

SOIL SURVEY OF

Chautauqua County, Kansas



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

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

Major fieldwork for this survey was completed in the period 1963-70. Soil names and descriptions were approved in 1971. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1970. This survey was made cooperatively by the Soil Conservation Service and the Kansas Agricultural Experiment Station. It is part of the technical assistance furnished to the Chautauqua County Soil Conservation District.

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

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

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

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

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the 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.

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

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

Ranchers and others can find, under "Management of Soils for 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 "Management of Soils for Recreational Purposes."

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

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

Newcomers to Chautauqua 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 section "Additional Facts About the County."

Cover; Clime-Sogn complex in native grass pasture. Ranch headquarters is on gently sloping Longford silty clay loam. A watershed lake is behind the headquarters.

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SOIL SURVEY OF CHAUTAUQUA COUNTY, KANSAS

BY ELBERT L. BELL AND HAROLD T. ROWLAND,
SOIL CONSERVATION SERVICE

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

CHAUTAUQUA COUNTY is in the southeastern part of Kansas (fig. 1). It has a land area of 647 square miles, or 414,080 acres. Sedan is the county seat.

In 1970 the Federal census reported a total population of 4,642. Farming and the oilfield industry are the two major sources of income.

About 91 percent of the total acreage is in farms. Ranching is the principal farm enterprise. The livestock is mainly beef cattle. Most cultivated crops are grown to support the livestock production program, but some cash crops are grown on the alluvial soils in the larger valleys.

In the western half of the county, part of the Kansas Flint Hills, rolling limestone hills and broad ridges separate the narrow valleys. In the eastern half, part of the Chautauqua Hills, rolling sandstone hills and narrow ridges separate the valleys. The hills are an intermingled pattern of prairie and woods. The landscape is scenic in many areas.

Farming and ranching have been the principal uses of the land since the county was originally settled. Commercial woodland and the development of wildlife and recreational resources can be considered in planning future additional land use.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Chautauqua County, where they are located, and how they can be used. The soil scientists

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

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

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, 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. Mason and Niotaze, 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 soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Martin silty clay loam, 1 to 4 percent slopes, is one of several phases within the Martin series.

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

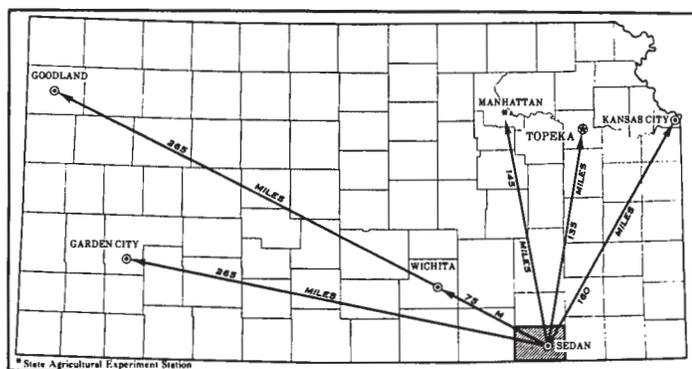


Figure 1.—Location of Chautauqua County in Kansas.

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. A soil complex is one such kind of mapping unit shown on the soil map of the county.

A soil complex consists of areas of two or more soils, so intermingled 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. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Clime-Sogn complex is an example.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are 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.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland and rangeland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, 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 present 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 Chautauqua County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

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

in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The six soil associations in Chautauqua County are described on the following pages.

1. Clime-Martin-Sogn association

Deep to shallow, moderately well drained and well drained, nearly level to steep soils formed in material weathered from shale and limestone; on uplands

This soil association is a sharply dissected landscape of shale interbedded with limestone. Outcrops of these layers of rock form prominent ledges. Broad ridges separate the narrow valleys of the drainageways.

This association makes up about 41 percent of the county. It is 30 percent Clime soils (fig. 2), 29 percent Martin soils, 27 percent Sogn soils, and 14 percent less extensive soils.

Clime soils are strongly sloping to steep, moderately deep, and moderately well drained. They are on hillsides. They formed in material weathered from shale. The surface layer is very dark gray, calcareous silty clay about 10 inches thick. The subsoil is dark grayish-brown, calcareous silty clay about 18 inches thick. Shale is at a depth of 28 inches.

Martin soils are nearly level to gently sloping and sloping, deep, and moderately well drained. The nearly level to gently sloping soils are on upland ridges, and the sloping soils are at the base of strongly sloping to steep hillsides. The surface layer is very dark brown silty clay loam about 12 inches thick. The subsoil, about 42 inches thick, is very dark grayish brown in the upper part and dark yellowish brown in the lower part. Clay shale is at a depth of 54 inches.

Sogn soils are gently sloping, shallow, and somewhat excessively drained. They are on ridgetops and hillsides. They formed in material weathered from limestone. The surface layer is very dark brown silty clay loam about 10 inches thick. It is underlain by limestone bedrock.

Less extensive in this association are Clareson, Longford, Kenoma, Mason, Ivan, and Lula soils. Clareson soils, mapped with Sogn soils, are on convex ridges. Longford, Kenoma, and Lula soils are on the broad ridgetops. Mason and Ivan soils are on stream terraces and flood plains.

This association is considered part of the Flint Hills, a large tract of tall prairie grasses in Kansas and northern Oklahoma. Ranching is the typical agricultural enterprise. Only the broader upland ridges and the low slopes are cultivated. Wheat and alfalfa are grown as livestock feed. Suitable sites for stock water ponds occur along the many drainageways. Weed and brush control and other effective management are needed to keep the native grasses in good condition.

2. Mason-Ivan association

Deep, well-drained, nearly level and gently sloping soils formed in alluvium; on terraces and flood plains

This soil association is on the alluvial plain along the Caney River. It makes up about 3 percent of the county. It is 58 percent Mason soils, 36 percent Ivan soils, and 6 percent less extensive soils.

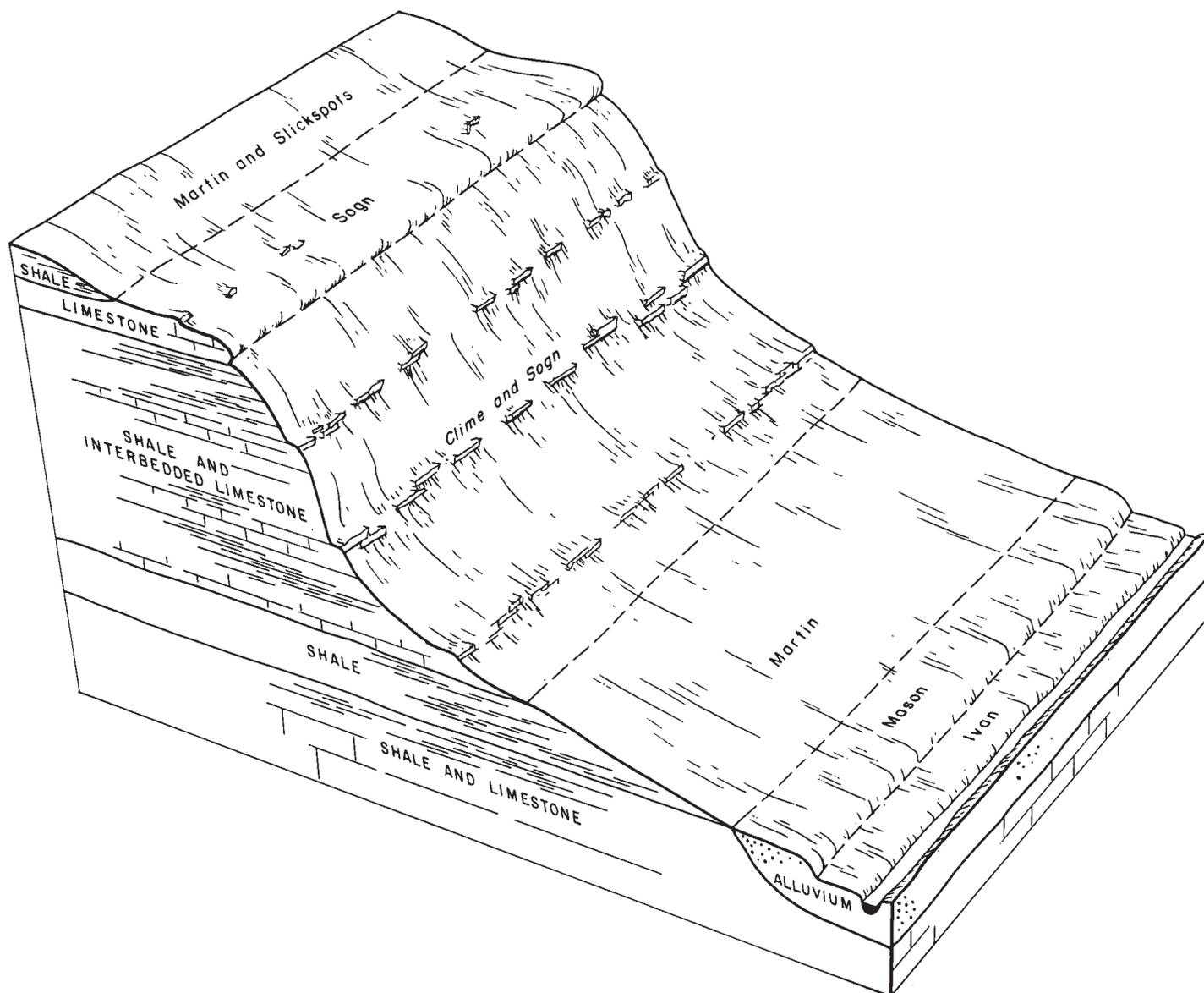


Figure 2.—Pattern of soils in Clime-Martin-Sogn association.

Mason soils are nearly level. They are on terraces along major streams (see figure 2) and are subject to occasional flooding. They have a surface layer of very dark grayish-brown silt loam about 12 inches thick. The subsoil is dark-brown silty clay loam about 46 inches thick. The underlying material is dark-brown silty clay loam.

Ivan soils are nearly level to gently sloping. They are on flood plains and are subject to annual flooding. The surface layer is very dark grayish-brown silt loam about 25 inches thick. The next layer is dark-brown silty clay loam about 30 inches thick. The underlying material is dark-brown loam.

Osage soils, which are less extensive in this association, are in slight depressions adjoining the sloping upland soils.

Most of this association is cultivated. Alfalfa and wheat are the main crops.

3. Niotaze-Stephenville-Darnell association

Moderately deep and shallow, somewhat poorly drained, well drained, and excessively drained, gently sloping to strongly sloping soils formed in material weathered from shale and sandstone; on uplands

This soil association consists of rolling, wooded hills capped with thick layers of sandstone (fig. 3). It makes up about 23 percent of the county. It is 33 percent Niotaze soils, 31 percent Stephenville soils, 20 percent Darnell soils, and 16 percent less extensive soils.

Niotaze soils are strongly sloping, moderately deep, and somewhat poorly drained (fig. 4). They are on hill-

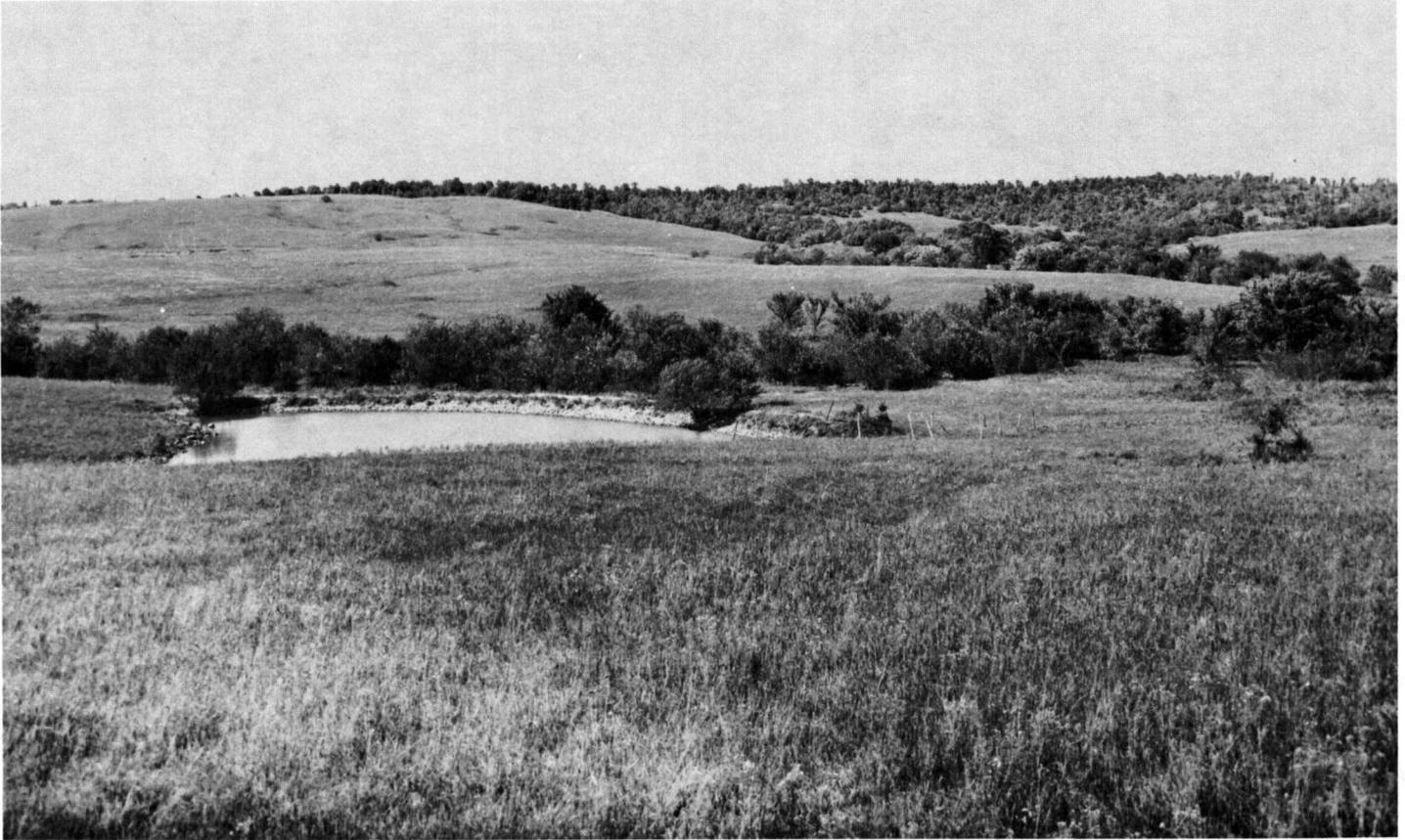


Figure 3.—Grass-covered Steedman-Dennis-Eram association in foreground and wooded Niotaze-Stephenville-Darnell association in background. The wooded area near the pond is Verdigris silt loam.

sides. They formed in material weathered from shale and interbedded sandstone. Niotaze soils, which are mapped only with Darnell soils, have a surface layer of very dark grayish-brown cobbly fine sandy loam about 3 inches thick. The subsurface layer is about 7 inches of brown cobbly fine sandy loam. The subsoil, about 18 inches thick, is reddish-brown and dark-brown silty clay and silty clay loam. Shale is at a depth of 28 inches.

Stephenville soils are gently sloping to sloping, moderately deep, well-drained soils on ridgetops. They formed in material weathered from sandstone. They have a surface layer of very dark grayish-brown fine sandy loam, about 4 inches thick, that is underlain by an 8-inch layer of brown fine sandy loam. The subsoil, about 22 inches thick, is yellowish-red and strong-brown sandy clay loam. Sandstone is at a depth of 34 inches.

Darnell soils, which are mapped only with Niotaze and Stephenville soils, are shallow, gently sloping to sloping and strongly sloping, and excessively drained. They formed in material weathered from sandstone. The gently sloping to sloping soils are on ridgetops, and the strongly sloping soils are on hillsides. The surface layer is very dark grayish-brown fine sandy loam about 5 inches thick. The subsoil is 9 inches of brown

fine sandy loam. Sandstone is at a depth of about 14 inches.

Less extensive in this association are Bates, Dennis, Eram, Mason, Verdigris, and Steedman soils. Bates and Eram soils are near the summit on the sides and tops of ridges. Steedman soils are on hillsides above Dennis soils. Mason soils are on terraces, and Verdigris soils are on flood plains.

This association is the wooded part of the Chautauqua Hills physiographic province. The vegetation is oak-hickory and an understory of grasses. All the acreage is used for grazing. More effective methods of controlling growth of trees and sprouts are needed if the area is to be used for grazing.

4. Osage-Mason association

Deep, poorly drained and well drained, nearly level soils formed in alluvium; on flood plains and terraces

This association is on the alluvial plain along the Little Caney River. It is commonly referred to as the Niotaze Bottoms. It makes up 2 percent of the county. It is 64 percent Osage soils, 9 percent Mason soils, and 27 percent less extensive soils.

