good	Poor	Very poor	Good	Good	Very poor.	
Fair	Fair	Fair	Fair	Good	Fair	Fair.
	Poor	Poor	Good	Good	Poor	Good.
Fair	Poor	Very poor	Good		Very poor	Fair.
	Good	Good	Fair	Fair	Good.	
Good	Poor	Very poor	Fair	Good	Very poor	Good.
Poor	Poor	Very poor	Poor	Poor	Very poor	Poor.
Good	Poor	Fair	Good	Good	Poor.	
	Very poor	Poor	Good	Good	Poor.	
Good	Poor	Good	Fair		Fair	Fair.

2. Selecting soils that are suitable for creating, improving, or maintaining specific elements of wildlife habitat.
3. Determining the intensity of management needed for each element of the habitat.
4. Determining areas that are suitable for acquisition to manage for wildlife habitat.

The potential of the soil is expressed as good, fair, poor, or very poor. A rating of *good* means that the element of wildlife habitat or the kind of habitat is easily created, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected. *Fair* means that the element of wildlife habitat or kind of habitat can be created, improved, or maintained in most places. A moderate intensity of management and fairly frequent attention are required for satisfactory results. *Poor* means that limitations are severe for the designated element or kind of wildlife habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and requires intensive effort. *Very poor* means that restrictions for the element of wildlife habitat or kind of wildlife are very severe and that unsatisfactory results can be expected. It is impractical or even impossible to create, improve, or maintain wildlife habitat on soils having such a rating.

The elements of wildlife habitat are briefly described in the following paragraphs.

Grain and seed crops are seed-producing annuals used by wildlife. Examples are corn, sorghum, wheat, oats, barley, and soybeans. The major soil properties that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations.

Grasses and legumes are domestic perennial grasses and herbaceous legumes that are planted for wildlife food and cover. Examples are fescue, bluegrass, switchgrass, bromegrass, timothy, orchardgrass, clover, alfalfa, trefoil, and crownvetch. The major soil properties that affect the growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, flood hazard, and slope. Soil temperature and soil moisture are also considerations.

Wild herbaceous plants are native or naturally established herbaceous grasses and forbs, including weeds, that provide food and cover for wildlife. Examples are bluestem, indiangrass, goldenrod, beggarweed, pokeweed, switchgrass, partridgepea, wheatgrass, and grama. The major soil properties that affect the growth of these plants are thickness of the soil, texture of the surface layer, available water capacity, wetness, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations.

Hardwood trees and the associated woody understory provide cover for wildlife and produce nuts or other fruit, buds, catkins, twigs, bark, or foliage that wildlife eat. The plants generally regenerate naturally, but can be planted. Examples of native plants are oak, cherry, sweetgum, apple, hawthorn, dogwood, persimmon, cottonwood, hickory, sycamore, black walnut, blackberry, grape, blackhaw, viburnum, gooseberry, and briers. Examples of fruit-producing shrubs that are commercially available and suitable for planting on soils rated good are Russian-olive, autumn-olive, and crabapple. The major soil properties that affect the growth of hardwood trees and shrubs are depth of the root zone, available water capacity, and wetness.

Coniferous plants are cone-bearing trees, shrubs, and ground cover that furnish habitat or supply food in the form of browse, seeds, or fruitlike cones. They are commonly established through natural processes, but can be planted or transplanted. Examples are pine, spruce, redcedar, and juniper. The major soil properties that affect the growth of coniferous plants are depth of the root zone, available water capacity, and wetness.

Shrubs are bushy woody plants that produce fruit, buds, twigs, bark, or foliage used by wildlife or that provide cover and shade for some species of wildlife. Examples are buckbrush, sassafras, and sumac. The major soil properties that affect the growth of shrubs are depth of the root zone, available water capacity, salinity, and moisture.

Wetland plants are annual and perennial wild herbaceous plants, exclusive of submerged or floating aquatics, that grow on moist or wet sites. They produce food or cover for wildlife that use wetland as habitat. Examples are smartweed, wild millet, rushes, sedges, reeds, arrowhead, saltgrass, cordgrass, and cattail. The major soil properties affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness.

Shallow water areas are bodies of surface water that have an average depth of less than 5 feet and that are useful to wildlife. They can be naturally wet areas, or they can be created by dams or levees or by water-control devices in marshes or streams. Examples are muskrat marshes, waterfowl feeding areas, wildlife watering developments, beaver ponds, and other wildlife ponds. The major soil properties affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. The availability of a dependable water supply is important if water areas are to be developed.

The kinds of wildlife habitat are briefly described in the following paragraphs.

Openland habitat is croplands, pastures, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. It provides grain and seed crops, grasses and legumes, and wild herbaceous plants. The kinds of wildlife attracted to this habitat are bobwhite quail, meadowlark, field sparrow, killdeer, cottontail rabbit, red fox, and woodchuck.

Woodland habitat is tracts of hardwoods or conifers, or a mixture of both, and associated grasses, legumes, and wild herbaceous plants. Examples of wildlife attracted to this habitat are wild turkey, owls, hawks, thrushes, vireos, woodpeckers, tree squirrels, grey fox, raccoon, deer, opossum, and badger.

Wetland habitat is open, marshy, or swampy shallow water areas. The vegetation is water-tolerant plants. Examples of wildlife attracted to this habitat are ducks, geese, herons, shore birds, rails, kingfishers, muskrat, mink, and beaver.

Rangeland habitat is areas of wild herbaceous plants and shrubs on range. Examples of wildlife attracted to this habitat are deer, coyote, prairie chicken, meadowlark, and lark bunting.

The soils of Anderson County provide suitable habitat for many kinds of animals and birds. The most important game bird is bobwhite quail. Alluvial soils provide suitable habitat for deer, raccoon, fox squirrel, gray squirrel, mink, muskrat, beaver, and opossum and for songbirds, such as thrushes and cardinals.

The preferred habitat for prairie chickens is extensive areas of mixed native grasses interspersed with small fields of cultivated crops, generally in the ratio of two-thirds grassland to one-third cropland.

Numerous farm ponds provide good to excellent fishing for bass, bluegill, and channel catfish. These multipurpose ponds also provide stockwater. The estimated fish production is 100 to 300 pounds per acre of water. Good opportunities for fishing are also provided by several perennial streams.

Mourning dove, a popular game bird in Kansas, nests throughout the county. This dove depends heavily on seeds as a food source, and consequently, herbaceous plants are vitally important as food. Doves largely depend on farm ponds and streams for their water. Migrating waterfowl alight on the many farm ponds throughout the county.

The white-tailed deer population is increasing in the county. During hunting seasons each fall, hunters are allowed to shoot surplus animals. Deer habitat is available on all soils, but the best habitat is on alluvial soils along the major streams.

Cottontail rabbits inhabit the entire county. If the proper kind of food and cover is interspersed throughout the habitat, the carrying capacity for this species is increased. Heavy brushy thickets are required to shelter a large population of rabbits. A good habitat has one cottontail per acre.

Developing a specific habitat for wildlife requires that the plant cover is the kind that the soils can produce and that it is properly located. Onsite technical assistance in planning developments for wildlife and in determining suitable species of vegetation for planting can be obtained from the local office of the Soil Conservation Service. Additional information and assistance can be obtained from the Fish and Wildlife Service; the Kansas Forestry, Fish and Game Commission; and the Extension Service.

Recreation [5]

Anderson County is served by two major highways. U.S. Highway 59 transects the county in a north-south direction. U.S. Highway 169 divides the county in a northeast-southwest direction. All-weather access roads within the county provide adequate access to about 96 percent of the county.

Lake Garnett, about 1 mile north of Garnett, was established as a city park in 1937. The park area is 265 acres, of which 48 acres is water. The lake was constructed for multipurpose use, including a water supply for the city, boating, water skiing, picnicking, fishing, and camping. Sanitary facilities, police patrol, and a full-time groundskeeper help enhance the area for visitors. The hard-surface road around the lake attracts nationally recognized races to this community.

A 9-hole golf course north of Garnett and east of Lake Garnett is available on a fee basis.

Crystal Lake is a small lake and park within the south city limits of Garnett and east of U.S. Highway 59. Picnic facilities and fishing are the main recreation activities available. This park is about 20 acres in size.

Pottawatomie Creek, the major stream in the county, provides fair fishing for bass, bluegill, bullheads, and catfish.

Knowledge of soils is necessary in planning, developing, and maintaining areas used for recreation. In table 5 the soils of Anderson County are rated according to limitations that affect their suitability for camp areas, playgrounds, picnic areas, and paths and trails. Limitations are expressed as slight, moderate, or severe. For all of these ratings, it is assumed that a good cover of vegetation can be established and maintained. A limitation of *slight* indicates soil properties that are generally favorable and limitations so minor that they easily can be overcome. A *moderate* limitation can be overcome or modified by planning, by design, or by special maintenance. A *severe* limitation indicates that costly soil reclamation, special design, intensive 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 for tent and parking areas. Camp areas are subject to heavy foot traffic and limited vehicular traffic. The best soils have gentle slopes, good drainage, a surface free of rocks and coarse fragments, no flooding during periods of heavy use, and a surface that is firm after rains but not dusty when dry.

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 have a nearly level surface free of coarse fragments and rock outcrop, good drainage, no flooding during periods of heavy use, and a surface that is firm after rains but not dusty when dry. If grading and leveling are required, depth to rock is important.

Picnic areas are attractive natural or landscaped tracts. 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 from flooding during the season of use; and do not have slopes or stones that greatly increase the cost of leveling sites or of building access roads.

Paths and trails are used for local and cross-country travel by foot or on 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 no 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.

For further assistance in planning for recreation areas, contact the local Soil Conservation Service office.

Engineering

This section is useful to those who need information about soils used as structural material or as foundation upon which structures are built. Among those who can benefit from this section are planning commissions, 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 bedrock, and soil 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.

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

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

[An asterisk in the first column indicates that at least one mapping unit is made up of two or more kinds of soils. The soils in such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for referring to other series that appear in the first column of this table]

Soil series and map symbols	Camp areas	Picnic areas	Playgrounds	Paths and trails
Catoosa: Cb	Slight	Slight	Slight	Slight.
Clareson: Cc	Moderate: silty clay loam.	Moderate: silty clay loam.	Moderate: coarse fragments.	Moderate: coarse fragments and silty clay loam.
Collinsville: Cd	Slight where slopes are less than 8 percent. Moderate where slopes are more than 8 percent.	Slight where slopes are less than 8 percent. Moderate where slopes are more than 8 percent.	Severe: slope; depth to bedrock.	Slight.
Dennis: Db, De	Moderate: slow permeability; moderately well drained.	Slight	Moderate: slow permeability; moderately well drained.	Slight.
*Eram: Eb, Ec, Ed, Eh, Ek, Eo, Ep, Ev. For Clareson part of Ek, see Clareson series; for Talihina part of Ep, see Talihina series; and for Verdigris part of Ev, see Verdigris series. Gullied land part of Eo is too variable to be rated.	Moderate: slow permeability; silty clay loam; moderately well drained.	Moderate: silty clay loam; moderately well drained.	Moderate where slopes are less than 6 percent: slow permeability; silty clay loam; depth to bedrock. Severe where slopes are more than 6 percent.	Moderate: silty clay loam.
*Kenoma: Kb, Kd, Kh. For Olpe part of Kh, see Olpe series.	Severe: very slow permeability.	Slight	Severe: very slow permeability.	Slight.
Lanton: La	Severe: flooding; poorly drained.	Moderate: flooding; silty clay loam.	Severe: flooding; poorly drained.	Moderate: flooding; poorly drained; silty clay loam.
Leanna: Le	Severe: flooding	Moderate: flooding; somewhat poorly drained.	Severe: very slow permeability; somewhat poorly drained.	Moderate: somewhat poorly drained.
Lula: Lh	Slight	Slight	Slight where slopes are less than 2 percent. Moderate where slopes are more than 2 percent.	Slight.
Mason: Me	Severe: flooding	Severe: flooding	Moderate: moderately slow permeability; flooding.	Slight.
Mayes: Mf	Severe: somewhat poorly drained; very slow permeability.	Moderate: somewhat poorly drained.	Severe: somewhat poorly drained; very slow permeability.	Moderate: somewhat poorly drained.
Okemah: Ok	Moderate: slow permeability; moderately well drained.	Slight	Moderate: slow permeability; moderately well drained.	Slight.
Olpe: Op	Moderate: coarse fragments.	Moderate: coarse fragments.	Moderate where slopes are less than 6 percent: coarse fragments. Severe where slopes are more than 6 percent.	Moderate: coarse fragments.
Osage: Os	Severe: poorly drained; flooding.	Severe: poorly drained; flooding.	Severe: poorly drained; flooding.	Severe: poorly drained.