Osage soils are poorly drained. They are on flood plains in slackwater areas next to the uplands. They typically

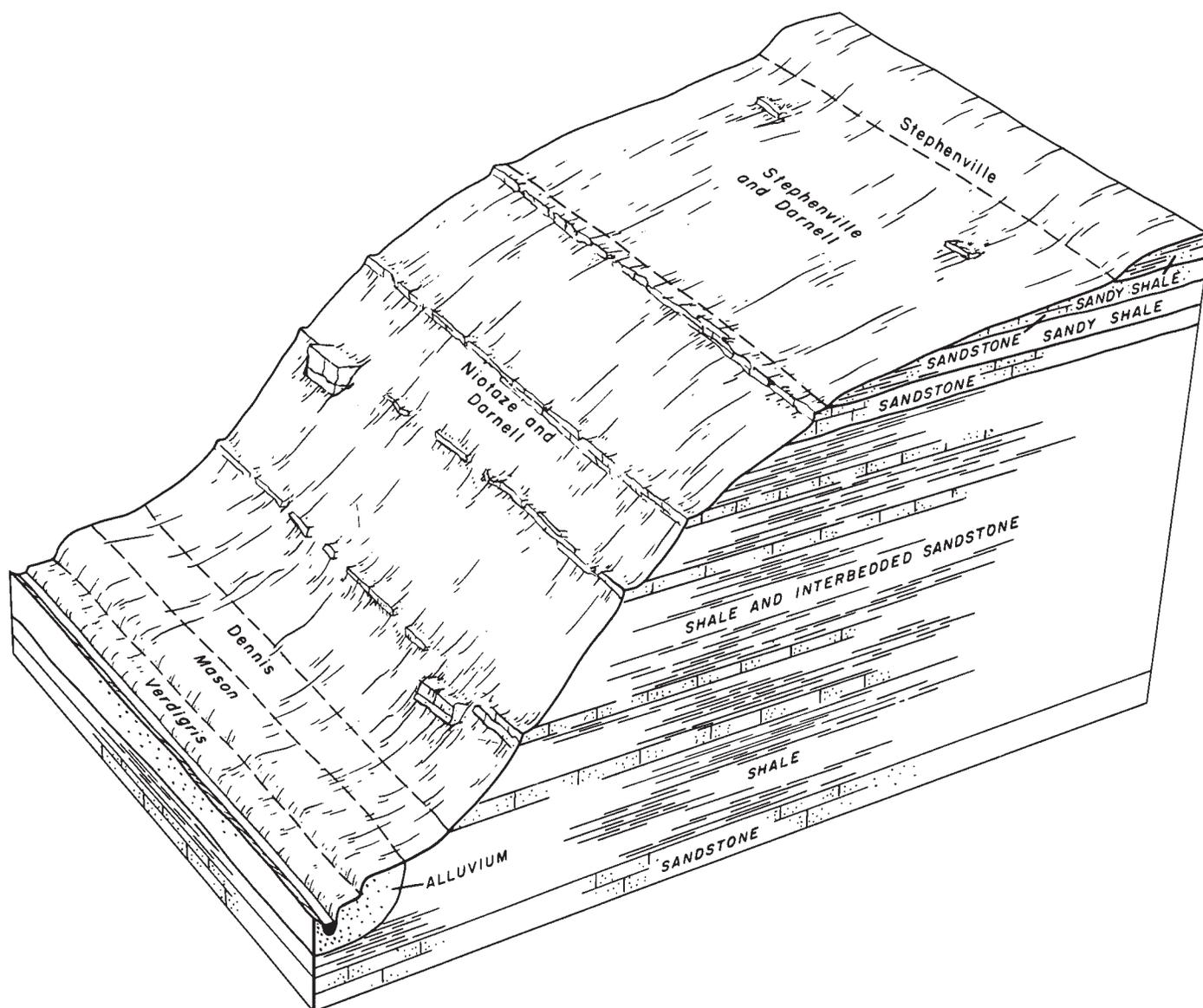


Figure 4.—Pattern of soils in Niotaze-Stephenville-Darnell association.

have a surface layer of very dark gray silty clay about 20 inches thick. The next layer is very dark gray heavy silty clay about 28 inches thick. The underlying material is very dark gray silty clay.

Mason soils are well drained. They are on natural levees adjoining the channel of the stream. The surface layer is very dark grayish-brown silt loam and silty clay loam about 12 inches thick. The subsoil is dark-brown silty clay loam about 46 inches thick. The underlying material is dark-brown light silty clay loam.

Less extensive in this association are Osage silty clay loams and Kenoma and Verdigris soils. The Osage silty clay loams are on low terraces at the upstream margin of this association. Kenoma soils are in slightly

higher areas within areas of Osage soils and along the upland margin of the association. Verdigris soils are on low flood plains along bends in the river.

All but the wet areas of Osage soils and the frequently flooded areas is cultivated. Wheat, soybeans, and grain sorghum are the main crops. Flooding has made crop production hazardous. Surface drainage is needed on the Osage soils (fig. 5).

5. *Steedman-Dennis-Eram association*

Moderately deep and deep, moderately well drained, gently sloping to strongly sloping soils formed in material weathered from shale and interbedded sandstone; on uplands



Figure 5.—Drainage ditch removes surface water from Osage silty clay in the Osage-Mason association. Mason silt loam, in the background next to the trees, is on the bank along the Little Caney River.

This soil association consists of rolling, grass-covered hills that have smooth, rounded tops (see figure 3). It makes up about 24 percent of the county. It is 48 percent Steedman soils (fig. 6), 30 percent Dennis soils, 17 percent Eram soils, and 5 percent less extensive soils.

Steedman soils are strongly sloping and moderately deep. They are on the sides of rounded hills. They formed in material weathered from shale and interbedded sandstone. The surface layer is very dark grayish-brown stony clay loam about 6 inches thick. The subsoil is dark-brown and dark grayish-brown silty clay and clay about 24 inches thick. Shale is at a depth of 30 inches.

Dennis soils are gently sloping to sloping and deep. They are at the base of slopes. They formed in material weathered from shale. The surface layer is very dark grayish-brown silt loam about 14 inches thick. The subsoil, about 50 inches thick, is dark-brown and dark yellowish-brown silty clay loam and silty clay. The underlying material is yellowish-brown silty clay loam. Shale is at a depth of 76 inches.

Eram soils are gently sloping to sloping and moderately deep. They are on ridgetops. They formed in material weathered from shale. The surface layer is very grayish-brown silty clay loam about 8 inches thick.

The subsoil is dark-brown and light olive-brown silty clay loam and silty clay about 24 inches thick. Shale is at a depth of about 32 inches.

Less extensive in this association are Bates, Collinsville, Mason, Verdigris, and Kenoma soils. Bates and Kenoma soils are on ridgetops. Collinsville soils are on hillsides and are mapped with Eram soils. Mason and Verdigris soils are on terraces and flood plains along the streams.

This association is the tall grass prairie part of the Chautauqua Hills physiographic province in Kansas (6).¹ The area is mostly range. Some of the lower slopes are cultivated. Wheat and soybeans are cash crops grown in the narrow alluvial valleys that dissect the rolling hills. Hardwood trees grow along the streambanks and on the flood plains. The arable soils on uplands are suited to the crops commonly grown in the county. Controlling runoff and erosion and maintaining soil tilth and fertility are needed in cultivated areas. The many small cultivated fields, on upland ridges, that have been abandoned can be reseeded to native grasses. In many places ground water for domestic use is not available.

¹Italic numbers in parentheses refer to Literature Cited, p. 60.

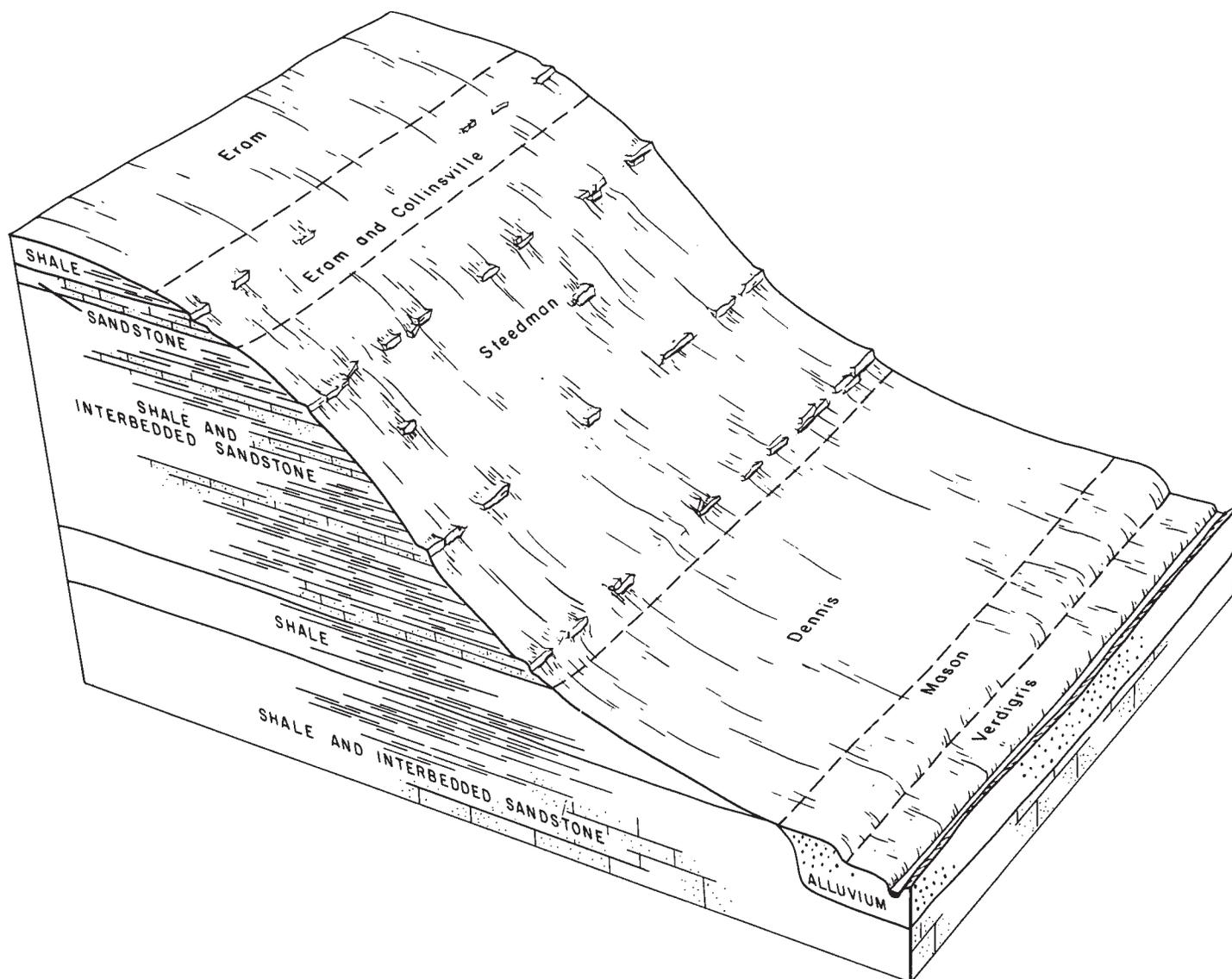


Figure 6.—Pattern of soils in the Steedman-Dennis-Eram association.

6. Verdigris-Mason association

Deep, moderately well drained and well drained, nearly level and gently sloping soils formed in alluvium; on flood plains and terraces

This soil association consists of the alluvial flood plains along the North and Middle Branches of Caney Creek and the larger creeks and drainageways. It makes up about 7 percent of the county. It is 39 percent Verdigris soils, 31 percent Mason soils, and 30 percent less extensive soils.

Verdigris soils are nearly level to gently sloping and moderately well drained. They are on low flood plains adjoining the stream channels. They typically have a surface layer of very dark grayish-brown silt loam and light silty clay loam about 38 inches thick. The underlying material is dark grayish-brown silty clay loam.

Mason soils are nearly level and well drained. They are on terraces. The surface layer is very dark grayish-brown silt loam and silty clay loam about 12 inches thick. The subsoil, about 46 inches thick, is dark-brown silty clay loam. The underlying material is dark-brown light silty clay loam.

Less extensive in this association are Osage silty clay loam, the Osage-Slickspots complex and Cleora soils. Osage silty clay loam and the Osage-Slickspots complex are at the back side of terraces adjacent to the sloping upland soils. Cleora soils are on narrow flood plains along the smaller drainageways.

Nearly all of this association is cultivated. A few small areas of the Osage-Slickspots complex are in native grasses. Wheat, alfalfa, grain sorghum, and tame pasture are the most common crops. Floodwater retarding structures in the Twin Caney Watershed Dis-

tract have reduced the frequency and damage of flooding on Verdigris soils. Drainage is needed on Osage silty clay loam during wet periods (fig. 7).

Descriptions of the Soils

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

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

Coarse fragments are reported as a percentage of the total volume of the soil material.

Management of the soils for crops and pasture is suggested in the description of each mapping unit. Lime and fertilizer are to be applied according to results of soil tests.

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

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary at the end of this survey, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (9).

A given soil in this county may be identified by a different name in a recently published soil survey of an adjacent county. Such differences in name result from changes in the concepts of soil classification that have occurred since publication. The characteristics of the soils described in this county are considered to be with-



Figure 7.—Ponded slickspots in association 6. Osage soils are in the foreground, and Mason soils are in the background.

in the range defined for that series. In those instances where a soil has one or more features outside the defined range, the differences are explained.

Bates Series

The Bates series consists of moderately deep, gently sloping, well-drained soils. These soils are on uplands. They formed in material weathered from sandstone. The natural vegetation is tall prairie grasses.

In a representative profile the surface layer is a very dark grayish-brown fine sandy loam that is medium acid and 12 inches thick. The subsoil is about 22 inches thick. The upper 4 inches is dark-brown, friable fine sandy loam. The lower part is mainly dark yellowish-brown, friable sandy clay loam that has a few sandstone fragments. The subsoil is underlain by sandstone.

Bates soils have low available water capacity, but release moisture readily to plants. Permeability is moderate. Natural fertility and the organic-matter content are low.

Most of the acreage is used for grazing. Many cultivated fields have been seeded to tame pasture. Summer maturing crops are affected by drought. Suitable crops are oats, barley, wheat, sweetclover, and tame pasture. Crops respond fairly well to lime and fertilizer. Cool-season grasses respond better to management than warm-season grasses.

Representative profile of Bates fine sandy loam, 1 to 4 percent slopes, one-fourth mile west of southeast corner of sec. 13, T. 34 S., R. 11 E., north side of U.S. Highway No. 166, in native grass pasture:

A1—0 to 12 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, dark grayish brown (10YR 4/2) dry; weak, medium, granular structure; slightly hard,

very friable; many fine roots; medium acid; clear, smooth boundary.

B1—12 to 16 inches, dark-brown (10YR 3/3) fine sandy loam that is slightly higher in clay content than the A1 horizon, dark grayish brown (10YR 4/2) dry; weak, medium, granular structure; slightly hard, friable; many fine roots; medium acid; clear, smooth boundary.

B2t—16 to 28 inches, dark yellowish-brown (10YR 4/4) sandy clay loam, yellowish brown (10YR 5/6) dry; weak, medium, subangular blocky structure; hard, friable; common fine roots; clay films coating ped surfaces; medium acid; gradual, smooth boundary.

B3—28 to 34 inches, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/4) sandy clay loam, yellowish brown (10YR 5/6) and light yellowish brown (10YR 6/4) dry; structureless; slightly hard, friable; few fine roots; few sandstone fragments 2 to 5 millimeters in diameter in lower part; medium acid; abrupt, wavy boundary.

R—34 inches, sandstone rock.

Thickness of the solum and depth to sandstone range from 20 to 40 inches. In most places the R horizon is a thin bed of sandstone that is cracked and fractured, but not displaced. In most areas the A1 horizon is fine sandy loam. In places it is loam. The B2t horizon is sandy clay loam or clay loam that is 20 to 35 percent clay.

Bates soils are associated with Collinsville, Eram, and Stephenville soils. They are deeper over sandstone than the Collinsville soils. In contrast with Eram soils, they have a coarser textured solum and are underlain by sandstone. They have a thicker, darker colored A1 horizon than Stephenville soils, are not so acid, and do not have an A2 horizon.

Bates fine sandy loam, 1 to 4 percent slopes (Bc).—This soil is on narrow, convex ridges. Included in mapping were small areas of Eram silty clay loam and Collinsville loam.

This soil is suited to all crops commonly grown on Bates soils. Most of the acreage is used for grazing.

Runoff is slow, but water erosion is a hazard. Maintaining fertility and the supply of organic matter and

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

Soil	Area	Extent	Soil	Area	Extent
	<i>Acres</i>	<i>Percent</i>		<i>Acres</i>	<i>Percent</i>
Bates fine sandy loam, 1 to 4 percent slopes.....	1,500	0.4	Martin silty clay loam, 3 to 7 percent slopes, eroded.....	10,500	2.5
Clareson silty clay loam, 0 to 2 percent slopes.....	3,200	.8	Martin-Slickspots complex.....	14,000	3.4
Clareson-Sogn complex.....	7,000	1.7	Mason silt loam.....	17,100	4.1
Cleora fine sandy loam.....	970	.2	Mason-Slickspots complex.....	760	.2
Clime-Sogn complex.....	65,000	15.7	Niotaze-Darnell complex.....	36,950	8.9
Dennis silt loam, 1 to 3 percent slopes.....	7,100	1.7	Osage silty clay loam.....	4,000	1.0
Dennis silt loam, 3 to 7 percent slopes.....	16,300	3.9	Osage silty clay.....	2,900	.7
Dennis silty clay loam, 3 to 7 percent slopes, eroded.....	12,900	3.1	Osage-Slickspots complex.....	5,500	1.3
Dennis-Slickspots complex.....	2,600	.6	Sogn soils.....	24,000	5.8
Eram silty clay loam, 1 to 3 percent slopes.....	12,800	3.1	Steedman stony clay loam, 8 to 20 percent slopes.....	61,500	14.9
Eram-Collinsville complex.....	11,400	2.8	Stephenville fine sandy loam, 1 to 4 percent slopes.....	3,500	.8
Ivan silt loam.....	5,000	1.2	Stephenville-Darnell fine sandy loams.....	31,750	7.7
Kenoma silt loam.....	2,950	.7	Verdigris silt loam.....	12,200	2.9
Longford silty clay loam, bedrock substratum, 1 to 4 percent slopes.....	3,400	.8	Water (lakes and large ponds).....	4,450	1.1
Longford silty clay loam, bedrock substratum, 1 to 4 percent slopes, eroded.....	1,150	.3	Pits.....	20	(¹)
Lula silt loam, 0 to 2 percent slopes.....	7,200	1.7	Quarry.....	30	(¹)
Martin silty clay loam, 0 to 1 percent slopes.....	1,450	.4			
Martin silty clay loam, 1 to 4 percent slopes.....	10,700	2.6			
Martin silty clay loam, 4 to 7 percent slopes.....	12,300	3.0			
			Total.....	414,080	100.0

¹ Less than 0.05 percent.

conserving moisture are essential in cultivated areas. A soil-conserving cropping sequence, crop residue management, minimum tillage, and contour farming are needed. Capability unit IIe-1; Loamy Upland range site; not assigned to a woodland suitability group.

Clareson Series

The Clareson series consists of moderately deep, nearly level and gently sloping, well-drained soils. These soils are on uplands. They formed in material weathered from limestone. The natural vegetation is tall prairie grasses.

In a representative profile the surface layer is dark-brown silty clay loam that is slightly acid and 10 inches thick. The subsoil is stony and 25 inches thick. The upper 7 inches is dark reddish-brown, friable silty clay loam that has a few, flat limestone fragments. The next 12 inches is dark reddish-brown, firm silty clay that has many flat limestone fragments. The rest is dark-red, firm silty clay that has many flat limestone fragments and a few black concretions. Below this is limestone bedrock.

Clareson soils have a high rate of water infiltration in the surface layer. They have low available water capacity and release moisture slowly to plants. Permeability is moderately slow. Natural fertility is fairly low. The supply of organic matter is moderate.

Most of the acreage is range. Small areas are cultivated. These soils are droughty for summer-maturing crops. They are suited to oats, barley, wheat, sweet-clover, and cool-season tame pasture. Crops respond fairly well to lime and fertilizer.

Representative profile of Clareson silty clay loam, 0 to 2 percent slopes, SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 33, T. 33 S., R. 11 E., 300 feet north of quarter section line, 50 feet east of State Highway No. 99, in native grass meadow:

- A1—0 to 10 inches, dark-brown (7.5YR 3/2) light silty clay loam, dark brown (7.5YR 4/2) dry; strong, medium, granular structure; slightly hard, friable; many fine roots; few, thin, flat fragments of limestone less than 15 inches long; slightly acid; gradual, smooth boundary.
- B1—10 to 17 inches, dark reddish-brown (5YR 3/3) silty clay loam, reddish brown (5YR 4/3) dry; strong, medium, granular structure; hard, friable; many fine roots; 15 percent thin flat fragments of limestone less than 15 inches long; slightly acid; gradual, smooth boundary.
- B21t—17 to 29 inches, dark reddish-brown (2.5YR 3/4) flaggy light silty clay, reddish brown (2.5YR 4/4) dry; weak, coarse and medium, subangular blocky structure; very hard, firm; few fine roots; 50 to 60 percent limestone fragments; medium acid; gradual, irregular boundary.
- B3—29 to 35 inches, dark-red (2.5YR 3/6) flaggy light silty clay, red (2.5YR 4/6) dry; moderate, medium and fine, subangular blocky structure; very hard, firm; few fine roots; 50 to 60 percent flaggy limestone fragments; few fine iron-manganese concretions; continuous clay films on ped surfaces; black organic stains or spots on surface of some peds; neutral; abrupt, wavy boundary.
- R—35 inches, limestone bedrock.

Depth to bedrock ranges from 20 to 40 inches. The A1 horizon ranges from 8 to 18 inches in thickness. The B2t horizon is heavy silty clay loam or silty clay that is 35 to 45 percent clay and 35 to 75 percent flat limestone fragments.

Clareson soils are associated with Sogn and Lula soils. They are shallower over bedrock and are finer textured than Lula soils. In contrast with Sogn soils, they have a B2t horizon and are deeper over bedrock.

Clareson silty clay loam, 0 to 2 percent slopes (Ca).—This soil is on narrow, convex ridges. It has the profile described as representative of the Clareson series. Included in mapping were small areas of Lula and Sogn soils.

This soil is suited to all crops commonly grown on the Clareson soils. A few small tracts are cultivated, but most of the acreage is range. Rock fragments interfere with tillage. Virgin areas of prairie should be examined closely for stones and rock outcrops before cultivation.

Droughtiness and stones are hazards. Maintaining fertility and the supply of organic matter and conserving moisture are essential in cultivated areas. A soil-conserving cropping sequence, crop residue management, minimum tillage, and contour farming are needed. Capability unit IIIs-1; Shallow Flats range site; not assigned to a woodland suitability group.

Clareson-Sogn complex (1 to 3 percent slopes) (Cs).—This soil complex is on convex ridges. It is about 65 percent Clareson silty clay loam and 35 percent Sogn soils. Except for a few more stones in the surface layer and exposed at the surface, the profile of the Clareson soil is similar to the one described as representative of the series.

These soils are used for grazing because they are too shallow, too droughty, and too stony for cultivation. Also, some areas are difficult to cross with mechanized equipment.

Runoff is slow. Range management that conserves moisture is needed. Capability unit VIe-1; Clareson soil in Shallow Flats range site and Sogn soil in Shallow Limy range site; not assigned to a woodland suitability group.

Cleora Series

The Cleora series consists of deep, nearly level to gently sloping, well-drained soils. These soils are on flood plains along streams. They formed in recent alluvium. The natural vegetation is lowland hardwood forest.

In a representative profile the surface layer is a very dark grayish-brown fine sandy loam that is neutral and about 18 inches thick. The next layer is about 26 inches thick. The upper 10 inches is dark-brown, very friable loamy fine sand. The lower part is very dark grayish-brown, friable fine sandy loam. The underlying material is dark-brown and brown fine sandy loam.

Cleora soils are subject to annual flooding. They have medium available water capacity and release moisture rapidly to plants. Permeability is moderately rapid. The level of natural fertility is moderate. The supply of organic matter is high. The surface layer is very friable.

Cleora soils are used mostly as tame pasture. Some wooded areas are grazed along with adjoining pastures. Suitable crops are oats, barley, wheat, sweetclover, and tame pasture. Crops respond well to fertilizer.

Representative profile of Cleora fine sandy loam, in a bermudagrass pasture SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 11, T. 35 S., R. 11 E., 75 feet west and 50 feet north of bridge across Turkey Creek:

- A1—0 to 18 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) dry; weak, very fine and fine, granular structure; soft, very friable; many fine roots; neutral; gradual, wavy boundary.
- AC1—18 to 28 inches, dark-brown (10YR 4/3) loamy fine sand, brown (10YR 5/3) dry; weak, very fine, granular structure and single sand grains; loose, very friable; few fine roots; neutral; clear, smooth boundary.
- AC2—28 to 44 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, dark brown (10YR 4/3) dry; weak, fine, granular structure; slightly hard, friable; lower 10 inches stratified with grayish-brown loamy fine sand; slightly acid; diffuse, smooth boundary.
- C1—44 to 75 inches, dark-brown (10YR 3/3) and brown (10YR 5/3) fine sandy loam; weak, fine, granular structure and single sand grains; slightly hard, friable; lower 6 inches is a darker colored loam; neutral; diffuse, wavy boundary.
- C2—75 to 84 inches, yellowish-brown (10YR 5/4) sand.

Average texture between depths of 10 and 40 inches is fine sandy loam that is less than 18 percent clay and more than 15 percent sand coarser than fine sand. In some places the texture is sandy loam or loam.

Cleora soils are associated with Verdigris and Mason soils. They are more stratified in the lighter and darker colored layers of the AC2 horizon than Verdigris soils and are coarser textured throughout. In contrast with Mason soils, they are coarser textured throughout the profile, do not have a B2t horizon, and are on flood plains.

Cleora fine sandy loam (0 to 2 percent slopes) (Ct).—This soil is on narrow flood plains. Included in mapping were areas of Verdigris silt loam.

This soil is suited to all crops commonly grown on Cleora soils. It is used mostly as tame pasture. The few wooded areas that remain are grazed by livestock.

Flooding is a hazard. Johnsongrass is difficult to control where row crops are grown. A soil-conserving cropping sequence is needed in cultivated areas. Capability unit IIw-1; woodland suitability group 1; not assigned to a range site.

Clime Series

The Clime series consists of moderately deep, strongly sloping to steep, moderately well drained soils. These soils are on uplands. They formed in material weathered from shale. The natural vegetation is tall prairie grasses.

In a representative profile the surface layer is very dark gray silty clay that is calcareous, has a few fragments of limestone, and is 10 inches thick. The subsoil is dark grayish-brown, calcareous, very firm silty clay about 18 inches thick. Shale is at a depth of 28 inches.

Clime soils have low available water capacity and release moisture slowly to plants. Permeability is slow. The level of natural fertility is low. The supply of organic matter is moderate. The surface layer is very firm.

Clime soils are extensive. They are better suited to range than crops. Practically all the acreage is range. Only small areas on the margin of cultivated fields have been plowed.

Representative profile of Clime silty clay, 500 feet east, 300 feet south of northeast corner of SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 15, T. 34 S., R. 8 E., along trail to top of Lookout Mountain; 1 mile south of Cedar Vale, in native grass pasture:

- A1—0 to 10 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; moderate, medium, granular and weak, fine, subangular blocky structure; many fine roots; few small limestone fragments; calcareous; moderately alkaline; gradual, smooth boundary.
- B2—10 to 18 inches, dark grayish-brown (2.5Y 4/2) silty clay; few, fine, faint, yellowish-brown (10YR 5/4) mottles, light brownish gray (2.5Y 6/2) dry; moderate, fine and medium, subangular blocky structure; very hard, very firm; few fine roots; calcareous; moderately alkaline; gradual, smooth boundary.
- B3—18 to 28 inches, dark grayish-brown (2.5Y 4/2) silty clay; few, fine, faint, yellowish-brown (10YR 5/4) mottles, grayish brown (2.5Y 5/2) dry; weak, coarse, angular blocky structure; very hard, very firm; few fine roots; calcareous; moderately alkaline; diffuse boundary.
- C—28 inches, soft, weakly laminated shale.

Depth to shale ranges from 20 to 40 inches. The solum is moderately alkaline; free lime occurs throughout the profile. In most places limestone fragments are on the surface. None of the horizons differ significantly in content of clay. All are heavy silty clay loam or silty clay and have a clay content of 37 to 50 percent.

Clime soils are associated with the Martin and Sogn soils. In contrast with Martin soils, they are shallower, do not have a B2t horizon, and are calcareous throughout. They are deeper and more clay than the Sogn soils.

Clime-Sogn complex (8 to 30 percent slopes) (Cx).—This soil complex is on convex hillsides. It is about 62 percent Clime silty clay, 25 percent Sogn soil, 10 percent Martin silty clay loam, and 3 percent Claeson silty clay loam.

The Clime soil has a profile similar to the one described for the Clime series, but the surface layer is stony. Sogn soils are described under the heading "Sogn Series."

These soils are used as range. They are too steep and too stony for cultivation.

Runoff is rapid, and water erosion is a hazard. Weed and brush control and a protective cover of grasses at all times are needed. Capability unit VIe-1; Clime soil in Limy Upland range site and Sogn soil in Shallow Limy range site; not assigned to a woodland suitability group.

Collinsville Series

The Collinsville series consists of shallow, gently sloping to sloping, well-drained soils. These soils are on uplands. They formed in material weathered from sandstone. The natural vegetation is tall prairie grasses.

In a representative profile the surface layer is a very dark brown loam that is medium acid and about 12 inches thick. Below this is sandstone.

Collinsville soils have very low available water capacity, but release moisture readily to plants. Permeability is moderately rapid. Natural fertility and the supply of organic matter are low.

Collinsville soils are used as range. They are droughty in summer and are not suitable for cultivation.

The Collinsville soils in this county are mapped only with Eram soils.

Representative profile of Collinsville loam, in native grass pasture, NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 30, T. 33 S., R. 11 E., on south side of public road:

- A1—0 to 12 inches, very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) dry; weak, medium, granular structure; slightly hard, friable; numerous fine roots; few sandstone fragments in lower 3 inches; medium acid; abrupt, irregular boundary.
R—12 inches, fractured sandstone rock.

Depth to bedrock ranges from 10 to 20 inches. The bedrock is fractured in some places. In places stones are on the surface. In most places the A1 horizon is loam. In places it is fine sandy loam.

Collinsville soils are associated with Bates, Eram, and Steedman soils. In contrast with Bates and Eram soils, they are shallower and do not have a B2t horizon. They are shallower over sandstone than Steedman soils.

Darnell Series

The Darnell series consists of shallow, gently sloping to strongly sloping, excessively drained soils. These soils are on uplands. They formed in material weathered from sandstone. The natural vegetation is oak-hickory forest and an understory of grasses.

In a representative profile the surface layer is very friable, very dark grayish-brown fine sandy loam. It is slightly acid and about 5 inches thick. The subsoil is brown, very friable fine sandy loam about 9 inches thick. Below this is cracked and fractured sandstone. Roots extend into the cracks.

Darnell soils have a high rate of water infiltration in the surface layer. They have very low available water capacity, but release moisture readily to plants. Permeability is rapid. Natural fertility and the organic-matter content are low.

Darnell soils are used for pasture and wildlife. They are droughty in summer and are not suitable for cultivation.

The Darnell soils in this county are mapped only with Niotaze soils.

Representative profile of Darnell fine sandy loam in a wooded pasture above a prominent sandstone outcrop on the south side of a natural drainageway, 1,700 feet north of southeast corner of sec. 12, T. 35 S., R. 9 E.

- O1— $\frac{1}{2}$ to $\frac{1}{4}$ inch, twigs and leaves of trees and grass.
O2— $\frac{1}{4}$ inch to 0, decomposing mulch of twigs and leaves.
A1—0 to 5 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) dry; weak, very fine, granular structure and single grains of sand; slightly hard, very friable; many fine roots; slightly acid; clear, wavy boundary.
B—5 to 14 inches, brown (10YR 4/3) fine sandy loam, light brownish gray (10YR 6/2) dry; weak, very fine, granular structure and single grains of sand; soft, very friable; few streaks of organic staining from A1 horizon; few fine roots; strongly acid; abrupt, irregular boundary.
C—14 inches, cracked and fractured sandstone.

The depth to bedrock ranges from 10 to 20 inches. The sandstone bedrock is fractured and thin and in most places is underlain by shale. No O horizons are evident in areas that have been burned or closely grazed. The B horizon is fine sandy loam.

Darnell soils are associated with Stephenville and Niotaze soils. In contrast with Stephenville soils, they are shallower and do not have a B2t horizon. They are shallower than Niotaze soils, which are underlain by shale.

Dennis Series

The Dennis series consists of deep, gently sloping to sloping, moderately well drained soils. These soils are on uplands. They formed in material weathered from shale. The natural vegetation is tall prairie grasses.

In a representative profile the surface layer is very dark grayish-brown silt loam that is medium acid and 14 inches thick. The subsoil is about 50 inches thick. The upper 5 inches is dark-brown, firm silty clay loam that has a few gray mottles. The rest is dark-brown, very firm and firm silty clay and silty clay loam that has gray mottles and a few black concretions in the upper part and is mottled with yellowish brown throughout. The underlying material is yellowish-brown silty clay loam. Shale is at a depth of 76 inches.

Dennis soils have high available water capacity, but they release moisture slowly to plants. Permeability is slow. The content of organic matter is moderate. The level of natural fertility is fairly high.

A large acreage is native grass pasture. Suitable crops are grain sorghum, oats, barley, wheat, soybeans, alfalfa, sweetclover, and tame pasture. Crops respond well to lime and fertilizer.