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

Soil series and map symbols	Camp areas	Picnic areas	Playgrounds	Paths and trails
*Stony land: Se. For Talihina part, see Talihina series.	Severe: slope.	Severe: slope.	Severe: slope; coarse fragments.	Moderate where slopes are 15 to 25 percent: coarse fragments. Severe where slopes are more than 25 percent.
*Summit: Sf, Sh, Sk, So. For Eram part of So, see Eram series.	Moderate: slow permeability; silty clay loam.	Moderate: silty clay loam.	Moderate: slow permeability; slope; silty clay loam.	Moderate: silty clay loam.
Talihina. Mapped only with Eram soils and Stony land.	Moderate where slopes are 5 to 15 percent: silty clay loam. Severe where slopes are more than 15 percent.	Moderate where slopes are 5 to 15 percent: silty clay loam. Severe where slopes are more than 15 percent.	Severe: slope; depth to bedrock.	Moderate: silty clay loam.
Verdigris:				
Vf	Severe: flooding	Moderate: flooding	Moderate: flooding	Slight.
Vx	Severe: flooding	Severe: flooding	Severe: flooding	Moderate: flooding.
Welda: Wb, Wc	Moderate: moderately slow permeability.	Slight	Moderate: moderately slow permeability.	Slight.
Woodson: Wd, Wf, Wh	Severe: very slow permeability; somewhat poorly drained.	Moderate: somewhat poorly drained.	Severe: very slow permeability; somewhat poorly drained.	Moderate: somewhat poorly drained.

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 construction 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 in engineering; interpretations for various engineering uses; and results of engineering laboratory tests on soil samples.

This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in tables 4 and 5, and it also can be used to make other useful maps.

This information, however, does not eliminate 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 5 feet. Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given soil 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 terms used in this soil survey have special meaning in soil science that may not be familiar to engineers. The Glossary defines many of these terms.

Engineering classification

The two systems most commonly used in classifying samples of soils for engineering are the Unified system used by the SCS engineers, Department of Defense, and others, and the AASHTO system adopted by the American Association of State Highway and Transportation Officials.

The Unified system (*2*) classifies soils according to engineering uses for building material or for the support of structures other than highways. 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 that are 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; and plastic classes are CL and CH. There is one class of highly organic soils, Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, CL-ML.

The AASHTO system (*1*) is used to classify soils according to those properties that affect use in highway construction and maintenance. In this system, a soil is assigned to 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, which have high bearing strength and are the best soils for subgrade, or foundation. At the other extreme, in group A-7, are clay soils which have low strength when wet and are 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 additional refinement, the engineering value of a soil material can be indicated by a group

TABLE 6.—*Estimated physical and*

[An asterisk in the first column indicates that at least one mapping unit is made up of two or more kinds of soils. The soils in such mapping units appear in the first column of this table. Absence of data indicates that the soil is too variable to be

Soil series and map symbols	Depth to bedrock	Depth from surface	USDA texture	Classification		Percentage less than 3 inches passing sieve—	
				Unified	AASHTO	No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Ft	*In*					
Catoosa: Cb	20–40	0–8	Silt loam	CL	A–4 or A–6	100	100
		8–28	Silty clay loam	CL	A–4, A–6, or A–7	100	100
		28	Limestone.				
Clareson: Cc	20–40	0–7	Flaggy silty clay loam.	CL	A–6	80–100	70–95
		7–24	Very flaggy silty clay.	CL or CH	A–7	80–100	70–95
		24	Limestone.				
Collinsville: Cd	4–20	0–6	Loam	ML or SM	A–4	80–100	60–100
		6–11	Channery loam	ML or SM	A–4	80–100	60–100
		11	Sandstone.				
Dennis: Db, De	40–70	0–10	Silt loam	ML or CL	A–4 or A–6	100	100
		10–21	Silty clay loam	CL	A–6 or A–7	100	100
		21–56	Silty clay loam and silty clay.	CL or CH	A–6 or A–7	100	100
		56	Shale.				
*Eram: Eb, Ec, Ed, Eh, Ek, Eo, Ep, Ev.	20–40 Shale	0–15	Silty clay loam	ML or CL	A–6 or A–7	100	100
For Clareson part of Ek, see Clareson series; for Talihina part of Ep, see Talihina series; for Verdigris part of Ev, see Verdigris series. Gullied land part of Eo is too variable to be rated.		15–28	Clay loam	CL, CH, or MH	A–6 or A–7	100	100
		28–33	Silty clay loam	CH or CL	A–6 or A–7	100	100
		33	Shale.				
*Kenoma: Kb, Kd, Kh	40–70	0–7	Silt loam	ML or CL	A–4 or A–6	85–100	85–100
For Olpe part of Kh, see Olpe series.		7–56	Silty clay	CH or CL	A–7	85–100	85–100
		56–61	Silty clay loam	CH or CL	A–7	80–100	80–100
Lanton: La	>60	0–60	Silty clay loam	CL	A–6 or A–7	100	100
Leanna: Le	>60	0–17	Silt loam	ML or CL	A–4 or A–6	100	98–100
		17–64	Silty clay	CH or CL	A–7	98–100	98–100
Lula: Lh	40–60	0–13	Silt loam	ML or CL	A–4 or A–6	100	100
		13–49	Silty clay loam	CL	A–6 or A–7	100	97–100
		49	Limestone.				
Mason: Me	>60	0–13	Silt loam	ML or CL	A–4 or A–6	100	100
		13–60	Silty clay loam	CL	A–6 or A–7	98–100	98–100
Mayes: Mf	>60	0–11	Silty clay loam	CL or CH	A–6 or A–7	100	100
		11–64	Silty clay	CH	A–7	100	100
Okemah: Ok	>60	0–9	Silt loam	CL or ML	A–4, A–6, or A–7	100	100
		9–22	Silty clay loam	CL or CH	A–7	100	100
		22–60	Silty clay	CH or CL	A–7	100	100

chemical properties of the soils

may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for referring to other series that rated or that no estimate was made. The symbol > means greater than; the symbol < means less than]

Percentage less than 3 inches passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Risk of corrosion for—	
No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
				In per hr	*In per in of soil*	*pH*			
96–100	75–90	30–37	9–13	0.6–2.0	0.15–0.24	6.1–6.5	Low	Low	Moderate.
90–100	85–95	30–43	9–20	0.6–2.0	0.15–0.22	5.6–6.5	Moderate	Moderate	Moderate.
65–90	60–85	30–40	11–18	0.2–2.0	0.21–0.23	6.6–7.3	Moderate	Moderate	Moderate.
65–90	60–85	41–60	18–35	0.06–0.6	0.11–0.13	6.6–7.3	Moderate to high.	Moderate	Moderate.
60–95	36–75	<30	[1] NP–10	2.0–6.0	0.12–0.16	5.6–6.0	Low	Low	Moderate.
60–95	36–75	<30	NP–10	2.0–6.0	0.09–0.13	5.6–6.0	Low	Low	Moderate.
96–100	65–97	21–37	1–15	0.6–2.0	0.15–0.21	5.6–6.0	Low	Low to moderate.	Low to moderate.
96–100	75–98	33–48	13–25	0.2–0.6	0.18–0.22	5.1–5.5	Moderate	Moderate	Moderate to high.
96–100	75–98	33–65	13–35	0.06–0.2	0.14–0.22	5.6–7.3	High	High	Low to moderate.
85–100	75–95	33–48	8–25	0.6–2.0	0.15–0.19	5.6–6.5	Moderate	High	Moderate.
90–100	85–98	37–65	15–33	0.2–0.6	0.14–0.18	6.1–6.5	Moderate to high.	High	Moderate.
94–100	90–98	37–65	15–35	0.06–0.2	0.14–0.18	6.1–6.5	Moderate to high.	High	Moderate.
85–100	85–100	25–42	5–20	0.2–0.6	0.22–0.24	6.1–6.5	Low	High	Moderate.
85–100	85–100	45–85	25–60	<0.06	0.11–0.13	5.6–8.4	High	High	Moderate.
75–100	75–95	41–60	25–45	0.06–0.2	0.18–0.20	7.9–8.4	High	High	Low.
95–100	95–100	35–50	15–25	0.2–0.6	0.18–0.22	6.6–7.3	Moderate	High	Low.
99–100	85–100	30–40	6–16	0.2–0 6	0.15–0.19	5.1–5.5	Low	High	Moderate.
95–100	90–100	45–65	25–40	<0.06	0.14–0.18	5.6–7.3	High	High	Low to moderate.
96–100	65–100	21–37	1–20	0.6–2.0	0.15–0.12	5.6–6.5	Low	Low	Low to moderate.
95–100	75–98	30–50	11–26	0.6–2.0	0.18–0.22	5.1–6.0	Moderate	Moderate	Low to moderate.
96–100	65–98	20–35	1–13	0.6–2.0	0.16–0.20	5.6–6.5	Low	Low	Moderate.
96–100	65–98	30–43	11–20	0.2–6.0	0.16–0.20	5.1–7.3	Moderate	Moderate	Moderate.
95–100	90–100	35–55	13–35	0.2–0.6	0.14–0.22	6.6–7.3	Moderate to high.	High	Low to moderate.
95–100	90–100	50–65	30–45	<0.06	0.12–0.15	6.6–7.8	High	High	Low.
96–100	80–98	20–48	1–23	0.2–2.0	0.16–0.20	5.6–6.0	Low	Moderate	Moderate.
96–100	80–99	45–65	19–38	0.06–0.2	0.15–0.19	5.6–6.5	High	High	Low.
96–100	90–99	48–72	21–46	0.06–0.2	0.15–0.19	6.6–8.4	High	High	Low.