Representative profile of Dennis silt loam, 3 to 7 percent slopes, in native grass pasture, 1,650 feet west of the southeast corner of the northeast quarter of sec. 22, T. 34 S., R. 12 E., on north side of U.S. Highway No. 166:

- A1—0 to 14 inches, very dark grayish-brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate, fine and medium, granular structure; slightly hard, friable; many fine roots; lower 2 inches is lighter colored and has lower chroma; medium acid; gradual, smooth boundary.
B1—14 to 19 inches, dark-brown (10YR 3/3) silty clay loam; common, medium, distinct, reddish-brown (5YR 5/4) and few, fine, distinct, gray (10YR 5/1) mottles, grayish brown (10YR 5/2) dry; moderate, medium and coarse, subangular blocky structure; hard, firm; many fine roots; few black organic stains and gray silt coatings on some peds; medium acid; clear, smooth boundary.
B21t—19 to 35 inches, dark-brown (10YR 4/3) silty clay; few, fine, distinct mottles of yellowish brown (10YR 5/5) and gray (10YR 5/1), grayish brown (10YR 5/2) dry; moderate, medium and coarse, angular blocky structure; very hard, very firm; few fine roots; continuous clay films on ped faces; dark organic stains; few, fine, black iron-manganese concretions; medium acid; gradual, smooth boundary.
B22t—35 to 51 inches, dark-brown (10YR 4/3) heavy silty clay loam; common, fine, distinct mottles of yellowish brown (10YR 5/6), brown (10YR 5/3) dry; moderate, medium, subangular blocky structure; very hard, very firm; continuous clay films on ped faces; few, fine, black iron-manganese concretions; medium acid; gradual, smooth boundary.
B3—51 to 64 inches, dark yellowish-brown (10YR 4/4) heavy silty clay loam; many, coarse, distinct, yellowish-brown (10YR 5/6) and common, medium, prominent, gray (10YR 6/1) mottles; hard, firm; few clay films and organic stains on ped surfaces; slightly acid; diffuse, irregular boundary.
C—64 to 76 inches, yellowish-brown (10YR 5/4) silty clay loam; few, medium, distinct mottles of yellowish brown (10YR 5/6), light yellowish brown (10YR 6/4) dry; massive; hard, firm; slightly acid; diffuse, irregular boundary.
R—76 to 82 inches, soft, weakly laminated shale.

The solum ranges from 60 to 84 inches in thickness. In most places the A1 horizon is silt loam, but in some places it is silty clay loam or loam. The B2t horizon ranges from heavy silty clay loam to light silty clay that is 37 to 45 percent clay. The solum is medium acid in most profiles. In some places, just above the shale, the C horizon is slightly acid.

Dennis soils are associated with Steedman, Eram, and Collinsville soils. In contrast with those soils, they are deeper over bedrock. Bedrock is within 20 to 40 inches of the surface in Steedman and Eram soils and within 20 inches of the surface in Collinsville soils. Dennis soils also differ from Collinsville soils in having a B horizon.

Dennis silt loam, 1 to 3 percent slopes (Db).—This soil has a profile similar to the one described as representative of the series, but has a darker colored, thicker surface layer and a thicker subsoil. It is also deeper over shale, has slightly more organic matter in the surface layer, and is less susceptible to erosion. Slopes are long and concave.

Included with this soil in mapping were areas of Eram silty clay loam. Also included were a few areas of slickspots, which are identified by spot symbols on the soil map.

This soil is well suited to all crops commonly grown on Dennis soils. Most of the acreage is cultivated.

Runoff is slow, but water erosion is a hazard. A soil-conserving cropping sequence, crop residue management, minimum tillage, and contour farming are needed in cultivated areas. Terraces are optional, depending on other management. Onsite determination is needed. Capability unit IIe-2; Loamy Upland range site; not assigned to a woodland suitability group.

Dennis silt loam, 3 to 7 percent slopes (Dc).—This soil has the profile described as representative of the Dennis series. Slopes are short and convex. Included in mapping were small areas of Martin silty clay loam, Eram silty clay loam, and slickspots.

This soil is used for crops, tame pasture, and native grass pasture. It is suited to all crops commonly grown on Dennis soils.

Runoff is rapid. Water erosion is a hazard because this soil also receives runoff from adjacent higher areas. Intensive erosion control is needed, including a soil-conserving cropping sequence, crop residue management, minimum tillage, diversions, terraces, and contour farming. Capability unit IIIe-1; Loamy Upland range site; not assigned to a woodland suitability group.

Dennis silty clay loam, 3 to 7 percent slopes, eroded (De).—This soil has a profile similar to the one described as representative of the Dennis series, but all of the original surface layer has been lost through erosion. The present surface layer is mixed with material from the subsoil. Slopes are short and convex.

Included with this soil in mapping were areas of Dennis soils that have been severely eroded, and a few slickspots. In the severely eroded areas are gullies that are difficult to cross with modern machinery.

Runoff is rapid, and many cultivated fields have been abandoned. The vegetation (fig. 8), commonly called "go-back," is returning to the original tall prairie grasses. Further erosion control is essential in cultivated areas. A soil-conserving cropping sequence, crop residue management, minimum tillage, diversion ditch-

es, terraces, and contour farming are needed. Range seeding is needed to restore the native vegetation. Capability unit IIIe-2; Clay Upland range site; not assigned to a woodland suitability group.

Dennis-Slickspots complex (1 to 3 percent slopes) (Ds).—This complex is about 60 percent Dennis silt loam and 23 percent slickspots. The rest is a soil having profile characteristics intermediate between those of the Dennis soil and the slickspots. Slopes are long and concave.

The Dennis soil has a profile similar to the one described as representative of the series, but it has a thicker solum and is deeper over shale. Slickspots are in round or long or irregularly shaped areas 30 square feet to 3 acres in size. They are slick when wet, are ponded after rains, and have a white, salty, crusted surface when dry. On these it is difficult to plow and prepare a seedbed. Slickspots are described in more detail under the heading "Parent Material" in the section "Formation and Classification of the Soils."

Most of the acreage is tame pasture and range. Old cultivated fields are abandoned. The vegetation, commonly called "go-back," is returning to the original tall prairie grasses. Barren areas are common.

These soils are best suited to permanent tame pasture or tall prairie grasses. Bermudagrass and tall fescue are the commonly grown tame pasture grasses. Suitable crops are wheat, barley, sweetclover, bermudagrass, and tall fescue.

A soil-conserving cropping sequence, crop residue management, minimum tillage, and contour farming are needed. Also needed are special amendments, applied according to soil tests, to correct soil salinity or alkalinity. Terraces are optional, depending on other management. Onsite determination is needed. Range seeding is needed to reestablish the natural vegetation. Capability unit IVs-1; Dennis soil in Loamy Upland range site, Slickspots in Upland Slickspots range site; not assigned to a woodland suitability group.

Eram Series

The Eram series consists of moderately deep, gently sloping to sloping, moderately well drained soils. These soils are on uplands. They formed in material weathered from shale. The natural vegetation is tall prairie grasses.

In a representative profile the surface layer is very dark grayish-brown silty clay loam that is medium acid and 8 inches thick. The subsoil is about 24 inches thick and has many yellowish-red and yellowish-brown mottles in the lower 20 inches. The upper 4 inches is dark-brown, firm silty clay loam. The next 8 inches is dark-brown, very firm silty clay. The lower 12 inches is light olive-brown, very firm silty clay loam. Shale is at a depth of about 32 inches.

Eram soils have medium available water capacity and release moisture slowly to plants. Permeability is slow, natural fertility is fairly low, and the supply of organic matter is low.

Eram soils are extensive and are mostly in pasture. Many formerly cultivated fields are used for tame pasture. Drought affects crops that mature in summer.



Figure 8.—Cattle wintering on bermudagrass on Dennis silty clay loam, 3 to 7 percent slopes, eroded. The strongly sloping Niotaze-Darnell complex is on the hillside.

Cool-season tame pasture responds better to management than warm-season pasture. Suitable crops are oats, barley, wheat, sweetclover, and tame pasture. Crops respond fairly well to lime and fertilizer.

Representative profile of Eram silty clay loam, 1 to 3 percent slopes, 210 feet north and 26 feet west of southwest corner of southeast quarter of sec. 29, T. 34 S., R. 12 E., in native grass pasture:

- A1—0 to 8 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, dark grayish brown (10YR 4/2) dry; moderate, fine and medium, granular structure; slightly hard, friable; many fine roots; a few fragments of sandstone less than 10 millimeters in diameter; medium acid; gradual, smooth boundary.
- B1—8 to 12 inches, dark-brown (7.5YR 3/3) silty clay loam, dark brown (7.5YR 4/3) dry; moderate, very fine and fine, subangular blocky structure; hard, firm; many fine roots; a few fragments of sandstone; medium acid; gradual, smooth boundary.
- B2t—12 to 20 inches, dark-brown (7.5YR 3/2) silty clay; common, fine, yellowish-red (5YR 3/6) mottles, dark brown (7.5YR 4/2) dry; moderate, medium and coarse, angular blocky structure; very hard, very firm; few fine roots; continuous clay films on faces of peds; dark organic coatings on surface of some peds; few, fine, faint, yellowish-brown mottles on some ped surfaces; medium acid; gradual, smooth boundary.
- B3—20 to 32 inches, light olive-brown (2.5Y 5/3) silty clay

loam, common, fine, yellowish-brown (10YR 5/6) and very dark brown (10YR 2/2) mottles, the dry colors of which are mixed yellowish brown (10YR 5/6) to dark brown (7.5YR 4/4); weak, coarse, angular blocky structure; very hard, very firm; few fine roots; dark organic coatings on surface of some peds; slightly acid; diffuse, irregular boundary.

R—32 inches, weakly laminated shale; no roots.

Depth to shale ranges from 20 to 40 inches. Black concretions 2 to 5 millimeters in diameter occur in the B2t and B3 horizons in most places. Mottles of yellowish brown or gray occur in the B2t horizon in most areas. The A1 horizon is silty clay loam. The B2t horizon is silty clay that is 38 to 55 percent clay. The B3 horizon is silty clay loam or silty clay.

Eram soils are associated with Dennis and Steedman soils. They are shallower over shale than Dennis soils. They have a thicker A1 horizon than Steedman soils.

Eram silty clay loam, 1 to 3 percent slopes (Ea).—This soil is on narrow, convex ridges. Included in mapping were areas of Dennis silt loam, Bates fine sandy loam, and a few slickspots.

This soil is suited to all crops commonly grown on Eram soils. Most of the acreage is pasture. Many small cultivated fields have been abandoned. In these fields the vegetation is “go-back” to the original tall prairie grasses.

Runoff is medium, and water erosion is a hazard. The

subsoil has slow permeability. A soil-conserving cropping sequence, crop residue management, minimum tillage, terracing, and contour farming are essential. Capability unit IIe-2; Clay Upland range site; not assigned to a woodland suitability group.

Eram-Collinsville complex (1 to 7 percent slopes) (Ec).—This soil complex is on convex hilltop rims and ridges (fig. 9). It is about 70 percent Eram silty clay loam, 20 percent Collinsville loam, and 10 percent Bates fine sandy loam.

The Eram soil has a profile similar to the one described as representative of the Eram series, but it has a thinner solum and is not so deep over shale. The Collinsville soil has the profile described as typical of the Collinsville series.

These soils are too shallow and stony for cultivation and are used as range. Most areas of the Collinsville soil are difficult to cross with mechanized equipment.

These soils tend to be droughty. Range management that conserves moisture is needed. Runoff is medium. Capability unit VIe-1; Eram soil in Clay Upland range site and Collinsville soil in Shallow Sandstone range site; not assigned to a woodland suitability group.

Ivan Series

The Ivan series consists of deep, nearly level to gently sloping, well-drained soils. These soils are on

flood plains along streams. They formed in recent alluvium. The natural vegetation is lowland hardwood forest.

In a representative profile the surface layer is very dark grayish-brown silt loam and silty clay loam that is moderately alkaline and about 25 inches thick. The next layer is dark-brown, friable silty clay loam about 30 inches thick. Below this is dark-brown loam.

Ivan soils are flooded annually. They have high available water capacity and release moisture readily to plants. Permeability is moderate. The level of natural fertility and the content of organic matter are high.

Most of the acreage is cultivated. Suitable crops are oats, barley, wheat, alfalfa, sweetclover, and tame pasture. Alfalfa responds favorably to the free lime that occurs in these soils. No additional lime is needed. Crops respond well to fertilizer.

Representative profile of Ivan silt loam in fescue tame pasture, 100 feet north and 520 feet east of bridge across Caney River, 1 mile south of Hewins, Kans., NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 10, T. 35 S., R. 9 E.

A11—0 to 16 inches, very dark grayish-brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; weak granular structure; slightly hard, friable; few fine strata of lighter colored soil; few worm casts; slight effervescence; moderately alkaline; gradual, smooth boundary.



Figure 9.—Eram-Collinsville complex in foreground. Stephenville-Darnell fine sandy loams on the ridge in the background.

A12—16 to 25 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, dark grayish brown (10YR 4/2) dry; moderate, medium, granular structure; slightly hard, friable; many worm casts; slight effervescence; moderately alkaline; diffuse, smooth boundary.

AC—25 to 55 inches, dark-brown (10YR 3/3) light silty clay loam, brown (10YR 5/3) dry; weak, fine and medium, subangular structure; hard, friable; strong effervescence; moderately alkaline; diffuse, smooth boundary.

C—55 to 80 inches, dark-brown (10YR 4/3) loam, pale brown (10YR 6/3) dry; massive; hard, friable; few strata of slightly sandier textures; strong effervescence; moderately alkaline.

Below a depth of 48 inches the soil is saturated for short periods during high streamflow. It is calcareous in all horizons below a depth of 10 inches. The A horizon ranges from 24 to 60 inches in thickness. In most places the A1 horizon is silt loam. In some it is light silty clay loam.

Ivan soils are associated with Mason and Osage soils. They do not have a B2t horizon, which is typical of Mason soils. They are not so clayey throughout the profile as Osage soils.

Ivan silt loam (0 to 2 percent slopes) (Iv).—This soil is on narrow flood plains. Included in mapping were small areas of Mason silt loam and Verdigris silt loam.

This soil is suited to all crops grown on Ivan soils. Most of the acreage is cultivated.

Flooding is a hazard. Runoff is medium. Johnson-grass is difficult to control in cultivated areas. A soil-conserving cropping sequence is essential. Capability unit IIw-1; woodland suitability group 1; not assigned to a range site.

Kenoma Series

The Kenoma series consists of deep, nearly level, moderately well drained soils. These soils are on uplands. They formed in loess that grades into material weathered from shale. The natural vegetation is tall prairie grasses.

In a representative profile the surface layer is black silt loam 11 inches thick. The boundary between the surface layer and subsoil is abrupt. The subsoil is 43 inches thick and has gray and brown mottles throughout. The upper 13 inches is very dark grayish-brown, extremely firm clay. The rest is dark-brown and strong-brown very firm silty clay. The underlying material is strong-brown silty clay loam. Shale is at a depth of 84 inches.

Kenoma soils have high available water capacity, but release moisture slowly to plants. Permeability is very slow. Natural fertility and organic-matter content are high.

Most of the acreage is cultivated. Grain sorghum, oats, barley, wheat, soybeans, alfalfa, sweetclover, and tame pasture are suitable crops. Corn is affected by drought. Crops respond well to lime and fertilizer.

Representative profile of Kenoma silt loam (0 to 1 percent slopes) 300 feet north and 20 feet west of southeast corner of the northeast quarter of sec. 3, T. 32 S., R. 10 E., on west side of State Highway No. 99, in native grass pasture:

A1—0 to 11 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; fine and medium granular structure; slightly hard, friable; many fine roots; lower 2 inches more grayish in color; slightly acid; clear, smooth boundary.

B21t—11 to 24 inches, very dark grayish-brown (10YR 3/2) clay; few, fine, distinct, dark-brown (7.5YR 3/3) mottles, dark grayish brown (10YR 4/2) dry; weak, coarse, angular blocky structure, approaching structureless; extremely hard, extremely firm; continuous clay films on ped surfaces; few, fine, black concretions; slightly acid; gradual, smooth boundary.

B22t—24 to 38 inches, dark-brown (7.5YR 4/4) silty clay; common, medium, distinct, grayish-brown (10YR 5/2) mottles, yellowish brown (10YR 5/4) dry; weak, coarse, angular blocky structure; very hard, very firm; continuous clay films and few dark organic stains on ped surfaces; few, fine, black concretions; neutral; gradual, smooth boundary.

B3—38 to 54 inches, strong-brown (7.5YR 5/6) silty clay; many, common, distinct, gray (10YR 5/1) mottles, reddish brown (7.5YR 6/6) dry; weak, coarse, angular blocky structure; very hard, very firm; few, fine, black concretions; mildly alkaline; diffuse, smooth boundary.

C—54 to 84 inches, strong-brown (7.5YR 5/6) heavy silty clay loam, reddish yellow (7.5YR 6/6) dry; massive; hard, firm; few, fine, black concretions; mildly alkaline; diffuse, irregular boundary.

R—84 to 90 inches, impervious shale.

Depth to shale ranges from 48 to 96 inches. The dark colors extend into the upper part of the B2t horizon. The boundary between the A1 and B2t horizons is abrupt to clear. The B2t horizon is mottled with common to many yellowish or brownish mottles. The upper part of the B2t horizon has relic cracks filled with darker colored soil from the A1 horizon. These cracks dissect natural soil peds.

Kenoma soils are associated with Martin and Eram soils. They have a coarser textured A1 horizon and a more abrupt transition to the B2t horizon than Martin soils. In contrast with Eram soils, they are darker colored in the upper part of the B2t horizon and are deeper over shale.

Kenoma silt loam (0 to 1 percent slopes) (Ke).—This soil is on broad upland ridges. Included in mapping were areas of Eram silty clay loam and slickspots.

This soil is suited to all crops commonly grown on Kenoma soils. Most of the acreage is cultivated. A few large tracts are in native pasture.

Maintaining the supply of organic matter is important. A soil-conserving cropping sequence, crop residue management, minimum tillage, and contour farming are needed. Capability unit IIs-1; Clay Upland range site; not assigned to a woodland suitability group.

Longford Series

The Longford series consists of deep, gently sloping, well-drained soils. These soils are on uplands. They formed in old alluvial material. The natural vegetation is tall prairie grasses.