TABLE 6.—*Estimated physical and*

Soil series and map symbols	Depth to bedrock	Depth from surface	USDA texture	Classification		Percentage less than 3 inches passing sieve—	
				Unified	AASHTO	No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Ft	*In*					
Olpe: Op	>60	0–10	Gravelly silt loam	ML or CL	A-4	70–100	65–95
		10–16	Gravelly silty clay loam.	GC or SC	A-2 or A-6	30–65	25–60
		16–34	Gravelly clay loam	GC or SC	A-2 or A-6	30–65	25–60
		34–60	Gravelly silty clay	GC or SC	A-2, A-6, or A-7	30–65	25–70
Osage: Os	>60	0–13	Silty clay loam	CL or CH	A-6 or A-7	100	100
		13–64	Silty clay	CH	A-7	100	100
*Stony land: Se. For Talihina part, see Talihina series. Stony land too variable to rate.							
*Summit: Sf, Sh, Sk, So. For Eram part of So, see Eram series.	>40	0–8	Silty clay loam	CL, MH, or CH	A-6 or A-7	100	100
		8–60	Silty clay	CH or CL	A-7	100	100
Talihina: Mapped only with Eram soils and Stony land.	10–20	0–15	Silty clay loam	CL or CH	A-6 or A-7	100	100
		15	Shale.				
Verdigris: Vf, Vx	>60	0–18	Silt loam	ML or CL	A-4 or A-6	100	100
		18–38	Silty clay loam	ML or CL	A-4 or A-6	100	100
		38–50	Silt loam	ML or CL	A-4 or A-6	100	100
		50–65	Loam	ML or CL	A-4 or A-6	100	100
Welda: Wb, Wc	>60	0–12	Silt loam	ML or CL	A-4 or A-6	100	100
		12–60	Silty clay loam	CL	A-6 or A-7	100	100
Woodson: Wd, Wf, Wh	>60	0–8	Silt loam	ML or CL	A-4 or A-6	100	100
		8–64	Silty clay	CH	A-7	100	100

[1] NP = nonplastic.

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

Estimated soil properties

Estimates of soil properties significant in engineering are listed in table 6. These estimates are made for layers of representative soil profiles having significantly different soil properties. The estimates are based on field observations made in the course of mapping, on test data given in table 8, on experience with the same kinds of soil in other counties, and on tests made by the State Highway Commission. 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.

Soil texture is described in table 6 in the standard terms used by the Department of Agriculture (*15*). 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 is 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 loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary of this soil survey.

Liquid limit and plasticity index are water contents obtained by specified operations. As the water content of a dry clayey soil from which the particles coarser than 0.42 milli-

chemical properties of the soils—Continued

Percentage less than 3 inches passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Risk of corrosion for—	
No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
				In per hr	*In per in of soil*	*pH*			
65–95	60–90	15–30	7–10	0.6–2.0	0.14–0.18	5.1–6.5	Low	Low	Low to moderate.
20–55	15–50	15–30	8–20	0.06–0.2	0.06–0.13	5.6–6.5	Low	Low	Low to moderate.
20–55	15–50	20–40	11–22	0.06–0.2	0.04–0.10	5.6–6.5	Low	Low	Low to moderate.
20–60	15–50	30–60	25–40	0.06–0.2	0.04–0.10	5.6–7.3	Moderate	Low	Low to moderate.
95–100	95–100	35–60	15–40	0.06–0.2	0.21–0.23	6.6–7.3	High	High	Low to moderate.
95–100	95–100	55–78	30–55	<0.06	0.10–0.12	6.1–8.4	High	High	Low to moderate.
95–100	90–99	35–60	13–30	0.2–0.6	0.14–0.22	6.1–6.5	Moderate to high.	High	Low to moderate.
85–100	85–99	41–70	25–40	0.06–0.2	0.14–0.18	6.1–7.3	High	High	Low to moderate.
96–100	75–95	35–65	13–35	0.06–0.2	0.12–0.22	6.6–7.8	High	High	Low to moderate.
90–100	70–95	30–40	6–16	0.6–2.0	0.22–0.24	6.1–6.5	Low	Low	Low to moderate.
95–100	70–90	30–40	6–16	0.6–2.0	0.18–0.20	6.1–7.3	Low	Low	Low to moderate.
90–100	70–90	30–40	6–16	0.6–2.0	0.22–0.24	6.1–6.5	Low	Low	Low to moderate.
85–95	60–75	20–35	1–20	0.6–2.0	0.16–0.20	6.6–7.3	Low	Low	Low to moderate.
95–100	95–100	25–35	5–15	0.6–2.0	0.22–0.24	5.1–6.5	Low	Low	Low.
90–100	90–100	30–45	18–27	0.2–0.6	0.18–0.22	5.1–6.5	Moderate	Moderate	Moderate.
90–100	90–100	25–40	5–20	0.6–2.0	0.22–0.24	6.6–7.3	Low	Moderate	Low.
95–100	90–100	50–65	27–45	<0.06	0.12–0.15	5.6–7.8	High	High	Moderate.

meter have been removed is increased, the material changes from semisolid to plastic. If the moisture content is further increased, the material changes from plastic to liquid. The plastic limit is the moisture content at which the soil material changes from semisolid to plastic; and the liquid limit, from plastic to liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of 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 in table 6, is the estimated rate at which saturated soil transmits water in a vertical direction under a unit head of pressure. It is estimated on basis of those 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. Permeability is given for the various textural classes of each soil, rather than for the most restrictive layer of the soil, as in the section "Descriptions of the Soils."

Available water capacity is the estimated 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

TABLE 7.—*Engineering*

[Lawrence E. Robins, civil engineer, helped prepare this table. An asterisk in the first column indicates that at least one mapping unit is made up follow carefully the instructions for referring to other

Soil series and map symbols	Degree and kind of limitation for—						
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings	Local roads and streets [1]	Sanitary landfill	
						Trench type	Area type
Catoosa: Cb	Severe: bedrock at a depth of 20 to 40 inches.	Severe: bedrock at a depth of 20 to 40 inches.	Severe: bedrock at a depth of 20 to 40 inches.	Severe with basements: bedrock at a depth of 20 to 40 inches. Moderate without basements: bedrock at a depth of 20 to 40 inches; low strength; moderate shrink-swell potential.	Moderate: limestone at a depth of 20 to 40 inches; moderate shrink-swell potential.	Severe: bedrock at a depth of 20 to 40 inches.	Slight.
Clareson: Cc	Severe: bedrock at a depth of 20 to 40 inches; more than 35 percent coarse fragments in subsoil.	Severe: bedrock at a depth of 20 to 40 inches; more than 35 percent coarse fragments in subsoil.	Severe: bedrock at a depth of 20 to 40 inches; more than 35 percent coarse fragments in subsoil.	Severe with basements: bedrock at a depth of 20 to 40 inches. Moderate without basements: bedrock at a depth of 20 to 40 inches; more than 35 percent coarse fragments in subsoil.	Moderate to severe: moderate to high shrink-swell potential; coarse fragments; bedrock at a depth of 20 to 40 inches.	Severe: bedrock at a depth of 20 to 40 inches; coarse fragments in subsoil.	Slight.
Collinsville: Cd	Severe: bedrock at a depth of 4 to 20 inches.	Severe: bedrock at a depth of 4 to 20 inches.	Severe: bedrock at a depth of 4 to 20 inches.	Severe: bedrock at a depth of 4 to 20 inches.	Severe: bedrock at a depth of 4 to 20 inches.	Severe: bedrock at a depth of 4 to 20 inches.	Severe: moderately rapid permeability.
Dennis: Db, De	Severe: slow permeability.	Slight where slope is less than 2 percent. Moderate where slope is 2 to 4 percent.	Severe: silty clay below a depth of 21 inches.	Severe: high shrink-swell potential.	Severe: high shrink-swell potential.	Severe: silty clay.	Slight.

interpretations

of two or more kinds of soils. The soils in such mapping units may have different properties and limitations, and for this reason it is necessary to series that appear in the first column of this table]

Degree and kind of limitation for—Continued	Suitability as source of—			Soil features affecting—			
Sanitary landfill—Continued: Cover material	Topsoil	Road subgrade [1]	Road fill [1]	Highway location [1]	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions, and waterways
Fair: bedrock at a depth of 20 to 40 inches; silty clay loam below a depth of 8 inches.	Fair: silty clay loam below a depth of 8 inches.	Fair: medium soil support.	Good	Limestone at a depth of 20 to 40 inches; 0 to 3 percent slopes.	Bedrock at a depth of 20 to 40 inches.	Unstable fill; susceptible to piping; bedrock at a depth of 20 to 40 inches.	Bedrock at a depth of 20 to 40 inches; limited rooting depth; droughty.
Poor: more than 35 percent coarse fragments in subsoil.	Poor: more than 15 percent coarse fragments.	Poor: low soil support.	Fair: fair shear strength.	Limestone at a depth of 20 to 40 inches; more than 35 percent coarse fragments in subsoil; 1 to 4 percent slopes.	Bedrock at a depth of 20 to 40 inches.	Fair to poor compaction and stability; bedrock at a depth of 20 to 40 inches.	More than 35 percent coarse fragments in subsoil.
Poor: bedrock at a depth of 4 to 20 inches.	Fair to poor: bedrock at a depth of 4 to 20 percent.	Good	Good	Sandstone at a depth of 4 to 20 inches; erodible; 2 to 15 percent slopes.	Bedrock at a depth of 4 to 20 inches; moderately rapid permebility.	Bedrock at a depth of 4 to 20 inches; medium to high susceptibility to piping.	Bedrock at a depth of 4 to 20 inches; 2 to 15 percent slopes.
Poor: silty clay below a depth of 21 inches.	Fair: silty clay loam below a depth of 10 inches.	Fair to poor: low to medium soil support; medium to high plasticity.	Fair: moderate to high shrink-swell potential; fair shear strength.	1 to 4 percent slopes.	All features favorable.	Poor to fair compaction characteristics; unstable fill; susceptible to piping.	All features favorable.

TABLE 7.—*Engineering*

Soil series and map symbols	Degree and kind of limitation for—						
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings	Local roads and streets [1]	Sanitary landfill	
						Trench type	Area type
*Eram: Eb, Ec, Ed, Eh, Ek, Eo, Ep, Ev. For Clareson part of Ek, see Clareson series; for Talihina part of Ep, see Talihina series; for Verdigris part of Ev, see Verdigris series. Gullied land part of Eo is too variable to be rated.	Severe: slow permeability.	Severe: shale at a depth of 20 to 40 inches.	Severe: shale at a depth of 20 to 40 inches.	Severe: high shrink-swell potential.	Severe: high shrink-swell potential.	Severe: shale at a depth of 20 to 40 inches.	Slight.
*Kenoma: Kb, Kd, Kh. For Olpe part of Kh, see Olpe series.	Severe: very slow permeability.	Slight where slope is less than 2 percent. Moderate where slope is 2 to 4 percent: moderate where bedrock is at depths of 40 to 60 inches.	Severe: silty clay below a depth of 7 inches.	Severe: high shrink-swell potential.	Severe: high shrink-swell potential.	Severe: silty clay below a depth of 7 inches.	Slight.
Lanton: La	Severe: frequent flooding; high water table; moderately slow permeability.	Severe: frequent flooding; high water table.	Severe: frequent flooding; high water table.	Severe: frequent flooding; high water table.	Severe: frequent flooding.	Severe: frequent flooding; high water table; poorly drained.	Severe: frequent flooding; high water table.
Leanna: Le	Severe: occasional flooding; very slow permeability.	Severe: occasional flooding.	Severe: occasional flooding; silty clay; somewhat poorly drained.	Severe: occasional flooding; somewhat poorly drained; high shrink-swell potential.	Severe: floods more than once in 5 years.	Severe: occasional flooding; silty clay; somewhat poorly drained.	Severe: somewhat poorly drained; occasional flooding.
Lula: Lh	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; low strength.	Moderate: moderate shrink-swell potential.	Severe: bedrock at a depth of 40 to 60 inches.	Slight.

interpretations—Continued

Degree and kind of limitation for—Continued	Suitability as source of—			Soil features affecting—			
Sanitary landfill—Continued: Cover material	Topsoil	Road subgrade [1]	Road fill [1]	Highway location [1]	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions, and waterways
Fair: silty clay loam.	Fair: silty clay loam.	Fair: fair shear strength; medium plasticity.	Fair: fair shear strength.	Shale at a depth of 20 to 40 inches; 1 to 15 percent slopes; 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.
Poor: silty clay below a depth of 7 inches.	Poor: silty clay below a depth of 7 inches.	Poor: low soil support; high plasticity.	Fair: fair shear strength.	1 to 4 percent slopes; poor workability; slow internal damage.	1 to 4 percent slopes.	Fair to poor compaction characteristics; medium to low shear strength.	Silty clay subsoil at a depth of 7 inches.
Fair: poorly drained.	Fair: silty clay loam.	Fair: medium soil support.	Fair: fair shear strength.	High water table; frequent flooding; nearly level.	High water table; nearly level.	Medium to low shear strength; fair to good compaction characteristics.	Frequent flooding; nearly level.
Poor: silty clay below a depth of 17 inches.	Good	Poor: high plasticity; low soil support.	Fair: fair shear strength.	Occasional flooding.	Occasional flooding.	Fair to poor compaction characteristics; medium to low shear strength.	Nearly level; occasional flooding.
Fair: silty clay loam below a depth of 13 inches.	Fair: silt loam to a depth of 13 inches.	Poor: low soil support.	Fair: fair shear strength.	Limestone at a depth of 40 to 60 inches; 0 to 3 percent slopes.	Bedrock at a depth of 40 to 60 inches; moderate permeability; susceptible to piping.	Medium to low shear strength; susceptible to piping; bedrock at a depth of 40 to 60 inches.	All features favorable.

TABLE 7.—*Engineering*

Soil series and map symbols	Degree and kind of limitation for—						
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings	Local roads and streets [1]	Sanitary landfill	
						Trench type	Area type
Mason: Me	Severe: moderately slow permeability.	Slight	Moderate: rarely flooded.	Severe: rarely flooded.	Moderate: floods less than once in 5 years; moderate shrink-swell potential.	Moderate: rarely flooded; silty clay loam.	Moderate: rarely flooded.
Mayes: Mf	Severe: very slow permeability; very slow surface runoff.	Slight	Severe: silty clay below a depth of 11 inches; somewhat poorly drained.	Severe: high shrink-swell potential; low strength; table.	Severe: high shrink-swell potential.	Severe: silty clay below a depth of 11 inches.	Severe: high water table.
Okemah: Ok	Severe: slow permeability; perched water table.	Slight	Severe: silty clay below a depth of 22 inches; perched water table.	Severe: high shrink-swell potential; low strength.	Severe: high shrink-swell potential.	Severe: silty clay below a depth of 22 inches; perched water table.	Slight
Olpe: Op	Severe: slow permeability.	Severe: more than 35 percent coarse fragments; some slopes over 7 percent.	Moderate: more than 35 percent coarse fragments.	Moderate: moderate shrink-swell potential; some slopes over 8 percent.	Moderate: moderate shrink-swell potential; some slopes over 8 percent.	Severe: silty clay below a depth of 34 inches.	Slight where slope is less than 8 percent. Moderate where slope is 8 to 15 percent.
Osage: Os	Severe: very slow permeability; frequent flooding.	Severe: frequent flooding.	Severe: poorly drained; silty clay; frequent flooding.	Severe: poorly drained; high shrink-swell potential; low strength; frequent flooding.	Severe: poorly drained; high shrink-swell potential; frequent flooding.	Severe: poorly drained; silty clay; frequent flooding.	Severe: frequent flooding.
*Stony land: Se. For Talihina part, see Talihina series.	Severe where slope is 15 to 45 percent.	Severe where slope is 15 to 45 percent.	Severe where slope is 15 to 45 percent.	Severe where slope is 15 to 45 percent.	Severe where slope is 15 to 45 percent.	Severe where slope is 15 to 45 percent.	Severe where slope is 15 to 45 percent.
*Summit: Sf, Sh, Sk, So. For Eram part of So, see Eram series.	Severe: slow permeability; perched water table.	Moderate where slope is 2 to 7 percent. Slight on slopes of less than 2 percent.	Severe: silty clay.	Severe: high shrink-swell potential.	Severe: high shrink-swell potential.	Severe: silty clay.	Moderate: somewhat poorly drained.
Talihina: Mapped only with Eram soils and Stony land.	Severe: slow permeability; shale at a depth of 10 to 20 inches.	Severe: shale at a depth of 10 to 20 inches; some slopes over 7 percent.	Severe: perched water table; silty clay; some slopes over 7 percent.	Severe: high shrink-swell potential; low strength.	Severe: high shrink-swell potential.	Severe: shale at a depth of 10 to 20 inches.	Moderate: on slopes less than 15 percent; severe on slopes more than 15 percent. Severe: perched water table.

interpretations—Continued

Degree and kind of limitation for—Continued	Suitability as source of—			Soil features affecting—			
Sanitary landfill—Continued Cover material	Topsoil	Road subgrade [1]	Road fill [1]	Highway location [1]	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions, and waterways
Fair: silty clay loam below a depth of 13 inches.	Fair: silt loam to a depth of 13 inches.	Fair: medium soil support.	Good.	Rare flooding; nearly level.	Nearly level.	Medium to low shear strength; fair to good compaction characteristics.	Nearly level; rare flooding.
Poor: silty clay below a depth of 11 inches.	Poor: silty clay below a depth of 11 inches.	Poor: low soil support; high plasticity.	Fair: fair shear strength.	Nearly level; slow internal drainage.	Less than 1 percent slopes.	Unstable fill; high shrink-swell potential.	Less than 1 percent slopes; high shrink-swell potential.
Fair: silty clay loam below a depth of 9 inches.	Fair: silty clay loam below a depth of 9 inches.	Poor: high plasticity; low soil support.	Fair: fair shear strength.	0 to 2 percent slopes; poor workability.	0 to 2 percent slopes.	Low shear strength; high shrink-swell potential.	All features favorable.
Poor: more than 35 percent coarse fragments.	Poor: coarse fragments.	Good.	Good.	2 to 15 percent slopes.	Slow permeability; 5 to 15 percent slopes.	Medium to low shear strength.	2 to 15 percent slopes; coarse fragments in subsoil.
Poor: poorly drained; silty clay at a depth of 13 inches.	Poor: poorly drained; silty clay below a depth of 13 inches.	Poor: high plasticity; low soil support.	Fair: fair shear strength.	Frequent flooding; nearly level; poor workability.	Nearly level; frequent flooding; very slow permeability.	Fair to poor compaction characteristics; medium to low shear strength.	Frequent flooding; nearly level.
Poor where slope is 15 to 45 percent.	Poor where slope is 15 to 45 percent.	Poor: low soil support.	Fair: fair shear strength; 15 to 45 percent slopes.	15 to 45 percent slopes.	15 to 45 percent slopes.	15 to 45 percent slopes.	15 to 45 percent slopes.
Poor: silty clay at a depth of 8 inches.	Fair to poor: silty clay at a depth of 8 inches.	Poor: low soil support.	Fair: fair shear strength.	Possible seeps; 1 to 7 percent slopes; poor workability.	All features favorable.	Fair to poor: compaction characteristics; medium to low shear strength.	All features favorable.
Poor: shale at a depth of 10 to 20 inches.	Fair: silty clay loam; shale at a depth of 10 to 20 inches.	Fair to poor: moderate to high plasticity; medium to low soil support.	Fair: fair shear strength.	Shale at a depth of 10 to 20 inches; 1 to 20 percent slopes; poor workability.	Shale at a depth of 10 to 20 inches.	Shale at a depth of 10 to 20 inches.	7 to 15 percent slopes; shale at a depth of 10 to 20 inches.

TABLE 7.—*Engineering*

Soil series and map symbols	Degree and kind of limitation for—						
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings	Local roads and streets [1]	Sanitary landfill	
						Trench type	Area type
Verdigris: Vf, Vx	Severe: frequent flooding.	Severe: frequent flooding.	Severe: frequent flooding.	Severe: frequent flooding.	Severe: floods more than once in 5 years.	Severe: frequent flooding.	Severe: frequent flooding.
Welda: Wb, Wc	Severe: moderately slow permeability.	Moderate where slope is 2 to 6 percent. Slight on slopes less than 2 percent.	Slight	Moderate: moderate shrink-swell potential; low strength.	Moderate: moderate shrink-swell potential.	Moderate: silty clay loam.	Slight
Woodson: Wd, Wf, Wh.	Severe: very slow permeability.	Slight	Severe: somewhat poorly drained; silty clay below a depth of 8 inches.	Severe: high shrink-swell potential; low strength.	Severe: high shrink-swell potential.	Severe: silty clay below a depth of 8 inches.	Moderate: somewhat poorly drained.

[1] G. N. CLARK, soils engineer, and HERBERT E. WORLEY, soils research engineer, Kansas State Highway Commission, assisted in preparing the information in these columns.

when dry or swells when 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.

Risk of corrosion, as used in table 6, pertains to potential soil-induced chemical action that dissolves or weakens steel or concrete. 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. Risk of corrosion for concrete is influenced mainly by the content of sodium or magnesium sulfate, but also by soil texture and acidity. A corrosivity rating of *high* means that there is a high probability of damage, so that protective measures for steel and more resistant concrete should be used to reduce damage.

Depth to a high water table is not rated in table 6. The seasonal water table in Lanton and Osage soils fluctuates to within a few inches of the soil surface during wet periods. In all other soils in Anderson County, it is more than 5 feet below the surface. In Dennis, Eram, Okemah, Summit, and Talihina soils the water table is perched within 2 or 3 feet of the soil surface between December and June.

Flooding is common on Lanton, Osage, and Verdigris soils and occasionally on Leanna soils. Some depressional areas of Osage soils are inundated for as much as a month or two.

Engineering interpretations

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

Soil limitations are expressed as *slight*, *moderate*, and *severe*. *Slight* means soil properties generally favorable for the rated use, or in other words, limitations that 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 soil properties so unfavorable and so difficult to correct or overcome that major soil reclamation, special design, or intensive maintenance is required.

Soil suitability is expressed as *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 from a depth of 18 inches to 6 feet is evaluated. The soil properties considered

interpretations—Continued

Degree and kind of limitation for—Continued	Suitability as source of—			Soil features affecting—			
Sanitary landfill—Continued: Cover material	Topsoil	Road subgrade [1]	Road fill [1]	Highway location [1]	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions, and waterways
Good	Good	Fair: medium soil support.	Good	Frequent flooding; nearly level.	Frequent flooding; nearly level.	Fair compaction characteristics; medium to low shear strength.	Frequent flooding; nearly level.
Fair: silty clay loam below a depth of 12 inches.	Fair: silty clay loam below a depth of 12 inches.	Fair: medium soil support.	Fair: fair shear strength.	Erodible; 0 to 6 percent slopes.	0 to 6 percent slopes.	Fair to good compaction characteristics; medium to low shear strength.	All features favorable.
Poor: silty clay at a depth of 8 inches.	Fair: silty clay at a depth of 8 inches.	Poor: low soil support.	Fair: fair shear strength	0 to 3 percent slopes; poor workability.	0 to 3 percent slopes.	Fair to poor compaction characteristics; medium to low shear strength; high shrink-swell potential.	Silty clay at a depth of 8 inches; somewhat poorly drained; very slow permeability.