In a representative profile the surface layer is about 8 inches of very dark brown, slightly acid silty clay loam. A few rounded chert pebbles are on the surface. The subsoil is about 40 inches thick. The upper 5 inches is dark-brown firm silty clay loam that is slightly acid and has a few rounded chert pebbles. The rest is reddish-brown, extremely firm silty clay that has a few rounded chert pebbles and black concretions throughout. The underlying material is massive, dark-brown silty clay loam mottled with gray. Limestone bedrock is at a depth of 54 inches.

These soils have high available water capacity, but release moisture slowly to plants. Permeability is slow. Natural fertility is fairly low, and organic-matter content is low.

Most of the acreage is in native grasses and tame pasture. Suitable crops are grain sorghum, oats, barley, wheat, sweetclover, and tame pastures. Crops respond fairly well to lime and fertilizer.

Representative profile of Longford silty clay loam, bedrock substratum, 1 to 4 percent slopes, 500 feet west and 100 feet north of center of sec. 24, T. 34 S., R. 8 E., in native grass pasture:

- A1—0 to 8 inches, very dark brown (10YR 2/2) light silty clay loam, dark grayish brown (10YR 4/2) dry; moderate, medium, granular structure; hard, friable; many fine roots; less than 2 percent water-rounded chert pebbles; slightly acid; gradual, smooth boundary.
- B1—8 to 13 inches, mixed colors of dark-brown (7.5YR 3/3) and very dark grayish-brown (10YR 3/2) silty clay loam, dark brown (7.5YR 4/3) dry; moderate, medium, subangular blocky structure breaking to weak, medium, granular structure; hard, firm; many fine roots; less than 2 percent water-rounded chert pebbles; slightly acid, clear, smooth boundary.
- B2t—13 to 30 inches, dark reddish-brown (5YR 3/4) silty clay, reddish brown (5YR 4/4) dry; weak, coarse, angular blocky structure; extremely firm, extremely hard; few fine roots; few, fine, black concretions; less than 1 percent chert pebbles; slightly acid; gradual, smooth boundary.
- B2t—30 to 38 inches, reddish-brown (5YR 4/4) silty clay, reddish brown (5YR 5/4) dry; weak, coarse, angular blocky structure; extremely hard, extremely firm; few fine roots; continuous clay films on ped faces; neutral; gradual, smooth boundary.
- B3—38 to 48 inches, dark-brown (7.5YR 4/4) silty clay, brown (7.5YR 5/4) dry; weak, coarse, subangular blocky structure; very hard, firm; less than 2 percent chert pebbles; neutral; diffuse, smooth boundary.
- C—48 to 54 inches, dark-brown (7.5YR 4/4) silty clay loam; few, fine, distinct, gray (10YR 5/1) mottles, brown (7.5YR 5/4) dry; massive; neutral; abrupt, smooth boundary.
- R—54 inches, limestone bedrock.

Depth to bedrock ranges from 40 to 60 inches. Thin strata of gravel occur above the bedrock in some places. The A1 horizon is silty clay loam or heavy silt loam. The B2t horizon is silty clay that is about 45 percent clay. In places there is no C horizon.

Longford soils are associated with Martin, Lula, and Mason soils. They have a thinner A1 horizon and a more reddish B2t horizon than Martin soils. They have weaker and coarser structure in the A1, B1, and B2t horizons and are more clayey throughout the solum than Lula and Mason soils. They are more slowly permeable than Lula soils.

Longford silty clay loam, bedrock substratum, 1 to 4 percent slopes (Ln).—This soil is on narrow, convex ridges below steep areas of Clime and Sogn soils. It has the profile described as representative of the Longford series. Included in mapping were areas of Martin silty clay loam.

This soil is suited to all crops commonly grown on the Longford soils. Most of the acreage is pasture.

Runoff is medium. Water erosion is a hazard. Maintaining the supply of organic matter and the level of fertility is important. A soil-conserving cropping sequence, crop residue management, minimum tillage, terracing, and contour farming are needed. Capability unit IIe-2; Loamy Upland range site; not assigned to a woodland suitability group.

Longford silty clay loam, bedrock substratum, 1 to 4 percent slopes, eroded (Lo).—This soil is on narrow, convex ridges below the steep areas of Clime and Sogn

soils. It has a profile similar to the one described as representative of the Longford series, but most of the original surface layer has been lost through erosion. The present surface layer is a mixture of the lower part of the original surface layer and material from the subsoil. Included in mapping were areas of Martin silty clay loam and slickspots.

This soil is suited to oats, barley, wheat, sweetclover, and tame pasture. It is used mostly as tame pasture. Some cultivated fields have been abandoned, and the vegetation is "go-back" to the original tall prairie grasses.

Protection from further erosion is essential. Runoff is rapid. A soil-conserving cropping sequence, crop residue management, minimum tillage, terraces, and contour farming are the chief management needs. Range seeding is needed if the natural vegetation is to be restored. Capability unit IIIe-3; Loamy Upland range site; not assigned to a woodland suitability group.

Lula Series

The Lula series consists of deep, nearly level to gently sloping, well-drained soils. The natural vegetation is tall prairie grasses.

In a representative profile the surface layer is dark-brown silt loam that is slightly acid, is 10 inches thick, and has strong granular structure. The subsoil is 36 inches thick. The upper 7 inches is dark-brown, friable silty clay loam that has strong granular structure. The rest is dark-red, firm silty clay loam. Limestone bedrock is at a depth of 46 inches.

Lula soils have a high rate of water infiltration in the surface layer. They have high available water capacity and release moisture readily to plants. Permeability is moderate. The level of fertility and the supply of organic matter are moderate.

Lula soils are used for crops, native hay, and range. They are suited to grain sorghum, oats, barley, wheat, soybeans, alfalfa, sweetclover, and tame pasture. They are among the first soils in the uplands to dry out and become tillable after a rain. Crops respond well to lime and fertilizer. Alfalfa responds well to management. Under good management, the yield of native grasses is high.

Representative profile of Lula silt loam, 0 to 2 percent slopes, 1,320 feet north of southeast corner of sec. 25, T. 32 S., R. 11 E., west side of road, in a native-grass meadow:

- A1—0 to 10 inches, dark-brown (7.5YR 3/2) silt loam, dark brown (7.5YR 4/2) dry; strong, medium, granular structure; slightly hard, friable; many fine roots; slightly acid; gradual, smooth boundary.
- B1—10 to 17 inches, dark-brown (7.5YR 3/3) light silty clay loam, dark brown (7.5YR 4/3) dry; strong, medium, granular structure; slightly hard, friable; many fine roots; medium acid; gradual, smooth boundary.
- B2t—17 to 32 inches, dark-red (2.5YR 3/6) silty clay loam, reddish brown (2.5YR 4/5) dry; strong, fine, subangular blocky structure; hard, firm; few fine roots; few, fine, black concretions; medium acid; gradual, smooth boundary.
- B2t—32 to 46 inches, dark-red (2.5YR 3/6) heavy silty clay loam, reddish brown (2.5YR 4/5) dry; strong, medium, subangular blocky structure; hard, firm;

few fine roots; continuous clay films on faces of peds; common, fine, black concretions; lower 6 inches has limestone fragments; slightly acid in upper part to neutral in lower part; diffuse, irregular boundary.

R—46 inches, limestone bedrock.

Depth to bedrock ranges from 40 to 52 inches. In most places limestone fragments are just above the bedrock. The A1 horizon is very dark grayish brown or dark brown and ranges from 10 to 20 inches in thickness. The B2t horizon is light silty clay loam in the upper part and heavy silty clay loam or light silty clay in the lower part.

Lula soils are associated with Clareson, Martin, and Mason soils. In contrast with Clareson soils, they are deeper over bedrock and have a B2t horizon that is less than 35 percent clay and free of rock. In contrast with Martin soils, they have a redder B2t horizon and are underlain with limestone bedrock. They are similar to Mason soils, but are redder throughout and have bedrock within 60 inches of the surface.

Lula silt loam, 0 to 2 percent slopes (Lu).—This soil is on the summit of convex ridges. Included in mapping were areas of Clareson silty clay loam and Kenoma silt loam.

This soil is used for native meadow and cultivated crops. It is suited to all crops commonly grown on the Lula soils.

Runoff is slow. Controlling water erosion and maintaining the supply of organic matter are essential. A soil-conserving cropping sequence, crop residue management, minimum tillage, and contour farming are the chief management needs. Capability unit IIE-3; Loamy Upland range site; not assigned to a woodland suitability group.

Martin Series

The Martin series consists of deep, nearly level to sloping, moderately well drained soils. These soils are on uplands. They formed in material weathered from shale. The natural vegetation is tall prairie grasses.

In a representative profile the surface layer is very dark brown silty clay loam about 12 inches thick. The subsoil is about 42 inches thick. The upper 6 inches is very dark brown, firm silty clay loam. The next 22 inches is very dark grayish-brown and dark grayish-brown, very firm silty clay. The lower part is dark yellowish-brown, firm silty clay loam. The underlying material is weakly laminated clay shale.

Martin soils have a high available water capacity and release moisture slowly to plants. Permeability is slow. Natural fertility and the organic-matter content are high.

A large acreage of Martin soils is in native grass pasture. Suitable crops are grain sorghum, oats, barley, wheat, soybeans, alfalfa, sweetclover, and tame pasture.

Representative profile of Martin silty clay loam, 4 to 7 percent slopes, in a fescue meadow, 550 feet north and 12 feet east of southwest corner of northwest quarter of sec. 32, T. 33 S., R. 9 E.

A1—0 to 12 inches, very dark brown (10YR 2/2) silty clay loam, very dark grayish brown (10YR 3/2) dry; strong, medium and fine, granular structure; hard, friable; many fine roots; slightly acid; gradual, smooth boundary.

B1—12 to 18 inches, very dark brown (10YR 2/2) heavy silty clay loam, dark gray (10YR 4/1) dry; strong; fine,

subangular blocky structure; very hard, firm; many fine roots; slightly acid; gradual, smooth boundary.

B2t—18 to 28 inches, very dark grayish-brown (10YR 3/2) silty clay; common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles, dark grayish brown (10YR 4/2) dry; weak, medium and coarse, subangular blocky structure; very hard, very firm; common fine roots; black organic stains on surface of all peds; few, fine, black concretions; slightly acid; gradual, smooth boundary.

B2t—28 to 40 inches, dark grayish-brown (2.5Y 4/2) silty clay; common, distinct, light olive-brown (2.5Y 5/6) mottles, grayish brown (2.5Y 5/2) dry; weak, coarse, angular blocky structure; very hard, very firm; few fine roots; few black organic stains on some peds; continuous clay films on faces of peds; few, fine, black concretions; slightly acid; gradual, smooth boundary.

B3—40 to 54 inches, dark yellowish-brown (10YR 4/4) heavy silty clay loam; common, medium, distinct, yellowish-brown (10YR 5/6) mottles, yellowish brown (10YR 5/4) dry; weak, coarse, subangular blocky structure; hard, firm; few, fine, black concretions in upper part; few concretions of calcium carbonate 2 to 15 millimeters in diameter in lower part; neutral; diffuse, irregular boundary.

C—54 to 60 inches, weakly laminated, alkaline clay shale.

The solum ranges from 40 to 60 inches in thickness. The shale or clay beds are at a depth of 40 to 72 inches or more. The A1 horizon is very dark brown or very dark grayish brown. The B1 horizon has the same range in color as the A1 horizon, but is higher in clay content and has strong granular or fine subangular blocky structure. The B2t horizon is silty clay or clay that is 45 to 55 percent clay. In most areas relic cracks filled with dark-colored soil from upper horizons dissect the structural peds to a depth of 2 to 3 feet. Reaction in the solum is slightly acid or neutral.

Martin soils are associated with Sogn, Kenoma, and Clime soils. They are deeper over shale than Sogn soils. They do not have the abrupt textural change between the A and B horizons that is typical of Kenoma soils. Martin soils are deeper over shale than Clime soils but are not so calcareous. They also differ from those soils in having a B2t horizon.

Martin silty clay loam, 0 to 1 percent slopes (Ma).—This soil is on narrow uplands below steep areas of Clime and Sogn soils. It has a profile similar to the one described as representative of the series, but the lower part of the subsoil is calcareous and is underlain by beds of clay. Included in mapping were a few areas of slickspots that are identified by spot symbol on the soil map.

This soil is suited to all crops commonly grown on Martin soils. Most of the acreage is cultivated.

Runoff is slow. Maintaining soil tilth is important. A soil-conserving cropping sequence, crop residue management, minimum tillage, and contour farming are needed. Capability unit IIS-1; Loamy Upland range site; not assigned to a woodland suitability group.

Martin silty clay loam, 1 to 4 percent slopes (Mb).—This soil is on long, concave toe slopes and narrow, convex ridges. It has a profile similar to the one described as representative of the series, but on toe slopes the solum is deeper over shale and on ridges it is shallower over shale.

Included with this soil in mapping were small areas of Osage silty clay loam. Also included were areas of slickspots, which are identified by spot symbols on the soil map.

This soil is suited to all crops commonly grown on Martin soils. Most of the acreage is cultivated.

Runoff is medium. Water erosion is a hazard. A soil-conserving cropping sequence, crop residue management, minimum tillage, and contour farming are the chief management needs. Terracing is optional, depending on other management, and requires onsite determination. Capability unit IIe-2; Loamy Upland range site; not assigned to a woodland suitability group.

Martin silty clay loam, 4 to 7 percent slopes (Mc).—This soil is on short foot slopes below the steep Clime and Sogn soils. It has the profile described as representative of the Martin series.

Included with this soil in mapping were small areas of Clime silty clay. Also included were small areas of a soil that has a brown silty clay loam subsoil and fine blocky structure but is otherwise similar to this Martin soil.

This soil is suited to all crops commonly grown on Martin soils. Most of the acreage is cultivated. Some areas are native range.

Runoff is rapid. Water erosion is a hazard because this Martin soil receives runoff from adjacent higher areas. Intensive erosion control is essential. A soil-conserving cropping sequence, crop residue management, minimum tillage, diversions, contour farming, and terracing are important management needs. Capability unit IIIe-1; Loamy Upland range site; not assigned to a woodland suitability group.

Martin silty clay loam, 3 to 7 percent slopes, eroded (Me).—This soil is on foot slopes below the steep Clime and Sogn soils. It has a profile similar to the one described as representative of the Martin series, but most of the original surface layer has been lost through erosion. The present surface layer is a mixture of material from the subsoil and the subsurface layer.

Included with this soil in mapping were areas of Martin soils that have been severely eroded. These areas have gullies that are difficult to cross with modern machinery.

This soil is suited to oats, barley, wheat, alfalfa, sweetclover, and tame pasture. Many cultivated fields have been abandoned. The vegetation, commonly called "go-back," is returning to the original tall prairie grasses.

Runoff is rapid. Protection from further water erosion is essential. A soil-conserving cropping sequence, crop residue management, minimum tillage, contour farming, diversions, and terracing are needed. Range seeding is needed if the natural vegetation is to be restored. Capability unit IIIe-2; Clay Upland range site; not assigned to a woodland suitability group.

Martin-Slickspots complex (1 to 3 percent slopes) (Ms).—This complex is on narrow summits of upland ridges. It is about 75 percent Martin silty clay loam and 15 percent Slickspots. The rest is a soil that has profile characteristics intermediate between those of the Martin soil and the slickspots.

The Martin soil has a profile similar to the one described as representative of the series, but it has a thinner solum and is shallower over shale. Slickspots occur as round or long or irregularly shaped areas 15 square feet to 3 acres in size. They are slick when

wet, are ponded after rains, and have a white, salty, crusted surface when dry. In these areas it is difficult to plow and prepare a seedbed. Slickspots are described in more detail under the heading "Parent Material" in the section "Formation and Classification of the Soils."

Most of the acreage is range. Some old cultivated fields are abandoned, and the vegetation, commonly called "go-back," is returning to the original tall prairie grasses. Barren areas are common.

These soils are best suited to a permanent plant cover of tame pasture or tall prairie grasses. Bermudagrass and tall fescue are commonly grown. Suitable crops are wheat, barley, sweetclover, bermudagrass, and tall fescue.

A soil-conserving cropping sequence, crop residue management, minimum tillage, and contour farming are needed. Also needed are special amendments applied according to soil tests to correct soil salinity or alkalinity. Terraces are optional, depending on other management, and require onsite determination. Range seeding is needed to reestablish the natural vegetation. Capability unit IVs-1; Martin soil in Loamy Upland range site and Slickspots in Upland Slickspots range site; not assigned to a woodland suitability group.

Mason Series

The Mason series consists of deep, nearly level, well-drained soils. These soils are on terraces. They formed in alluvial sediments. The natural vegetation is tall prairie grass.

In a representative profile the surface layer is about 12 inches of very dark grayish-brown silt loam and silty clay loam. The subsoil is about 46 inches thick. The upper 18 inches is very dark grayish-brown, friable silty clay loam. The rest is dark-brown, firm silty clay loam. The underlying material is dark-brown light silty clay loam.

Mason soils have a high rate of water infiltration in the surface layer. They have high available water capacity and release moisture readily to plants. The level of natural fertility is high, and the content of organic matter is moderate.

Mason soils are among the first alluvial soils to dry out after long wet periods. Most of the acreage is cultivated. All crops commonly grown in the county are suited (fig. 10). Crops respond well to lime and fertilizer.