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 is a soil property that affects difficulty of layout and construction and also the risk of soil 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. It is assumed that the embankment is compacted to medium density and the pond is protected from flooding. Properties that affect the pond floor and the embankment are considered. 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 content of stones, if any, that influences 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, as for example, excavations for pipelines, sewer lines, phone and power transmission lines, basements, and open ditches. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, no rock outcrops or big stones, and no flooding or high water table.

Dwellings, as rated in table 7, are no 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.

Sanitary landfill is a method of disposing of refuse either in excavated trenches or on the surface of the soil. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. 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. Limitation ratings of *slight* or *moderate*, therefore, 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 regardless of that, every site should be investigated before it is selected.

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

TABLE 8.—*Engineering*

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

Soil name and location	Parent material	Report number	Depth	Moisture density [1]	
				Maximum dry density	Optimum moisture
			In	*Lb/ft³*	*Pct*
Eram silty clay loam:					
2,100 feet N. and 550 feet W. of the SE. corner of sec. 13, T. 23 S., R. 19 E. (Modal)	Clay shale	S72-Kans. 2-6-1	0–9	93	23
		S72-Kans. 2-6-4	20–28	96	22
		S72-Kans. 2-6-5	28–33	99	21
Kenoma silt loam:					
1,750 feet E. and 550 feet N. of the SW. corner of sec. 32, T. 22 S., R. 20 E. (Modal)	Weathered old clay alluvium	S72-Kans. 2-8-1	0–7	97	18
		S72-Kans. 2-8-2	7–11	95	24
		S72-Kans. 2-8-6	38–56	95	24
Lanton silty clay loam:					
2,800 feet E. and 650 feet S. of the NW. corner of sec. 5, T. 20 S., R. 20 E. (Modal)	Silty alluvium	S71-Kans. 2-5-2	9–17	102	18
		S71-Kans. 2-5-5	45–63	102	18
Okemah silt loam:					
1,425 feet N. and 700 feet W. of the SE. corner of sec. 13, T. 23 S., R. 19 E. (Modal)	Residuum or colluvium weathered from shaly clay.	S72-Kans. 2-7-1	0–9	91	22
		S72-Kans. 2-7-4	22–31	93	25
		S72-Kans. 2-7-7	47–60	97	23
Summit silty clay loam:					
1,000 feet W. and 200 feet S. of the NE. corner of sec. 25, T. 20 S., R. 19 E. (Nonmodal—B21t horizon low in clay content).	Residuum or colluvium weathered from clay or soft clay shale.	S72-Kans. 2-9-1	0–8	92	22
		S72-Kans. 2-9-2	12–19	93	25
		S72-Kans. 2-9-3	68–84	102	20

[1] Based on 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 crusher after drying; and (3) no time is allowed for dispersion of moisture after mixing with the soil material.

[2] Mechanical analysis is according to the AASHTO Designation T 88-57 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 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

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 and stability of the subgrade, and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material, and also the shrink-swell potential, indicate traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

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

Road subgrade, or the upper part of road fill, is the soil material used to form the base upon which the roadway is built. The ratings given in table 7 are based on the qualities of disturbed soil material borrowed for this use.

Highway location is influenced by features of the undisturbed soil that affect construction and maintenance of highways. The soil features given in table 7, favorable as well as unfavorable, are the chief ones that affect the location of highways. The organic surface layer of the soil is considered to have been removed.

Sand and gravel is used in great quantities in many kinds of construction. 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. Only Olpe soils are rated as a potential source of sand and gravel in Anderson County.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by the ease of working and spreading the soil material, as in preparing a seedbed; the 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. Also considered in the ratings is damage that will result at the area from which topsoil is taken.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable as pond reservoir areas have low *test data*

American Association of State Highway and Transportation Officials (AASHTO) except as stated in footnotes 2 and 3]

Mechanical analysis [2]							Liquid limit	Plasticity index	Classification	
Percentage less than 3 inches passing sieve—			Percentage smaller than—						AASHTO [3]	Unified [4]
No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	0.05 mm	0.02 mm	0.005 mm	0.002 mm				
							Pct			
100	99	94	88	61	32	21	46	16	A-7-5(12)	ML
100	99	95	91	76	57	45	54	25	A-7-6(17)	MH-CH
100	98	92	88	73	51	39	54	27	A-7-6(18)	CH
100	97	93	87	52	21	13	36	10	A-4(8)	CL-ML
100	99	97	95	76	46	40	50	26	A-7-6(16)	CL
100	98	95	92	80	60	52	81	57	A-7-6(20)	CH
100	100	98	96	85	47	32	45	21	A-7-6(13)	CL
100	100	99	98	88	50	37	48	25	A-7-6(16)	CL
100	98	94	91	67	34	21	47	16	A-7-5(12)	ML
100	99	98	96	86	62	53	70	44	A-7-6(20)	CH
100	99	98	95	83	59	48	64	38	A-7-6(20)	CH
100	98	91	86	67	43	30	59	29	A-7-5(19)	MH-CH
100	97	87	82	67	46	33	62	34	A-7-6(20)	CH
100	100	98	97	95	77	51	61	34	A-7-6(20)	CH

Soil Conservation 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.

[3] Based on AASHTO Designation M145-49.

[4] ASTM Stand. 0 2487-69 (*2*).

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 that is resistant to seepage and piping and has favorable stability, shrink-swell potential, shear strength, and compactibility. Stones and organic material in a soil are among factors that are unfavorable.

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; stones; permeability; and resistance to water erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff and is not difficult to vegetate.

Soil test data

Table 8 contains engineering test data for some of the major soil series in Anderson County. These tests were made to help evaluate the soils for engineering purposes. The engineering classifications given are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. The mechanical analyses were made by combined sieve and hydrometer methods.

Compaction, or moisture-density, data are important in earthwork. If a soil material is compacted at successively higher 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 of earthwork 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 is explained for table 6.

Formation and Classification of Soils

This section tells how the factors of soil formation have affected the soils in Anderson County. It also explains the system of soil classification currently used and classifies each soil series in the county according to that system.

Factors of Soil Formation

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

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that forms 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. Generally, a long time is required for the formation 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 formation are unknown.

Parent material

Parent material is the horizon of weathered rock or partly weathered material from which soils form. Weathering of rock takes place through the processes of freezing and thawing, abrasion, and soil blowing; water and glaciers acting on the soil; and chemical processes. Parent material affects the texture, structure, color, natural fertility, and many other properties of the soil. Soils differ partly because of differences in parent material. The texture of the parent material, which determines the rate of the downward movement of water, greatly influences soil formation. The composition of the geologic material largely determines the mineralogical composition of the soil and hence its natural chemical fertility. This material is the chief source of all plant nutrient elements except nitrogen (*6*).

In Anderson County the soils formed in material derived from Pennsylvanian age limestone, sandstone, and shale and from loess, old alluvium, and recent alluvium (fig. 9). Most of the bedrock represents sediment deposited in marine and marine-nonmarine, or mixed, environments. The formations of Pennsylvanian age rock from which the soils of Anderson County formed range from the Dennis Limestone in the southeast corner of the county to a member of the Oread Limestone Formation in the northwest corner of the county (*12*, *3*). Rocks in this part of Kansas tilt to the northwest about 20 feet per mile (*13*).

Although discontinuous, local in nature, and of small displacement, the Chesapeake Fault tending northwest across Anderson County alters the rock structure (*11*). The rock formations, faults, fractures, and parent material not only affect the soils that form, but also have an important effect on the quantity and quality of the water supply, possible outlets for pollution, sources of supply of salts, and water seeps on hillsides.

Collinsville soils formed in material weathered from the sandstone bedrock in the northwestern and southeastern parts of the county. The sand in the loamy soil material of Collinsville soils is derived from the weathered sandstone.

Dennis, Eram, Okemah, Summit, and Talihina soils formed in residuum and colluvium weathered mostly from shale. These soils have a loamy surface layer and a loamy or clayey subsoil. Depth to parent material and bedrock varies. For example, depth to shale ranges from 4 to 20 inches in Talihina soils and from 20 to 40 inches in Eram soils and is more than 40 inches in Dennis and Summit soils.

The residuum derived from shale restricts the downward movement of water. The soils formed in this material are more clayey than other soils. The slow movement of the water is shown by mottled olive and gray colors in the lower part of the subsoil and in the substratum. This slow movement is evident in Summit and Okemah soils.

The shale ranges in reaction from neutral to moderately alkaline. The soils formed in material weathered from shale are generally acid in the upper part and neutral in the lower part of the substratum. A few areas of alkaline soils are in the county, but they are very minor in extent and are included among the Eram soils because all other characteristics are similar.

Catoosa, Clareson, and Lula soils formed in material weathered from limestone. These soils are loamy and friable. Depth to bedrock varies. In some places, for example, in the Spring Hill Limestone Formation north of Garnett, limestone bedrock is 25 feet thick, but in others all or part of it has been removed by erosion. The soils formed from the limestone have unique characteristics in this survey area. Water moves more freely through the profile. Therefore, the reddish soils of the county dry more quickly than other soils. Also, tillage, cultivation, and harvesting generally start earlier following a rain than on the other soils.

Woodson and Kenoma soils formed in old clayey alluvial deposits. Woodson soils occupy the broad clayey flats mostly in the western part of the county. Kenoma soils occupy the undulating areas of the southern part of the county. These old clay beds contain interspersed pockets of waterworn chert pebbles. Throughout the undulating areas are hummocks or hills and rounded knolls. These knolls are capped with beds of waterworn chert gravel 1 to 20 feet thick. Olpe soils formed in these beds. These soils and the chert beds are on the highest landscape positions in Anderson County.

The more recent alluvium filled the stream valleys. Osage soils formed in the more clayey alluvial sediment. Lanton soils along Pottawatomie Creek have a high fluctuating water table. Verdigris soils, which are on flood plains, receive recent deposits in many places. Most areas of deposition show up as lighter colored material when tilled. Mason soils formed in alluvium on the higher, rarely flooded stream terraces.

Welda soils formed in loess on high terraces and upland slopes. These silty deposits are mostly along the eastern side of the South Fork of Pottawatomie Creek.

Erosion and the material deposited throughout the county greatly influenced the relationship of the soil to the geology of the area. Pennsylvanian age rock was laid down in shallow water or along beaches when most of eastern Kansas was a sea. Tilting changed the lay of most of the formations. The tilt is northwest. Erosion removed parts of many formations.

Erosion and the resistance to erosion of some limestone formations contributed much to the present topography. Erosion removed large amounts of rock, leaving areas where the limestone was more resistant and giving rise to the escarpments crossing the county and the isolated knolls, hills, and limestone-capped ridges. The highest

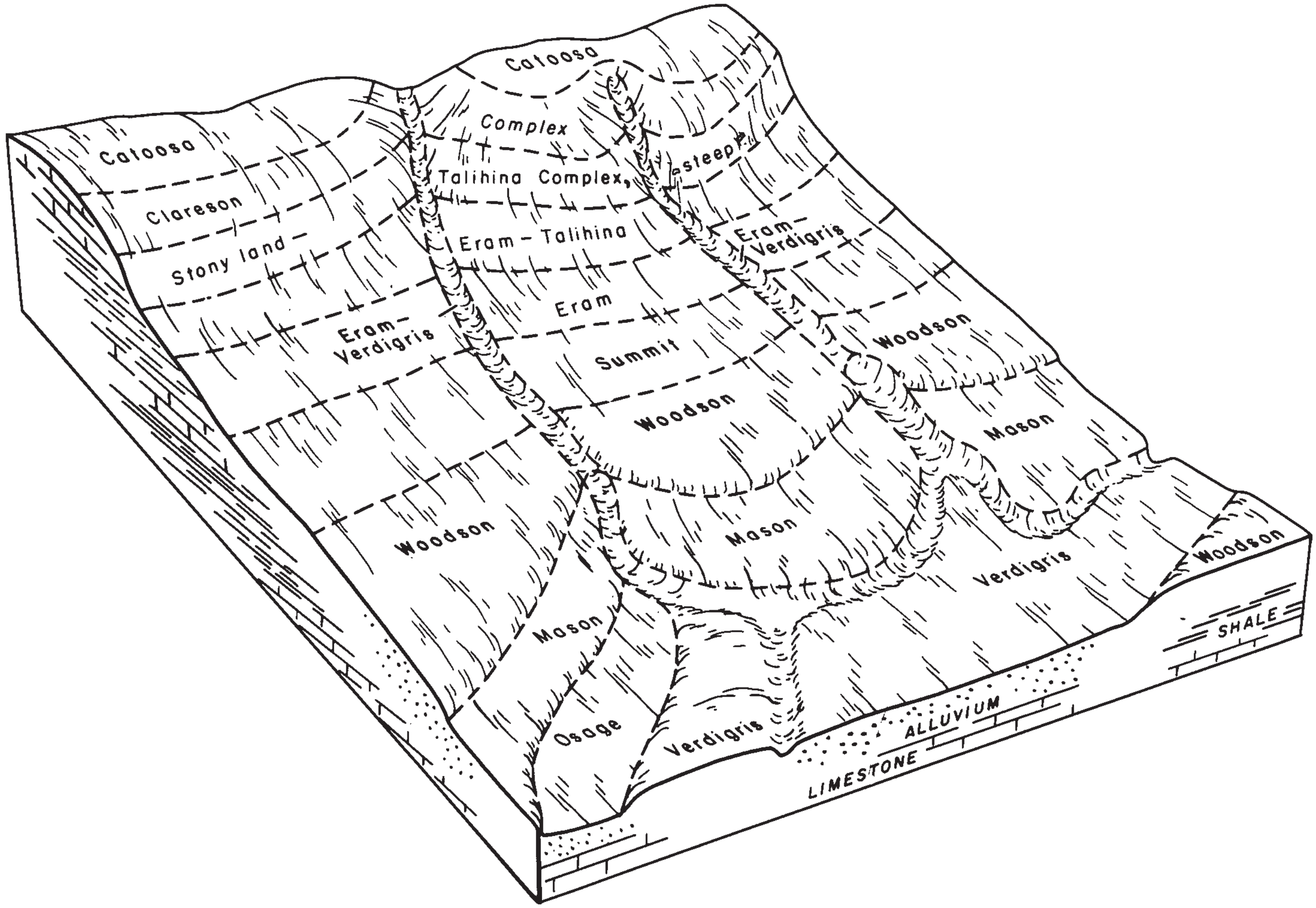

Figure 9.—**Pattern of soils and parent material on landscape.**

limestone-capped ridges are covered with beds of waterworn chert. The broad flats in the western part of the county lie below the hills to the west and also below the limestone-capped areas to the east of Garnett.

Climate

Climate influences both the physical and chemical processes of weathering and the biological forces at work in the soil material. If the supply of moisture is adequate, the soil-forming processes become more active as the soil temperature increases. They are limited by either inadequate or excess moisture.

The soils of Anderson County formed under a moist, humid to subhumid climate. Summers are hot, and winters are moderately cold. The average annual precipitation is 38 inches. The climate significantly affects soil formation.

Temperature affects the decomposition of organic matter, the growth of organisms, and the rate of chemical reaction in soils. The moderate amount of precipitation in Anderson County influences the growth of tall prairie grasses. The downward movement of water is one of the main factors in the transformation of the parent material into a soil that has distinct horizons. As water moves downward through the soil, calcium carbonate and salts are leached from the soil and carried downward and form a horizon of enrichment or are carried out of the profile. The translocation of clay is partly caused by the downward movement of water.

The amount of water that percolates downward through the soil depends not only on rainfall, temperature, humidity, and soil material, but also on relief, or lay of the land. For example, Lanton soils, on the flood plains along local streams, receive extra water and deposition from runoff and flooding and have excess subsoil moisture from a water table that fluctuates to within a few inches of the surface.

More information about precipitation and temperature in Anderson County is given in the section "Climate."

Plant and animal life

Two important functions of plants and animals in the soil-forming process are furnishing organic matter to the soil and mixing the soil by transporting soil and plant nutrients from one layer to another. Trunks, stems, leaves, and roots of plants are the chief sources of organic matter. This organic matter creates a more favorable environment for biological activity within the soil by providing food for micro-organisms. Animal life, consisting of bacteria, fungi, and other organisms, aids in weathering rock and in decomposing organic matter. These organisms influence the chemical, physical, and biological processes that strongly affect soil formation. Earthworms feed on organic matter and make channels, and in this way they thoroughly mix the soil in which they live. Burrowing animals affect soil formation mainly by mixing soil horizons. They also bring fresh material into the surface horizons.

Most soils in Anderson County formed under tall prairie grasses. These grasses add a great deal of organic matter to the soil, darken the surface layer, and strengthen soil structure. Welda soils formed under a cover of deciduous trees and a sparse stand of native grass. The surface layer of this soil is light brownish gray and very strongly acid.

Man has a great effect on the formation of soil. Management that controls erosion is changing the relief, or lay of the land, and the surface and subsurface drainage pattern. Erosion and earthmoving in some locations have removed the developed upper layer of the soil, the part containing the highest amount of organic matter and nutrients, and exposed the subsoil and substratum, both of which in many areas are deficient in plant nutrients. In this way, man has offset the normal processes of soil formation (7).

Relief

Relief, or lay of the land, influences soil formation through its effect on the amount of water retained, erosion, the direction that material in suspension or solution is moved, and plant cover. The amount of water that moves into the soil depends partly on topography. In the steeper areas the continued removal of surface soil and the loss of water through runoff slow down the processes of soil formation. The soils in nearly level and depressed areas receive the same amount of precipitation annually as the soils on steeper slopes, but they also receive the runoff and deposition from the sloping areas. Consequently, these soils generally show stronger evidence of soil formation than those in the sloping areas and are darkened to a greater depth. For example, Talihina soils, which are on the steeper upper side slopes, are shallow, and Summit soils, which are on the less steep lower side slopes, are deep.

Time

Time is required for soil formation. The length of time required depends mainly on the other factors of soil formation. Soils form slowly in a dry climate and under sparse vegetation and much more rapidly in a moist climate and under dense vegetation. Water moves through the soil profile and, gradually, soluble matter and fine particles are leached from the surface layer and deposited in the subsoil. The amount of leaching depends on how much time has elapsed and the amount of water that penetrates the soil. The continual loss of surface soil through erosion removes the material affected by soil-forming processes and exposes the material that is little altered by these processes. For example, Woodson soils in the nearly level and gently sloping areas have been exposed to soil-forming processes for thousands of years; consequently, they are deep and show strong evidence of soil formation. The younger Talihina soils in the steeper areas are shallow and show less evidence of soil formation.

Classification of the Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and 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. Because this system is under continual study readers interested in developments of the current system should search the latest literature available.

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 subdivisions of this property may be used in several different categories. In table 9, the soil series of Anderson County are placed in four categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

ORDER. Ten soils 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 identified by a word of three of four syllables ending in *sol* (Moll-i-sol).

SUBORDER. Each order is divided into suborders that are based on those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders are more narrowly defined than the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of a shallow water table; soil climate; the accumulation of clay, iron, or organic carbon in the upper part of the solum; cracking of soils caused by a decrease in soil moisture; and fine stratification. Each suborder is identified by a word of two syllables. The last syllable indicates the order. An example is *Aquoll* (*Aqu*, meaning water or wet, and *oll*, from Mollisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of uniformity in the kinds and sequence of soil horizons and features. The horizons used to make separations are those in which clay, carbonates, and other constituents have accumulated or have been removed and those that have pans that interfere with growth of roots, movement of water, or both. Among the features used are soil acidity, soil climate, soil composition, and soil color. Each great group is identified by a word of three or four syllables; a prefix is added to the name of the suborder. An example is Haplaquoll (*Hapl*, meaning simple horizons, *aqu* for wetness or water, and *oll*, from Mollisols).

SUBGROUP. Each great group is divided into subgroups, one representing the central (typic) segment of the group, and others called intergrades, which have properties of the group and also one or more properties of another great group, suborder, or order. Other subgroups may have soil

TABLE 9.—*Soil series classification*

Series	Family	Subgroup	Order
Catoosa	Fine-silty, mixed, thermic	Typic Argiudolls	Mollisols.
Clareson	Clayey-skeletal, mixed, thermic	Typic Argiudolls	Mollisols.
Collinsville	Loamy, siliceous, thermic	Lithic Hapludolls	Mollisols.
Dennis [1]	Fine, mixed, thermic	Aquic Paleudolls	Mollisols.
Eram	Fine, mixed, thermic	Aquic Argiudolls	Mollisols.
Kenoma	Fine, montmorillonitic, thermic	Vertic Argiudolls	Mollisols.
Lanton	Fine-silty, mixed, thermic	Cumulic Haplaquolls	Mollisols.
Leanna	Fine, mixed, thermic	Typic Argialbolls	Mollisols.
Lula	Fine-silty, mixed, thermic	Typic Argiudolls	Mollisols.
Mason	Fine-silty, mixed, thermic	Typic Argiudolls	Mollisols.
Mayes	Fine, montmorillonitic, thermic	Vertic Argiaquolls	Mollisols.
Okemah	Fine, mixed, thermic	Aquic Paleudolls	Mollisols.
Olpe	Clayey-skeletal, montmorillonitic,, thermic.	Typic Paleudolls	Mollisols.
Osage	Fine, montmorillonitic, thermic	Vertic Haplaquolls	Mollisols.
Summit	Fine, montmorillonitic, thermic	Vertic Argiudolls	Mollisols.
Talihina	Clayey, mixed, thermic, shallow	Aquic Hapludolls	Mollisols.
Verdigris	Fine-silty, mixed, thermic	Cumulic Hapludolls	Mollisols.
Welda	Fine, montmorillonitic, mesic	Typic Hapludalfs	Alfisols.
Woodson	Fine, mixed, thermic	Abruptic Argiaquolls	Mollisols.

[1] The Dennis soils are taxadjuncts to the Dennis series. They are not so deep over shale as is typical for the series. This difference, however, does not alter use or management.

properties unlike those of any other group, suborder, or order. Each subgroup is identified by the name of the great group preceded by one or more adjectives. An example is Typic Haplaquolls (a typical Haplaquoll).