Representative profile of Mason silt loam in a large cultivated field NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 1, T. 35 S., R. 9 E.

- Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, very fine and fine, granular structure; a few irregular clods; slightly hard, friable; medium acid; abrupt, smooth boundary.
- A1—8 to 12 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, grayish brown (10YR 5/2) dry; strong, fine and medium, granular structure; slightly hard, friable; medium acid; gradual, smooth boundary.
- B21t—12 to 30 inches, very dark grayish-brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; strong, fine and medium, subangular blocky struc-

ture; hard, friable; continuous clay films on ped faces; medium acid; gradual, smooth boundary.

B22t—30 to 42 inches, dark-brown (10YR 3/3) silty clay loam, brown (10YR 5/3) dry; strong, fine and medium, subangular blocky structure; hard, firm; continuous clay films on ped faces; slightly acid; gradual, smooth boundary.

B3—42 to 58 inches, dark brown (10YR 4/3) silty clay loam, yellowish brown (10YR 5/4) dry; weak, medium and coarse, subangular blocky structure; hard, firm; slightly acid; diffuse, smooth boundary.

C—58 to 72 inches, dark-brown (10YR 4/3) light silty clay loam, yellowish brown (10YR 5/4) dry; massive; hard, friable; slightly acid.

The solum ranges from 40 to 60 inches in thickness. The A1 horizon ranges from very dark grayish brown to very dark brown. The B2t horizon ranges from dark grayish brown to dark brown, is silty clay loam that is 30 to 50 percent clay, and has black iron-manganese concretion in some places. No mottles occur in the B2t horizon or within 40 inches of the surface. The undisturbed A1 and B2t horizons have strong grades of structure.

Mason soils are associated with Verdigris, Ivan, and Osage soils. In contrast with Verdigris and Ivan soils, they have a B2t horizon and are on terraces. In contrast with Osage soils, they are coarser textured, are more brownish, and are not so mottled.

Mason silt loam (0 to 1 percent slopes) (Mt).—This soil is on slightly convex terraces (fig. 11). It has the profile described as representative of the Mason series.

Included with this soil in mapping were areas of Ivan silt loam, Verdigris silt loam, and Osage silty clay loam. Also included were a few areas of slickspots, which are identified by spot symbols on the soil map.

This soil is suited to all crops commonly grown on Mason soils. Runoff is slow. Maintaining the supply of organic matter is essential. Important in management are a soil-conserving cropping system, crop residue management, minimum tillage, and grade stabilization structures where needed. Capability unit I; Loamy Lowland range site; woodland suitability group 3.

Mason-Slickspots complex (0 to 1 percent slopes) (Mx).—This complex is on slightly convex terraces. It is about 75 percent Mason silt loam and 15 percent Slickspots. The rest is a soil that has profile characteristics intermediate between those of the Mason soil and Slickspots.

The Mason soil is similar to the soil described as representative of the series. Slickspots occur as round or long or irregularly shaped areas. They are slick when wet and are ponded after rains. Tilling and preparing a seedbed are difficult. Slickspots are described in more detail under the heading "Parent



Figure 10.—Wheat on Mason silt loam provides good fall and winter pasture. The wooded Ivan soils are on the flood plain.



Figure 11.—Nearly level Mason silt loam on terrace next to stream, below sloping upland soils. Dennis silt loam, 3 to 7 percent slopes, is in the foreground.

Material” in the section “Formation and Classification of the Soils.”

Most of the acreage is cultivated. Barren spots are common. Suitable crops are grain sorghum, oats, barley, wheat, alfalfa, sweetclover, and tame pasture. Berumudagrass and tall fescue are better for tame pasture than other grasses.

Ponding in small areas and poor tilth are the main limitations. The chief management needs are a soil-conserving cropping sequence, crop residue management, minimum tillage, and special amendments applied according to soil tests to correct salinity or alkalinity. In places grade stabilization structures are needed. Capability unit IIIs-2; Mason soil in Loamy Lowland range site and woodland suitability group 3, Slickspots in Lowland Slickspots range site, not assigned to a woodland suitability group.

Niotaze Series

The Niotaze series consists of moderately deep, strongly sloping, somewhat poorly drained soils. These soils are on uplands. They formed in material weath-

ered from shale interbedded with sandstone. The natural vegetation is oak and hickory trees and an understory of grasses.

In a representative profile the surface layer is about 3 inches of strongly acid, very dark grayish-brown cobbly fine sandy loam. The next layer is brown cobbly fine sandy loam about 7 inches thick. The subsoil, about 18 inches thick, is mottled with gray and strong brown throughout. The upper 8 inches is reddish-brown, very firm silty clay, and the lower 10 inches is dark-brown, firm silty clay loam. Shale is at a depth of about 28 inches.

Niotaze soils have low available water capacity and release moisture slowly to plants. Permeability is slow. Natural fertility and the supply of organic matter are low.

Niotaze soils are used for pasture and wildlife. They are only marginal for wood crops. They are droughty during the summer and are not suitable for cultivation.

Representative profile of Niotaze cobbly fine sandy loam NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 14, T. 35 S., R. 11 E., 850 feet south of county road, along east side of oilfield road:

A1—0 to 3 inches, very dark grayish-brown (10YR 3/2) cobbly fine sandy loam, grayish brown (10YR 5/2) dry; weak, very fine and fine, granular structure; slightly hard, very friable; many fine roots; 40 percent angular fragments of sandstone less than 10 inches in diameter; medium acid; clear, irregular boundary.

A2—3 to 10 inches, brown (10YR 5/3) cobbly fine sandy loam, pale brown (10YR 6/3) dry; weak, very fine, granular structure; slightly hard, very friable; few fine roots; 30 percent angular sandstone fragments less than 10 inches in diameter; strongly acid; abrupt, smooth boundary.

IIB2t—10 to 18 inches, reddish-brown (5YR 4/4) silty clay, brown (7.5YR 5/4) dry; weak, medium, subangular blocky and moderate, fine, angular blocky structure; very hard, very firm; few fine roots; continuous clay films on faces of peds, grayish coatings on faces of peds in upper 3 inches; strongly acid; gradual, smooth boundary.

IIB8—18 to 28 inches, dark-brown (7.5YR 4/4) silty clay loam; common, fine, distinct mottles of strong brown (7.5YR 5/8) and gray (10YR 5/1), light brown (7.5YR 6/4) and gray (10YR 6/1) dry; weak, coarse, subangular blocky structure; hard, firm; few fine roots; thin continuous clay films on faces of peds; lower part has some laminated shale; medium acid; gradual boundary.

IIC—28 inches, soft, weakly laminated, grayish silty shale.

Depth to shale ranges from 20 to 40 inches. Sandstone fragments are on the surface. The A1 and A2 horizons are 50 percent sandstone fragments. They range from medium acid to strongly acid. The B horizon ranges from strongly acid to neutral. The B2t horizon is silty clay loam or silty clay that has a clay content of 35 to 55 percent. Mottles in the B horizon are both gray and yellowish brown. In some places where fire has not occurred, the soil has an O horizon.

In contrast with Stephenville soils, Niotaze soils have a fine-textured B2t horizon, are more mottled, and are underlain by shale. In contrast with Steedman soils, they have an A2 horizon and lower base saturation in the B2t horizon and are more mottled. They are deeper over shale than Darnell soils, which are underlain by sandstone.

Niotaze-Darnell complex (8 to 20 percent slopes) (Nd).

—This complex is on convex hillsides. It is about 65 percent Niotaze cobbly fine sandy loam, 20 percent Darnell fine sandy loam, 10 percent Steedman stony clay loam, and 5 percent Dennis silt loam. Niotaze and Darnell soils have the profiles described as representative of their respective series.

These soils are used for grazing and wildlife. They are difficult to cross with mechanized equipment because about 15 to 20 percent of the surface is covered with many rocks and a few large boulders.

Runoff is rapid, and water erosion is a hazard. Proper methods of burning and measures to control erosion and conserve moisture are needed in range management. Capability unit VII_s-1; Niotaze soil in Savannah range site and woodland suitability group 4, Darnell soil in Shallow Savannah range site and woodland suitability group 5.

Osage Series

The Osage series consists of deep, nearly level, poorly drained soils. These soils are in slack-water areas on low flood plains. They formed in alluvium. The natural vegetation is tall prairie grasses.

In a representative profile the surface layer is very firm, very dark gray silty clay that is neutral and about 20 inches thick. The subsoil is 28 inches of

extremely firm, very dark gray heavy silty clay. The underlying material is very dark gray silty clay. The lower 68 inches is mottled with yellowish-brown and gray mottles.

Osage soils are subject to flooding. They have high available water capacity and release moisture slowly to plants. Permeability is very slow. The level of natural fertility is fairly high, and the content of organic matter is high.

Most of the acreage is cultivated. A few small relic areas of grassland occur. Suitable crops are oats, barley, wheat, sweetclover, and tame pasture. Crop response to fertilizer is poor.

Representative profile of Osage silty clay, in native grass meadow NE¹/₄NE¹/₄ sec. 28, T. 34 S., R. 13 E., 75 feet east and 75 feet north of southwest corner of meadow:

A1—0 to 20 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; moderate, medium, granular structure; very hard, very firm; many fine roots; neutral; gradual, smooth boundary.

B2g—20 to 48 inches, very dark gray (2.5Y 3/1) heavy silty clay; common, medium, distinct, yellowish-brown (10YR 5/6) mottles, dark gray (2.5Y 4/1) dry; moderate, fine and medium, angular blocky structure; extremely hard, extremely firm; many fine roots, decreasing to few; neutral; diffuse, smooth boundary.

C—48 to 88 inches, very dark gray (5Y 3/1) silty clay; common, medium, distinct, yellowish-brown (10YR 5/6) mottles, dark gray (5Y 4/1) dry; massive; extremely hard, extremely firm; no roots below a depth of 70 inches; mildly alkaline.

These soils are saturated during wet periods. The B and C horizons have distinct mottles of yellowish brown and gray. In most years during dry periods, cracks at least 1 inch wide form at the surface and extend as far down as 24 inches or more. Texture throughout is silty clay loam or silty clay. The clay content is 35 to 55 percent.

Osage soils are associated with Cleora, Mason, Ivan, and Verdigris soils. They are finer textured and more mottled than Verdigris, Ivan, and Cleora soils. They are more frequently flooded and are more poorly drained than Mason soils and also differ in having a silty clay A1 horizon.

Osage silty clay loam (0 to 1 percent slopes) (O_c).—This soil is on slightly concave terraces. It has a profile similar to the one described as representative of the series, but the surface layer is silty clay loam and is more permeable.

Included with this soil in mapping were areas of Osage silty clay, Mason silt loam, Dennis silt loam, and slickspots. Slickspots are identified by spot symbols on the soil map.

Most of the acreage is cultivated. Suitable crops are grain sorghum, soybeans, oats, barley, wheat, alfalfa, sweetclover, and tame pasture (fig. 12).

This soil is subject to occasional flooding. Runoff is slow. Removing surface water and maintaining good soil tilth are essential. The chief management needs are drainage field ditches, land smoothing, a soil-conserving cropping sequence, crop residue management, and minimum tillage. Capability unit II_w-2; Loamy Lowland range site; woodland suitability group 2.

Osage silty clay (0 to 1 percent slopes) (O_c).—This soil is in slightly concave slack-water areas on low flood plains. It has the profile described as repre-

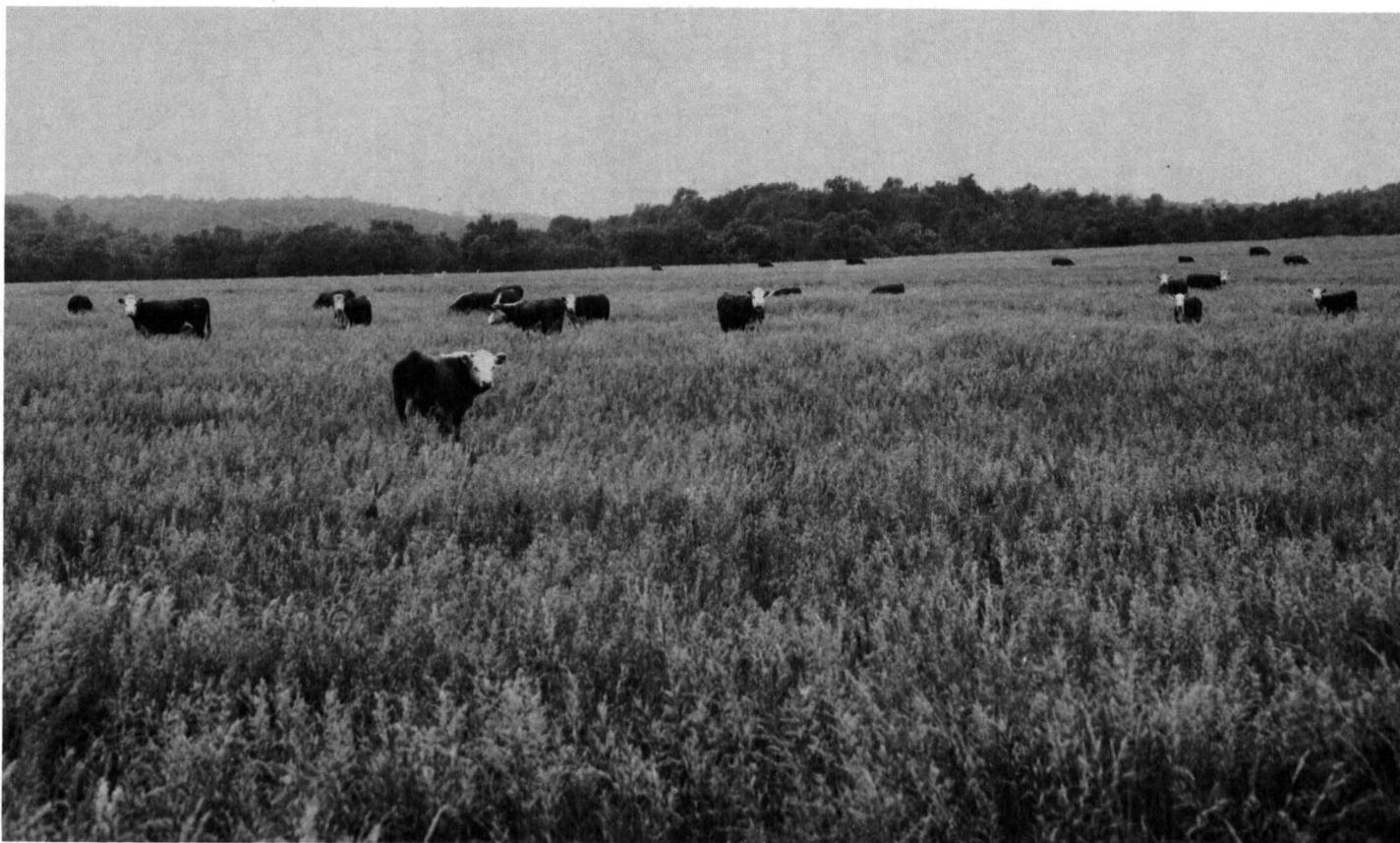


Figure 12.—Bromegrass on Osage silty clay loam provides excellent pasture.

sentative of the series. Included in mapping were areas of Verdigris silt loam and Osage silty clay loam.

This soil is suited to all crops commonly grown on the Osage soils (fig. 13). Most of the acreage is cultivated.

Frequent flooding is a hazard. Runoff is very slow or ponded. Removal of excess surface water is essential in cultivated areas. Land smoothing, drainage field ditches, and a soil-conserving cropping sequence are the chief management needs. Capability unit IIIw-2; Clay Lowland range site; woodland suitability group 2.

Osage-Slickspots complex (0 to 1 percent slopes) (Os).—This complex is on slightly concave terraces. It is about 60 percent Osage silty clay loam and 25 percent Slickspots. The rest is a soil that has profile characteristics intermediate between those of the Osage soil and the Slickspots.

The Osage soil has a profile similar to the one described as representative of Osage series, but it has a silty clay loam surface layer and is slightly more permeable. Slickspots occur as round or long or irregularly shaped areas 15 square feet to 1 acre in size. They are slick when wet, are ponded after rains, and have a white, salty, crusted surface when dry (fig. 14). Plowing and preparing a seedbed are difficult.

Most of the acreage is cultivated. A few small areas

of natural vegetation occur in the county, but they are too wet to cultivate. Barren areas are common.

These soils are best suited to permanent cover of tame pasture or tall prairie grasses. Bermudagrass and tall fescue are suitable for tame pasture. Suitable crops are barley, wheat, alfalfa, sweetclover, and tame pasture.

Removing surface water and improving tilth are essential. The chief management needs are drainage field ditches, land smoothing, a soil-conserving cropping sequence, crop residue management, minimum tillage, and special amendments applied according to soil tests to correct soil salinity or alkalinity. Capability unit IVs-2; Osage soil in Loamy Lowland range site and woodland suitability group 2; Slickspots in Lowland Slickspots range site, not assigned to a woodland suitability group.

Sogn Series

The Sogn series consists of shallow, gently sloping to steep, somewhat excessively drained soils. These soils are on uplands. They formed in material weathered from limestone. The natural vegetation is tall prairie grasses.

In a representative profile the surface layer is neutral, very dark brown silty clay loam about 10 inches thick. It is underlain by hard limestone bedrock.



Figure 13.—Fescue on Osage silty clay provides fall and winter pasture.