FAMILY. Soil families are established 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, soil temperature, permeability, soil depth, and consistence. A family name is the subgroup name preceded by a series of adjectives. The adjectives are the class names for texture and mineralogy, for example, that are used as family differentiae (see table 9). An example is the fine-silty, mixed, thermic family of Cumulic Haplaquolls.

Two soil orders are recognized in Anderson County: Mollisols and Alfisols.

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.

Alfisols are mineral soils that have horizons of clay accumulation. Unlike Mollisols, they lack the dark colored horizon dominated by bivalent cations. The base saturation of the lower horizons, however, is moderate to high.

Environmental Factors Affecting Soil Use

The first settlement in Anderson County, in 1854, was along Pottawatomie Creek near Greeley. Other settlements along the South Fork of Pottawatomie Creek established timber claims.

Anderson County was organized in 1855 (*10*). Shannon, the first county seat, was located about 1 mile south of the present site of Garnett. Garnett was founded in 1857. A vote by the county residents moved the county seat to Garnett. Greeley, in the northeast corner of the county, is the oldest town. A number of other towns were established. Some were established along the railroads built in the early 1870's. At one time three railroads junctioned at Garnett—the Atchison Topeka and Santa Fe, the Missouri Pacific, and the Kansas, Nebraska, and Dakota. The Kansas, Nebraska, and Dakota has since been abandoned. The Missouri-Kansas-Texas Railroad crosses the southeast corner of the county near Kincaid and Selma.

In 1887, according to records in the county clerk's office, the population of the county was 13,192. By 1933, it had decreased to 12,782. By 1971, the population had decreased to a low of 8,483, of which about 60 percent was rural.

Climate [6]

The climate of Anderson County is typically continental, as would be expected from the location of the county in the interior of a large land mass in the middle latitudes. This climate is 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 Rockies to the west and the Appalachian Mountains to the east.

Anderson County lies on the border between humid and subhumid climates, according to Thornthwaite (*14*). In regions that border humid and subhumid climates, precipitation exceeds evapotranspiration and the surplus becomes runoff and ground-water recharge. A moist subsoil is evident. Anderson 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 east-central and southeastern Kansas, making it the wettest part of the State (*5*).

Climatological records were kept at the weather station in Garnett from 1906 to 1914. Precipitation data have been recorded since 1918, and temperature data since 1950.

Precipitation totals for the year in Anderson County average 42 inches. Almost 70 percent of this annual total

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

falls in the April through September growing season. Measurable amounts of precipitation occur on an average of 89 days per year. In both May and June, rain falls on 11 days, which is the highest average number of rainy days per month. Precipitation amounts on a majority of the rainy days are very low. On more than 50 percent of the rainy days, the amount is less than 0.25 inch. On only about 13 percent of the days, it is more than 1 inch. The 12 days with the greatest precipitation totals contribute 50 percent to the annual total. The rest is spread over 77 days. These statistics show that a dry spell of 2 or 3 weeks between a period of significant showers is common. These dry spells can produce stress conditions in cultivated crops, native pastures, and meadows.

Most of the annual precipitation total comes from convective shower activity. Thunderstorms move across the county during all hours of the day. Rain is only slightly less frequent during the day than it is at night. The large number of rainy days each year and the fact that about 50 percent of them occur during the normal outdoor work period from 6 a.m. to 6 p.m. can be a deterrent to fieldwork.

Snowfall is light in eastern Kansas. Anderson County averages about 18 inches of snow per year. Snowfall is most frequent in January and February, but is also frequent in March and December. The snow cover from a particular storm seldom remains on the ground over 1 or 2 days. On the average, fewer 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 are generally from near 0°F. to above 100°. These extremes are of short duration and do not have a great importance to the overall climate. The average temperature shown in table 10 illustrates the somewhat short transition seasons of spring and fall that occur in Kansas. In winter, from December through February, the temperature averages 34°. In summer, warm temperatures necessary for plant growth continue from late in April to early in October. The average growing season, or the period between freeze in spring and fall, is 195 days. The probabilities of the first freeze in spring and the last in fall are given in table 11 (*4*).

The prevailing wind direction is usually southerly, but is northerly in January and February. Winds in east-central Kansas are generally lighter than those in the western part of the State. The greatest wind velocities occur in spring.

Tornadoes and severe windstorms occur occasionally in Anderson County. This area of Kansas is near the region of maximum tornado occurrence, which is in east-central Oklahoma. These storms are generally local in extent and of short duration so that the risk of damage is small. Hail occurs during the warmest part of the year, but is infrequent and of local extent. Anderson County is in the part of Kansas with minimal hail risk.

Droughts are not uncommon in east-central Kansas. For the period 1931 to 1968, droughts, classified as mild, moderate, and severe, or extreme, were recorded during 163 months (*8*). Severe or extreme drought periods occurred in 69 months, or 15 percent of the total period. This figure is high because the period for the study was selected to compare the droughts of the 30's and 50's. A longer period of study would reduce this percentage. The period from 1952 to 1957 had severe and extreme ratings for 36 months, making it the worst drought period on record.

Water Supply

Dug or drilled wells supply only a limited amount of water for domestic use on farms. Underground sources are

TABLE 10.—*Temperature and precipitation data*

[Data from records kept at Garnett, Kans.]

Month	Temperature				Precipitation			
	Average daily maximum [1]	Average daily minimum [1]	Two years in 10 will have about 4 days with— Maximum temperature equal to or higher than—[2]	Two years in 10 will have about 4 days with— Minimum temperature equal to or lower than—[2]	Average total [3]	One year in 10 will have— Totals less than—	One year in 10 will have— Totals greater than—	Average snowfall [3]
	°F	°F	°F	°F	Inches	Inches	Inches	Inches
January	41.3	20.2	59	0	1.35	0.19	2.73	5.3
February	47.3	25.0	64	9	1.34	.21	2.28	3.4
March	56.3	32.3	77	15	2.81	.83	4.97	3.6
April	69.7	44.8	84	30	4.26	2.11	8.67	.2
May	78.5	54.5	90	42	4.83	1.86	8.98	0
June	86.3	63.5	96	54	5.75	1.04	10.07	0
July	91.1	67.2	101	58	4.90	.65	10.32	0
August	90.4	67.8	100	56	4.38	.72	8.08	0
September	82.2	58.0	95	46	5.26	.71	10.94	0
October	71.5	47.5	85	33	3.46	.28	8.54	0
November	56.1	34.6	72	20	1.72	.16	6.87	.7
December	44.2	25.2	62	8	1.63	.33	3.12	4.5
Year	67.9	44.9	[4] 102	[5] −4	41.69	27.38	51.03	17.7

[1] 1951–73.
[2] 1953–73.
[3] 1941–70.
[4] Average annual highest temperature, 1951–73.
[5] Average annual lowest temperature, 1951–73.

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

Probability	Dates for given probability and temperature				
	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower
Spring:					
1 year in 10 later than	March 23	March 31	April 7	April 15	April 28
2 years in 10 later than	March 17	March 25	April 2	April 10	April 23
5 years in 10 later than	March 5	March 15	March 24	March 31	April 13
Fall:					
1 year in 10 earlier than	November 17	November 8	October 28	October 17	October 9
2 years in 10 earlier than	November 24	November 13	November 1	October 22	October 13
5 years in 10 earlier than	December 5	November 24	November 10	October 31	October 23

limited, except in the stream valleys. The main source of water for livestock is surface water impounded by dams and local streams. There are many spring-fed streams throughout the county. In the northern and western parts of the county, many rural residents are now served by rural water districts that pump water from reservoirs and from wells.

Farming

When Anderson County was founded, tall grasses covered the area. Hardwood trees covered many of the stream valleys. The Indians had grown corn in small patches mostly along streams. In the early 1850's, the first settlers moved into the county. They raised corn, spring wheat, oats, and vegetables on small farms. They built stone fences in many places, a number of which are evident today.

Cultivated crops were grown continuously on most of the cultivated land. Legumes were not grown extensively, only a small amount of fertilizer was used, and little effort was made to improve the soil or to protect it against erosion. Pastures were generally overgrazed. Because of this kind of farming, many of the soils were eroded and their supply of plant nutrients was depleted.

The use of the soils has changed in the past 30 years, partly because of necessity and partly by choice. In 1944, the farmers and landowners organized the Anderson County Soil Conservation District. Many areas have been reseeded to tame grasses to control erosion. About 1,500 miles of terraces have been constructed to control erosion and runoff. Over 1,000 structures have been constructed to provide reservoirs for water. Lime has been applied on most of the cultivated land to reduce acidity. In recent years large amounts of commercial fertilizer have been used to increase production.

In 1969, according to the Federal census, there were 921 farms in the county and the average farm was more than 402 acres in size. Almost half of the farmers own all the land they farm. Most farmers own enough equipment for tilling, planting, and harvesting. Much of the lime and fertilizer is applied by custom or commercial equipment. Many farmers have grain storage facilities on their farms.

In 1972, according to the Kansas State Board of Agriculture, soybeans were planted on 22,000 acres, sorghum on 22,000 acres, corn on 26,000 acres, and wheat on 18,000 acres. Harvested for hay was 12,100 acres of alfalfa and 23,600 acres of native hay. Crop failures or near failures occur about once every 10 years. They occur in years when rainfall is low between June and September.

About 31 percent of the acreage of Anderson County is in native grass and is used for range. Most of this land is nonarable or marginal for use as cropland. Native grass for hay is important for feeding locally, and some is shipped outside the area.

In 1968 about 23,000 acres of Anderson County was wooded; 20,800 acres was classified as commercial and 2,200 acres as noncommercial (*9*). The natural woodlands occur chiefly as narrow belts along the valleys of streams and on the sides of drainageways. The largest areas of hardwoods are along the Pottawatomie Creek and Sugar Creek drainageways.

The woodlands can be grouped into two broad forest-type groups. The Oak-Hickory group occurs on the sloping uplands, and the Elm-Ash-Cottonwood group occurs on bottom land. Many of the elms have been destroyed in recent years by the spreading of Dutch elm disease. Black walnut is the most valuable species grown in the county. Disease, lightning, and poor trunk growth limit the production of quality sawtimber on soils of the uplands.

Livestock and livestock products have always been a major source of income in Anderson County. In 1973, according to the Kansas State Board of Agriculture, there were 3,200 milk cows, 51,000 other cattle, 30,000 hogs, 1,200 sheep and lambs, and 40,000 chickens. Many farmers are using the most modern techniques in the production of hogs, including the latest pollution abatement systems. Dairying is important in the county; there were 225 dairy farms reported in 1972. A number of cattlemen raise registered breeding stock. Raising new breeds and crossing with the exotic breeds have increased at a rapid rate.

Industry and Natural Resources

Although farming is the major enterprise in Anderson County, there are a number of manufacturing industries in the county. These industries are manufacturing church furniture, clothing, cheese, sheet metal, truss rafters, recreational vehicle equipment, and other products. Most are in Garnett. An industrial welding firm is near Greeley. The buying, selling, and distributing of farm products are important enterprises.

Limestone was quarried extensively for railroad ballast north of Garnett in the early 1900's. At present limestone is crushed for road surfacing, for use in concrete, and for agricultural lime. Gravel used locally for road surfacing is obtained in limited amounts in the southern part of the county.

Oil and gas were formerly obtained from shallow wells in parts of the county. The largest boom was in the early 1920's when fields near Colony and Welda were brought into production. Production now is very limited. Natural gas storage, near Welda and Colony, is important in the county. The natural gas is piped in and stored underground, in natural reservoirs, until needed. A number of transporting pipelines cross the county.

Transportation and Markets

Except for a few areas, there are improved roads throughout the county. Most are graveled, and a few are hard surfaced. Two Federal highways and three State highways serve the county. U.S. Highway 59 passes through Garnett. U.S. Highway 169 joins U.S. Highway 59 near Garnett. Motor truck lines use all highways and hard-surfaced roads.

The Atchison, Topeka, and Santa Fe Railroad passes through Garnett, Welda, and Colony. The Missouri Pacific passes through Greeley, Garnett, Mont Ida, and Westphalia. A line of the Missouri-Kansas-Texas passes through Kincaid and Selma. Regular bus service is available to Garnett from the north and the south.

Markets for all farm products are readily available. Corn, wheat, and grain sorghum that are not fed to animals on the farm are sold to local elevators. Most of the soybeans are sold. Garnett, Greeley, Colony, Harris, Westphalia, and Kincaid have facilities for handling and storing grain, which is shipped by railroad and truck. Part of the hay is shipped by truck to Missouri, Arkansas, and Oklahoma. Most of the livestock is marketed outside the county. Much of the milk is sold to the local cheese plant. Poultry and eggs are marketed locally and outside the county.

Recreational Facilities

This county has many groups and civic organizations that work to improve recreational facilities. Facilities for boating, fishing, swimming, hunting, and picnicking are available. Baseball and softball diamonds are in several communities. In Garnett, a bowling alley, a roller rink, a theater, and a youth center are available. Also in Garnett are a park and Lake Garnett in the northern part of the city and another park and Crystal Lake in the southern part. In the north park are shelter houses, picnic facilities, campgrounds, a golf course, tennis courts, a swimming pool, a miniature golf course, an outdoor basketball practice area, a kiddy land area, lighted baseball and softball diamonds, a football field and stadium, a rifle range, nature trails, a community building, and fairgrounds. The south park has picnic facilities and play areas.

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Glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single mapping unit.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	More than 9

Bedding. Plowing, grading, or otherwise elevating the surface of a level field into a series of broad beds, in order to leave shallow surface drains between the beds.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Calcareous soil. A soil containing enough calcium carbonate (commonly with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid. A soil having measurable amounts of calcium carbonate or magnesium carbonate.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coat, clay skin.

Complex, soil. A mapping unit of two or more kinds of soil occurring in such an intricate pattern that they cannot be shown separately on a soil map at the selected scale of mapping and publication.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds 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; little affected by moistening.

Contour stripcropping (or contour farming). Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Cover crop. A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically for long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients, as for example in "hillpeats" and "climatic moors."

Erosion. The wearing away of the land surface by running water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes a bare surface.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fine textured (heavy textured) soil. Sandy clay, silty clay, and clay.

First bottom. The normal flood plain of a stream, subject to frequent or occasional flooding.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Glaciofluvial deposits (geology). Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur as kames, eskers, deltas, and outwash plains.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.5 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material from 15 to 50 percent, by volume, rounded or angular rock fragments, not prominently flattened, up to 3 inches (7.5 centimeters) in diameter.

Green manure (agronomy). A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. The major horizons of mineral soil are as follows:

O horizon.—An organic layer, fresh and decaying plant residue, at the surface of a mineral soil.

A horizon.—The mineral horizon, formed or forming at or near the surface, in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon most of which was originally part of a B horizon.

A2 horizon.—A mineral horizon, mainly a residual concentration of sand and silt high in content of resistant minerals as a result of the loss of silicate clay, iron, aluminum, or a combination of these.

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 a combination of these; (2) by prismatic or blocky structure; (3) by redder or browner colors than those in the A horizon; or (4) by a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that from which the solum is presumed to have formed. If the material is known to differ from that in the solum the Roman numeral II precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by wind.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Microrelief. Small-scale, local differences in topography, including mounds, swales, or pits.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

Moderately fine textured (moderately heavy textured) soil. Clay loam, sandy clay loam, and silty clay loam.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded 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 of the diameter along the greatest dimension. Fine indicates less than 5 millimeters (about 0.2 inch); medium, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and coarse, more than 15 millimeters (about 0.6 inch).

Parent material. The great variety of unconsolidated organic and mineral material in which soil forms. Consolidated bedrock is not yet parent material by this concept.

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Percolation. The downward movement of water through the soil.

Permeability. The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil. Terms describing permeability are very slow (less than 0.06 inch), slow (0.06 to 0.20 inch), moderately slow (0.2 to 0.6 inch), moderate (0.6 to 2.0 inches), moderately rapid (2.0 to 6.0 inches), rapid (6.0 to 20 inches), and very rapid (more than 20 inches).

Phase, soil. A subdivision of a soil series or other unit in the soil classification system based on differences in the soil that affect its management. A soil series, for example, may be divided into phases on the bases of differences in slope, stoniness, thickness, or some other characteristic that affects management. These differences are too small to justify separate series.

Piping. Moving water forms subsurface tunnels or pipelike cavities in the soil.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from a semisolid to a plastic state.

Poorly graded. Refers to soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Profile, soil. A vertical section of the soil extending through all its horizons and 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 described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH		pH
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Runoff. The precipitation discharged in stream channels from a drainage area. The water that flows off the land surface without sinking in is called surface runoff; that which enters the ground before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Shear strength. The resistance to sliding within the soil mass.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Soil. A natural, three-dimensional body at the earth's surface that is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows: very coarse sand (2.0 millimeters to 1.0 millimeter); coarse sand (1.0 to 0.5 millimeter); medium sand (0.5 to 0.25 millimeter); fine sand (0.2 to 0.10 millimeter); very fine sand (0.10 to 0.05 millimeter); silt (0.005 to 0.002 millimeter); and clay (less than 0.002 millimeter).

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in mature soil consists of 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 characteristics of the soil are largely confined to the solum.

Stripcropping. Growing crops in a systematic arrangement of strips or bands which provide vegetative barriers to wind and water erosion.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates that are separated from adjoining aggregates. 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 without any regular cleavage, as in many hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. The part of the soil below the solum.

Subsurface layer. Technically, the A2 horizon. Generally refers to a leached horizon lighter in color and lower in content of organic matter than the overlying surface layer.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it can soak into the soil or flow slowly to a prepared outlet without harm. A terrace in a field is generally built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea. A stream terrace is frequently called a second bottom, in contrast with a flood plain, and is seldom subject to overflow. A marine terrace, generally wide, was deposited by the sea.

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, silt loam, 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, especially the soil structure, as related to the growth of plants. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Water table. The upper limit of the soil or underlying rock material that is wholly saturated with water.

Water table, apparent. A thick zone of free water in the soil. An apparent water table is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil.

Water table, artesian. A water table under hydrostatic head, generally beneath an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole.

Water table, perched. A water table standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

Well graded. Refers to a soil or soil material consisting of particles well distributed over a wide range in size or diameter. Such a soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

GUIDE TO MAPPING UNITS

Map symbol	Mapping unit	Page	Capability unit	Range site		Woodland suitability group
			Symbol	Name	Page	Number
Cb	Catoosa silt loam, 0 to 3 percent slopes	6	IIe-2	Loamy Upland	27	--
Cc	Clareson complex, 1 to 4 percent slopes	8	VIs-1	Shallow Flats	28	--
Cd	Collinsville complex, 2 to 15 percent slopes	8	VIe-2	Shallow Sandstone	28	--
Db	Dennis silt loam, 1 to 4 percent slopes	9	IIe-1	Loamy Upland	27	--
De	Dennis silty clay loam, 1 to 4 percent slopes, eroded	9	IIIe-3	Clay Upland	27	--
Eb	Eram silty clay loam, 1 to 4 percent slopes	9	IIIe-5	Clay Upland	27	--
Ec	Eram silty clay loam, 4 to 7 percent slopes	10	IVe-2	Clay Upland	27	--
Ed	Eram soils, 1 to 4 percent slopes, eroded	10	IVe-3	Clay Upland	27	--
Eh	Eram soils, 4 to 7 percent slopes, eroded	10	VIe-1	Clay Upland	27	--
Ek	Eram-Clareson complex, 1 to 15 percent slopes	10	VIe-2	-----------------	--	--
	Eram soils	--	------	Clay Upland	27	--
	Clareson soils	--	------	Shallow Flats	28	--
Eo	Eram-Gullied land complex, 3 to 7 percent slopes	10	VIe-1	Clay Upland	27	--
Ep	Eram-Talihina silty clay loams, 5 to 20 percent slopes	11	VIe-2	Clay Upland	27	--
Ev	Eram-Verdigris complex, 0 to 8 percent slopes	11	IVe-4	-----------------	--	--
	Eram soils	--	------	Clay Upland	27	--
	Verdigris soils	--	------	Loamy Lowland	27	3o
Kb	Kenoma silt loam, 1 to 4 percent slopes	12	IIIe-1	Clay Upland	27	--
Kd	Kenoma soils, 1 to 4 percent slopes, eroded	12	IVe-4	Clay Upland	27	--
Kh	Kenoma-Olpe complex, 2 to 7 percent slopes	12	IVe-1	-----------------	--	--
	Kenoma soils	--	------	Clay Upland	27	--
	Olpe soils	--	------	Loamy Upland	27	--
La	Lanton silty clay loam	13	IIw-1	Loamy Lowland	27	3w
Le	Leanna silt loam	13	IIw-2	Clay Lowland	26	3w
Lh	Lula silt loam, 0 to 3 percent slopes	14	IIe-1	Loamy Upland	27	--
Me	Mason silt loam	15	I-1	Loamy Lowland	27	3o
Mf	Mayes silty clay loam	15	IIw-3	Clay Lowland	26	--
Ok	Okemah silt loam, 0 to 2 percent slopes	16	I-1	Loamy Upland	27	--
Op	Olpe gravelly silt loam, 3 to 15 percent slopes	17	VIe-2	Loamy Upland	27	--
Os	Osage silty clay loam	17	IIw-2	Clay Lowland	26	4w
Se	Stony land-Talihina complex, steep	18	VIIe-1	-----------------	--	--
	Stony land	--	------	Breaks	26	--
	Talihina soils	--	------	Clay Upland	27	--
Sf	Summit silty clay loam, 1 to 4 percent slopes	18	IIe-1	Loamy Upland	27	--
Sh	Summit silty clay loam, 4 to 7 percent slopes	19	IIIe-2	Loamy Upland	27	--
Sk	Summit soils, 1 to 4 percent slopes, eroded	19	IIIe-3	Clay Upland	27	--
So	Summit-Eram complex, 4 to 7 percent slopes, eroded	19	IVe-3	Clay Upland	27	--
Vf	Verdigris silt loam, occasionally flooded	20	IIw-1	Loamy Lowland	27	3o
Vx	Verdigris soils, frequently flooded	20	Vw-1	Loamy Lowland	27	3o
Wb	Welda silt loam, 0 to 2 percent slopes	21	I-2	Loamy Upland	27	4o
Wc	Welda silt loam, 2 to 6 percent slopes	21	IIIe-4	Loamy Upland	27	4o
Wd	Woodson silt loam, 0 to 1 percent slopes	21	IIs-1	Clay Upland	27	--
Wf	Woodson silt loam, 1 to 3 percent slopes	21	IIIe-1	Clay Upland	27	--
Wh	Woodson soils, 1 to 3 percent slopes, eroded	22	IVe-4	Clay Upland	27	--

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