Sogn soils have very low available water capacity, but release moisture readily to plants. Permeability is moderate. Natural fertility and the supply of organic matter are low.

Sogn soils are used for pasture. They are droughty in summer and are not suitable for cultivation.

Representative profile of Sogn silty clay loam in an area of Sogn soils in native grass pasture NW $\frac{1}{4}$ NE $\frac{1}{4}$ of sec. 7, T. 34 S., R. 11 E., on west side of State Highway No. 166:

A1—0 to 10 inches, very dark brown (10YR 2/2) silty clay loam, very dark grayish brown (10YR 3/2) dry; moderate, fine and medium, granular structure; hard, firm; many fine roots; fragments of limestone in lower 3 inches; neutral; abrupt, smooth boundary.

R—10 inches, hard limestone bedrock.

Depth to bedrock averages about 10 inches, but ranges from 4 to 20 inches. The A1 horizon ranges from loam to silty clay loam that is 20 to 35 percent clay. Reaction is neutral to moderately alkaline. In many places the soil has free carbonates and fragments of limestone.

Sogn soils are associated with Clareson, Clime, and Martin soils. In contrast with Clareson and Martin soils, they are shallower over bedrock and do not have a B horizon. In contrast with Clime soils, they are underlain by limestone bedrock.

Sogn soils (1 to 3 percent slopes) (So).—These soils are on convex hilltop rims and ridges. They have the profile described as representative of the Sogn series. The surface layer is silty clay loam or loam. Included in mapping were small areas of barren rock and Clareson silty clay loam.

These soils are used as range because they are too shallow, too droughty, and too stony for cultivation. Most areas have outcrops of bedrock exposed at the surface and are therefore difficult to cross with mechanized equipment.

Runoff is medium. Range management is needed that conserves moisture and makes adjustments in carrying capacity to allow for low forage yields. Capability unit VII_s-2; Shallow Limy range site; not assigned to a woodland suitability group.

Steedman Series

The Steedman series consists of moderately deep, strongly sloping, moderately well drained soils. These soils are on uplands. They formed in material weathered from shale. The natural vegetation is tall prairie grasses.



Figure 14.—Wheat on Osage-Slickspots complex. The darker colored areas are Osage silty clay loam. Slickspots are in the light colored areas where standing water has killed the wheat.

In a representative profile the surface layer is a very dark grayish-brown stony clay loam that is medium acid and about 6 inches thick. The subsoil is about 24 inches thick and has yellowish-brown mottles throughout. It is dark-brown, very firm silty clay in the upper part and dark grayish-brown, very firm clay in the lower part. The subsoil is underlain by shale.

Steedman soils have low available water capacity and release moisture slowly to plants. Permeability is slow. Natural fertility and the organic-matter content are low.

Practically all the acreage is range. Only small areas at the margin of cultivated fields have been plowed. These soils are more suitable for range than for crops.

Representative profile of Steedman stony clay loam 300 feet north of county road along trail through NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 14, T. 35 S., R. 12 E., in native grass pasture:

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) stony clay loam, dark grayish brown (10YR 4/2) dry; moderate, medium, granular structure; hard, firm; many fine roots; 40 percent sandstone fragments larger than 3 inches in diameter; medium acid; clear, smooth boundary.

B21t—6 to 15 inches, dark-brown (7.5YR 4/2) silty clay; common, fine, distinct, yellowish-brown (10YR 5/4) mottles, brown (10YR 5/3) dry; moderate, fine, angular blocky structure; very hard, very firm; few fine roots; medium acid; gradual, smooth boundary.

B22t—15 to 30 inches, dark grayish-brown (2.5Y 4/2) clay; common, medium, distinct, yellowish-brown (10YR 5/4) mottles, grayish brown (2.5Y 5/2) dry; moderate, medium, angular blocky structure; very hard, very firm; few fine roots; continuous clay films on ped surfaces; slightly acid; diffuse, smooth boundary.

C—30 inches, weakly laminated shale; no roots.

Depth to shale ranges from 20 to 40 inches. Content of sandstone fragments in the A1 horizon ranges from 25 to 50 percent, but is typically 40 percent. The A1 horizon ranges from 5 to 7 inches in thickness. It is typically stony clay loam, but is stony silty clay loam in places. The B2t horizon is mottled with yellowish brown or strong brown.

Steedman soils are associated with Dennis, Eram, and Niotaze soils. They have a thinner A1 horizon than Dennis and Eram soils and do not have the A2 horizon that is typical of Niotaze soils.

Steedman stony clay loam, 8 to 20 percent slopes (St).

—This soil is on convex hillsides. It has the profile described as representative of the Steedman series.

This soil is difficult to cross with mechanized equipment because it has many loose sandstone rocks on

the surface. Water erosion is a hazard. Management that protects the soil at all times is needed. Capability unit VIe-1; Loamy Upland range site; not assigned to a woodland suitability group.

Stephenville Series

The Stephenville series consists of moderately deep, gently sloping to sloping, well-drained soils. These soils are on uplands. They formed in material weathered from sandstone. The natural vegetation is oak-hickory forest and an understory of grasses.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam. It is strongly acid and about 4 inches thick. The subsurface layer is brown fine sandy loam about 8 inches thick. The subsoil, about 22 inches thick, is yellowish-red and strong-brown, firm and friable sandy clay loam. It is underlain by cracked and fractured sandstone rock.

Stephenville soils have a high rate of water infiltration in the surface layer. They have low available water capacity, but release moisture readily to plants. Permeability is moderate. Organic-matter content and natural fertility are low.

Stephenville soils are used mostly for grazing, but the carrying capacity is low. They are marginal in production of wood crops. Garden crops are grown in a few areas. The hazard of erosion is severe in cultivated areas. Crops maturing in summer are affected by drought. Suitable crops are oats, barley, wheat, sweetclover, and tame pasture. Crop response to lime and fertilizer is fair.

Representative profile of Stephenville fine sandy loam, 1 to 4 percent slopes, 220 feet north and 20 feet west of southeast corner of SE $\frac{1}{4}$ sec. 12, T. 35 S., R. 11 E., in wooded pasture:

- O2— $\frac{1}{4}$ inch to 0, partially decomposed leaves and twigs of local flora; some moss and mold.
- A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) dry; weak, fine, granular structure, few single sand grains; slightly hard, very friable; many fine roots; strongly acid; clear, smooth boundary.
- A2—4 to 12 inches, brown (10YR 5/3) fine sandy loam, light gray (10YR 7/2) dry; single grained and very weak, fine, granular structure; slightly hard, very friable; few fine roots; strongly acid; clear, smooth boundary.
- B2t—12 to 26 inches, yellowish-red (5YR 4/6) sandy clay loam, yellowish red (5YR 5/6) dry; weak, medium, subangular blocky structure; hard, firm; few fine roots; continuous clay films on ped surfaces; strongly acid; gradual, smooth boundary.
- B3—26 to 34 inches, strong-brown (7.5YR 5/6) light sandy clay loam, reddish yellow (7.5YR 6/6) dry; very weak, medium, subangular blocky structure grading to structureless in lower part; hard, friable; few fine roots; few sandstone fragments less than 15 millimeters in lower part; medium acid; abrupt, irregular boundary.
- R—34 inches, cracked and fractured sandstone rock.

Depth to sandstone ranges from 20 to 40 inches, but is dominantly less than 36 inches. The sandstone is thin bedded, cracked, and fractured. The A horizon is strongly acid, and the B horizon is strongly acid to medium acid.

The A horizon is fine sandy loam or loamy fine sand that is low in content of organic matter. The B2t is sandy clay loam or clay loam and is 22 to 35 percent clay.

Stephenville soils are associated with Darnell, Niotaze, and Bates soils. In contrast with Darnell soils, they have a B2t horizon and are deeper over bedrock. In contrast with Bates soils, they have thinner A1 and A2 horizons and are more acid in the B2t horizon. They have a coarser textured subsoil than Niotaze soils.

Stephenville fine sandy loam, 1 to 4 percent slopes (Sv).—This soil is on narrow convex ridges. It has the profile described as representative of the series. Included in mapping were small areas of Eram silty clay loam, Bates fine sandy loam, and Darnell fine sandy loam.

Most of the acreage is used for grazing. It is marginal in production of wood crops. A few small areas are cultivated. Runoff is slow. Controlling water erosion, conserving moisture, and maintaining the supply of organic matter and the level of fertility are essential in cultivated areas. A soil-conserving cropping sequence, crop residue management, minimum tillage, and contour farming are needed. Capability unit IIe-1; Savannah range site; woodland suitability group 4.

Stephenville-Darnell fine sandy loams (1 to 5 percent slopes) (Sx).—This mapping unit is on convex hilltop rims and ridges. It is about 60 percent Stephenville fine sandy loam, 25 percent Darnell fine sandy loam, and 5 percent each of Bates fine sandy loam, Eram silty clay loam, and Niotaze stony fine sandy loam.

The Stephenville soil has a profile similar to the one described as representative of the series, but it has a thinner solum and is not so deep over sandstone. The Darnell soil has a profile similar to the one described for the Darnell series, but the surface layer is stony.

These soils are used for woodland, pasture, and wildlife. They are too shallow and too stony for cultivation. About 10 to 25 percent of the surface area is covered with sandstone rocks. Crossing the areas with mechanized equipment is difficult.

These soils tend to be droughty. Range management that conserves moisture and provides a protective plant cover is needed. Runoff is slow. Capability unit VIe-1; Stephenville soil in Savannah range site and woodland suitability group 4, Darnell soil in Shallow Savannah range site and woodland suitability group 5.

Verdigris Series

The Verdigris series consists of deep, nearly level to gently sloping, moderately well drained soils. These soils are on the flood plains of streams. They formed in recent alluvium. The natural vegetation is lowland hardwood forest.

In a representative profile the surface layer is neutral and 38 inches thick. It is very dark grayish-brown and dark grayish-brown silt loam in the upper part and very dark brown light silty clay loam in the lower part. Below this is dark grayish-brown light silty clay loam. The lower part has brown and gray mottles.

Verdigris soils are flooded annually. They have high available water capacity and release moisture readily to plants. Permeability is moderate. The level of natural fertility and content of organic matter are high.

These soils are used for woodland pasture, tame pasture, and cultivated crops. Suitable crops are oats, barley, alfalfa, sweetclover, and tame pasture. Crop response to lime and fertilizer is good.

Representative profile of Verdigris silt loam in a fescue tame pasture 300 feet east of the northwest corner of SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 1, T. 34 S., R. 11 E.

A11—0 to 12 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, fine, granular structure; slightly hard, friable; few fine roots; evidence of recent sediments; neutral; gradual, smooth boundary.

A12—12 to 38 inches, very dark brown (10YR 2/2) light silty clay loam, dark grayish brown (10YR 4/2) dry; moderate, medium, granular structure; hard, firm; few fine roots; neutral; gradual, smooth boundary.

C—38 to 68 inches, dark grayish-brown (10YR 4/2) light silty clay loam, grayish brown (10YR 5/2) dry; massive; slightly hard, friable; few lenses of dark brown (10YR 4/3) fine sandy loam throughout horizon, and lower 10 inches of it has few, fine, distinct, strong-brown (7.5YR 5/6) mottles; slightly acid.

Brown and gray mottles occur below a depth of 36 inches in most places. The solum is typically 30 inches thick, but ranges from 24 to 40 inches in thickness. The A1 horizon is typically silt loam, but in some areas it is loam or light silty clay loam.

Verdigris soils are associated with Cleora, Mason, and Osage soils. They have a finer textured control section than Cleora soils. They have a coarser textured control section than Osage soils. In contrast with Mason soils, they do not have a B2t horizon. They do not have free carbonates in the control section, which is typical of Ivan soils.

Verdigris silt loam (0 to 2 percent slopes) (Ve).—This soil is on narrow flood plains. Included in mapping were areas of Cleora fine sandy loam and Mason silt loam.

This soil is cultivated and is also used as tame pasture and woodland pasture. It is suited to all crops commonly grown on Verdigris soils.

Flooding is a hazard. Runoff is medium. Johnson-grass is difficult to control in cultivated areas. A soil-conserving cropping sequence is essential. Capability unit IIw-1; woodland suitability group 1; not assigned to a range site.

Use and Management of Soils

The soils of Chautauqua County are used for range and to a lesser extent for crops, woodland, wildlife, and recreation. This section explains how the soils can be managed for those purposes. It explains the capability classification used by the Soil Conservation Service and shows predicted yields for the principal crops. Suggested use and management for crops of each soil in the county and its classification by capability unit can be found in the mapping unit description in the section "Descriptions of the Soils."

This part of the survey also reports data from engineering tests and interpretations of soil properties that affect highway construction and other engineering structures.

Management of Soils for Range²

Approximately 259,000 acres in Chautauqua County is range. This acreage represents about 63 percent of the total land area. An additional 71,300 acres of upland woods also is used mostly as range. The range is utilized mainly for cow-calf enterprises and partly for stocker feeders and yearlings. It also supports a large deer herd and provides food and cover for prairie chicken, quail, rabbits, and other game animals.

Range in the western half of the county is on soils derived from limestone and shale (fig. 15, *top*). In the eastern half of the county it is on soils derived from sandstone and shale (fig. 15, *bottom*). The sandstone associated soils have a significant influence on the kinds and amounts of vegetation on the different range sites in the county.

Alluvial soils, the most productive soils in the county, but limited in extent, occur throughout the county. On many livestock farms, these soils have been converted to tame pasture or to crops that provide forage and feed. Tame pastures are mainly cool-season grasses that extend the grazing season. Some areas are in native meadow from which hay is harvested for feed during the winter.

Range sites and condition classes

Most of the soils in Chautauqua County support climax vegetation that is suitable for grazing. Soils that produce similar kinds and amounts of climax, or potential, vegetation are grouped into range sites for inventory and management purposes. The plant cover in most of the county is dominantly grasses and forbs in climax condition. Woody vegetation is a climax component on some soils.

A range site is a distinctive kind of range that differs from other kinds of range in its potential to produce native plants. It is the product of all environmental factors responsible for its development. In the absence of abnormal disturbance and physical site deterioration, it supports a plant community that differs from that of other range sites in kind, proportion, and total annual yield.

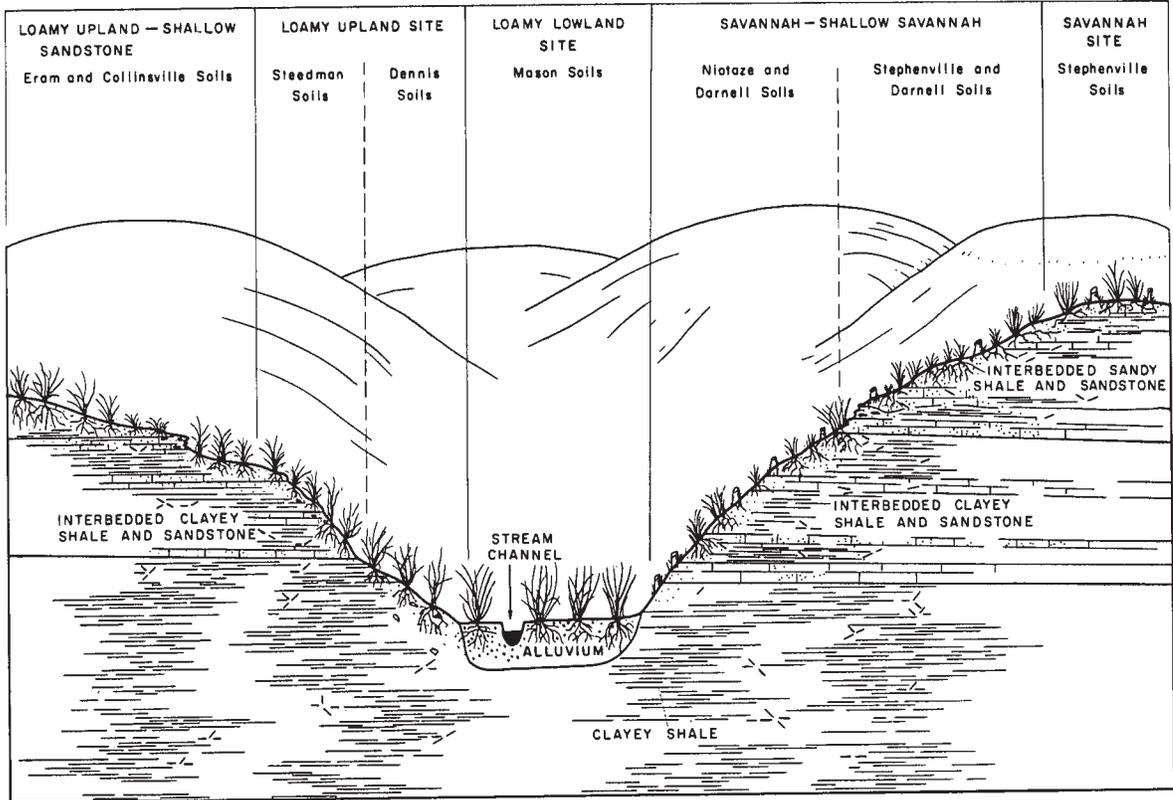
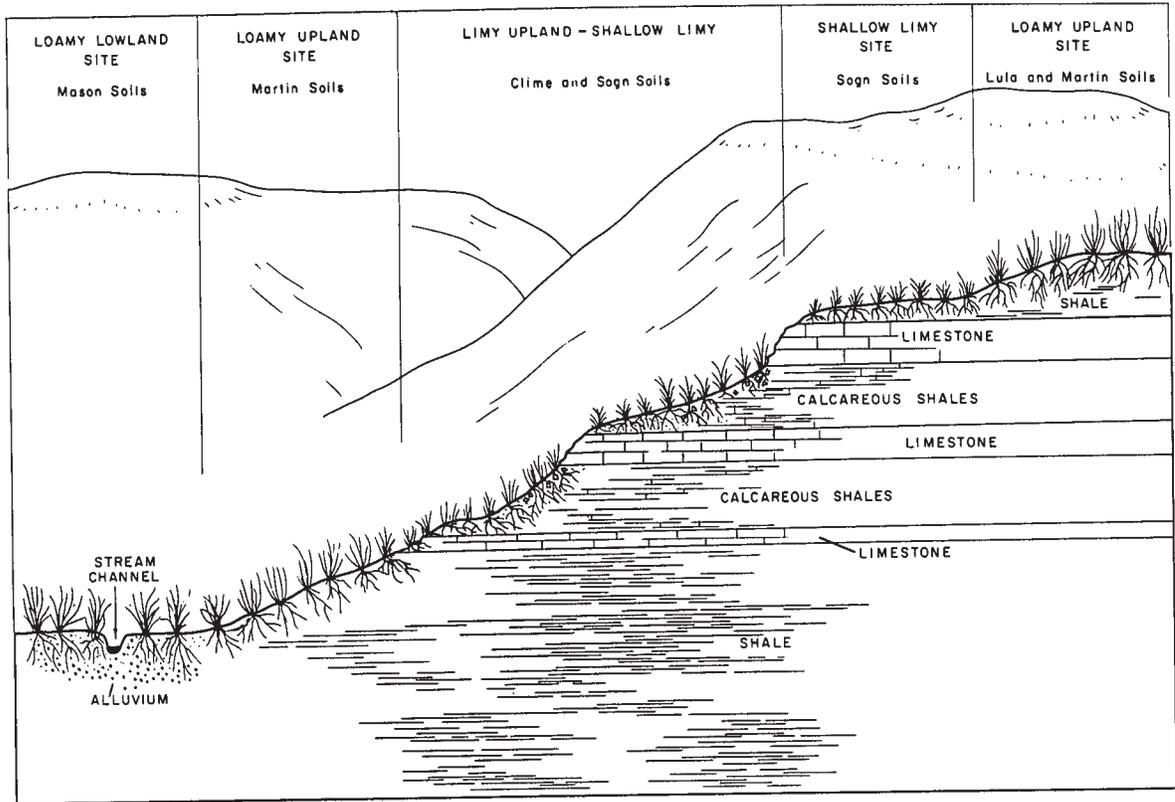
Range condition is the present state of vegetation on a site as related to the climax plant community for that site.

Range condition class indicates, in percent, the degree to which the present composition has deteriorated from that of the climax plant community. Four range condition classes are defined. Range is in *excellent* condition if 76 to 100 percent of the vegetation is characteristic of the climax vegetation on the same site; it is 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 26.

Range condition is determined in order to provide an approximate measure of change that has taken place in the plant cover and thereby provide a basis for predicting the degree of improvement possible. It is calculated by comparing present vegetation with the climax plant community. To facilitate this process,

² By LEONARD J. JURGENS, range conservationist, Emporia, Kans.

SOIL SURVEY



**Figure 15.—Top: Major range sites on limestone associated soils.
Bottom: Major range sites on sandstone associated soils.**

the kinds of vegetation are classified according to their response to the kind of grazing use on specific range sites. The plants are classified as decreasers, increasers, and invaders.

Decreasers are species in the climax plant community that decrease in relative amount under continued close grazing. This decrease usually results from excessive grazing and high animal preference for the species during the season of grazing. All decreaser species are counted in determining range condition class.

Increasers are species in the climax plant community that usually increase in relative abundance when the community is subject to continued excessive grazing. Plants that have a moderately high grazing value may initially increase and then decrease as grazing pressure continues. Others of a low, or negligible, grazing value may continue to increase in composition or in actual number. Under prolonged excessive grazing, increasers may be dominant on the site. In determining range condition, only the percentage of increaser species ordinarily in the climax vegetation is considered.

Invaders are not a part of the climax plant community. They invade the community as a result of various kinds of disturbance. They are not restricted to exotics. They can be annual or perennial and woody or herbaceous. Ordinarily they are components of the climax plant community on other range sites in the same area. Their forage value, or grazing preference, may be high or low. Invaders are not counted in determining range condition class.

The climax plant community is the native plant community best adapted to the particular environment of the site. It is fairly stable and in equilibrium with the environment, but varies within reasonable limits as the plant community responds to seasonal and annual growing conditions.

Descriptions of range sites

The 12 range sites in Chautauqua County are described on the pages that follow. Loamy Upland is the major range site in the county. Clay Upland, Loamy Lowland, and Clay Lowland occur in all parts of the county. Limy Upland, Shallow Flats, and Shallow Limy range sites are associated with soils derived from limestone. Savannah, Shallow Sandstone, and Shallow Savannah range sites are associated with soils derived from sandstone. Upland Slickspots and Lowland Slickspots range sites occur, as the names suggest, in areas of slickspots.

For a complete description of the various soils in these range sites, refer to the section "Descriptions of the Soils." The range site to which each soil in the county has been assigned is shown in the "Guide to Mapping Units" at the back of this survey.

CLAY LOWLAND RANGE SITE

The only soil in this site, Osage silty clay, is frequently flooded. It is used for native meadow. It produces approximately 10,000 pounds of air-dry forage per acre in years of favorable moisture and 4,000 pounds in years of unfavorable moisture.

The climax plant community is approximately 30 percent prairie cordgrass and 20 percent eastern gamagrass; 10 percent each of switchgrass, big bluestem, and indiagrass; and about 5 percent each of Maximilian sunflower, tall dropseed, perennial forbs, and sedges. All species furnish forage for livestock. When the range is in climax condition, half or more of the total plant community is prairie cordgrass and eastern gamagrass.

Under heavy grazing eastern gamagrass, big bluestem, and indiagrass decrease. As grazing pressure continues, prairie cordgrass and switchgrass also decrease. Tall dropseed, meadow dropseed, and ironweed increase. Sumpweed, lanceleaf ragweed, barnyardgrass, annual three-awn, and weed trees invade.

Under continued heavy grazing, the site is mainly weed trees, tall dropseed, purpletop, barnyardgrass, sumpweed, lanceleaf ragweed, three-awn, and other low-quality annual grasses and forbs, all of which are poor-quality forage.

Grazed areas are mostly in poor to fair condition. Brush and weed control along with deferred grazing is needed to restore productivity. Fencing can be considered if the site is large enough to be managed separately from surrounding sites.

CLAY UPLAND RANGE SITE

This range site consists of Eram and Kenoma soils and the eroded Dennis and Martin soils. It produces approximately 7,500 pounds of air-dry forage per acre in years of favorable moisture and 2,500 pounds per acre in years of unfavorable moisture.

The climax plant community is approximately 25 percent big bluestem, 20 percent little bluestem, 15 percent indiagrass, and 15 percent switchgrass; about 5 percent each of Virginia wildrye, side-oats grama, and tall dropseed; and no more than 3 percent each of rosette panicums, leadplant, amorphia, sedges, and perennial forbs. All species furnish forage for livestock.

Light summer grazing favors little bluestem at the expense of big bluestem. Under heavy grazing big bluestem, little bluestem, and indiagrass are replaced by tall dropseed, and to some extent by side-oats grama. Tall dropseed and heath aster increase as heavy grazing continues. Annual three-awn, annual brome, annual ragweed, and lanceleaf ragweed invade. Tall dropseed, heath aster, and annuals are dominant when the range is in poor condition.

Many cultivated fields of Martin silty clay loam, 3 to 7 percent slopes, eroded, and Dennis silty clay loam, 3 to 7 percent slopes, eroded, have been abandoned and are used for grazing. The cover is mainly annual three-awn. It provides little protection for the soil and inhibits establishment of climax vegetation. Reseeding to climax species is needed.

LIMY UPLAND RANGE SITE

This range site, along with the Shallow Limy range site in Chautauqua County, is on calcareous shales between limestone formations. It produces approximately 4,500 pounds of air-dry forage in years of favorable moisture and 2,500 pounds in years of unfavorable moisture. Clime soils, the only soils in the site, formed

in material weathered from the calcareous shales. They are calcareous within 10 inches of the surface in places, and in many areas they are calcareous at the surface.

The climax plant community is approximately 30 percent little bluestem, 20 percent big bluestem, and 15 percent side-oats grama; about 5 percent each of indiagrass, switchgrass, forb increasers, forb decreaseers, and jerseytea ceanothus; and no more than 3 percent each of hairy grama, blue grama, blacksamson, and prairie clovers. All climax species are readily grazed by livestock.

Under heavy grazing little bluestem, big bluestem, switchgrass, indiagrass, jerseytea ceanothus, and the decreaseer forbs are replaced by side-oats grama, hairy grama, and forb increasers. As heavy grazing continues, invaders, such as silver bluestem, annual brome, and annual broomweed, and forb increasers dominate in the site.

Weed control and deferred grazing are frequently needed to improve this site when it is in poor condition. Chemical weed control is not suitable. If the site is in excellent condition, 20 percent of the forage comes from forb decreaseers, prairie-clover, and jerseytea ceanothus.

LOAMY LOWLAND RANGE SITE

This range site consists of Mason and Osage silty clay loams. It is inextensive, but it is the most productive site in the county in climax condition. It provides approximately 10,000 pounds of air-dry forage per acre in years of favorable moisture and 6,000 pounds per acre in years of unfavorable moisture. Most of this acreage is in crops, introduced pasture, and native meadow used for hay.

The climax plant community is approximately 20 percent big bluestem, 20 percent eastern gamagrass, 15 percent indiagrass, and 10 percent switchgrass; about 5 percent each of prairie cordgrass, tall dropseed, sedges, forb decreaseers, forb increasers, and woody increasers; and 3 percent or less Virginia wildrye and Canada wildrye. All climax species but the forbs and woody increasers are readily grazed by livestock.

Grazed areas are usually overgrazed because they are accessible. Under heavy grazing eastern gamagrass and forb decreaseers are quickly reduced, and big bluestem, indiagrass, switchgrass, and the wildrye decline. They are replaced by buckbrush, tall dropseed, forb increasers, and weed trees. As the grazing pressure continues, a canopy of weed trees forms, and the site is reduced to annual grasses, buckbrush, green muhly, and sedges.

In many areas brush control and controlled burning are needed to restore this site. In some areas reseeding is needed to obtain adequate forage from the climax species.

LOAMY UPLAND RANGE SITE

This range site consists of Bates, Dennis, Longford, Lula, Martin, and Steedman soils. This is the largest and the most productive upland site in the county. It produces approximately 7,500 pounds of air-dry forage in years of favorable moisture and 3,500 pounds in years of unfavorable moisture.

The climax plant community is approximately 30 percent big bluestem, 25 percent little bluestem, 15 percent indiagrass, and 10 percent switchgrass; about 5 percent each of tall dropseed, forb decreaseers, and forb increasers; and no more than 3 percent each of side-oats grama and rosette panicums. All the climax vegetation is grazed by livestock.

If grazing is excessive, big bluestem, little bluestem, indiagrass, and switchgrass are replaced by tall dropseed, side-oats grama, and forb increasers. In the sandstone areas on the Bates and Dennis soils, broom-sedge, bluestem, and blackberry are the main increasers. In the limestone areas on Lula and Martin soils, blue grama and side-oats grama are the main increasers. As grazing pressure continues, the vegetation is reduced to tall dropseed, buckbrush, annual brome, annual three-awn, broomweed, annual ragweed, and other annuals.

Brush control is frequently needed before significant gains can be made in areas in poor range condition. The many abandoned crop fields on this site can be restored by seeding suitable native grasses. The sandstone rocks on the surface of Steedman soils limit mechanical practices.

LOWLAND SLICKSPOTS RANGE SITE

This range site consists only of Slickspots in areas of Mason-Slickspots complex and Osage-Slickspots complex. Based on limited clipping data, yields on a site in excellent condition are approximately 6,000 pounds of air-dry forage per acre in favorable years and 3,000 pounds in unfavorable years.

The climax plant community is 40 percent prairie cordgrass, 25 percent switchgrass, and 15 percent tall dropseed; and no more than 3 percent each of Canada wildrye, Virginia wildrye, sedge, blue grama, buffalograss, inland saltgrass, forb decreaseers, and forb increasers. All species are readily grazed by livestock.

Under heavy grazing prairie cordgrass and switchgrass are replaced by blue grama, buffalograss, saltgrass, and annual three-awn. Tall dropseed is also reduced as grazing pressure continues. In poor condition this site consists mostly of annual three-awn, lanceleaf ragweed, sumpweed, forb increasers, buffalograss, inland saltgrass, and some tall dropseed.

Livestock graze this site selectively in preference to the surrounding sites. Managing livestock is difficult because the site is so unevenly distributed. Short-term grazing is essential in maintaining and improving productivity.

SAVANNAH RANGE SITE

This range site consists of Niotaze and Stephenville soils. It produces up to 5,000 pounds of air-dry forage per acre in years of favorable moisture and 2,500 pounds in years of unfavorable moisture.

The climax plant community is approximately 25 percent big bluestem, 25 percent little bluestem, 15 percent post oak and blackjack oak, and 10 percent indiagrass; about 5 percent each of switchgrass, forb decreaseers, and woody increasers; and no more than 3 percent each of tall dropseed, Virginia wildrye, rosette panicum, and sedge. About 80 percent of the climax species furnish forage for cattle. Post oak,

blackjack oak, and the woody increasers are seldom grazed by cattle, but the sprouts are readily grazed by sheep and goats and lightly browsed by deer.

Under heavy grazing by cattle, little bluestem, big bluestem, indiagrass, and switchgrass are replaced by woody increasers, and broomsedge bluestem, purpletop, and annual grasses invade. If the site is overgrazed by goats and sheep, the woody sprouts and climax grasses are eliminated. A combination of light summer grazing by sheep and goats and moderate grazing by cattle during the dormant season is effective in maintaining the site near climax.

As the canopy cover exceeds 20 percent, the forage yield from the climax grasses is rapidly reduced.

On sites in poor to fair condition, brush control and proper grazing are needed to restore the site to excellent condition. More than 75 percent of this Savannah site is in poor to fair condition.

The following comparisons of herbage yields of trees and shrubs and of grasses and forbs, according to percent canopy coverage, are based on limited available clipping data. Herbage on trees and shrubs consists of leaves, twigs, and floral parts produced during a growing season.

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

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

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

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

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

SHALLOW FLATS RANGE SITE

This site consists of Claerson soils. It produces approximately 5,000 pounds of air-dry forage per acre in favorable years and 2,500 pounds in unfavorable years.

The climax plant community is approximately 30 percent little bluestem, 15 percent big bluestem, 15 percent side-oats grama, and 10 percent indiagrass; and about 5 percent each of switchgrass, tall dropseed, blue grama, hairy grama, forb decreaseers, forb increasers, and woody increasers. All the forage but the woody increasers is grazed by cattle.

Excessive grazing causes a decrease in big bluestem, indiagrass, switchgrass, and little bluestem and an increase in side-oats grama, tall dropseed, woody increasers, and forb increasers. Annual grasses, broomweed, buckbrush, and silver bluestem invade.

Continued heavy grazing reduces the plant composition to broomweed, silver bluestem, annual three-awn, annual brome, sumac, skunkbush, buckbrush, and other woody invaders. Brush control and deferred grazing are essential in restoring the site because tillage is not feasible.

SHALLOW LIMY RANGE SITE

This site consists of Sogn soils, and also Sogn soils mapped with Claerson and Clime soils. It produces approximately 3,500 pounds of air-dry forage per acre in years of favorable moisture and 1,500 pounds in unfavorable years.

The climax plant community is approximately 25 percent side-oats grama, 20 percent little bluestem, 10 percent blue grama, and 10 percent big bluestem; and about 5 percent each of indiagrass, switchgrass, buffalograss, hairy grama, forb decreaseers, forb increasers, and woody increasers. Woody increasers are not grazed by cattle.

Plant composition changes rapidly if the site is overgrazed. Indiagrass, little bluestem, switchgrass, and forb decreaseers are replaced by buffalograss, blue grama, and hairy grama. Side-oats grama increases slowly, but declines if grazing pressure continues and increases.

If the site is in poor condition, the plant cover is mainly silver bluestem, buffalograss, hairy grama, smooth sumac, skunkbush, annual brome, and prickly-pear. Good range management is essential. Crossing this site in vehicles is difficult because up to 20 percent of the surface area is limestone bedrock outcroppings.

SHALLOW SANDSTONE RANGE SITE

This range site (see figure 15, bottom) consists of Collinsville soils, which are mapped with Eram soils. It produces approximately 4,000 pounds of air-dry forage per acre in years of favorable moisture and 2,000 pounds in years of unfavorable moisture.

The climax plant community is approximately 30 percent little bluestem, 25 percent big bluestem, 10 percent indiagrass, and 10 percent switchgrass; about 5 percent each of forb decreaseers, forb increasers, and woody increasers; and no more than 3 percent each of rosette panicums, broomsedge, bluestem, purple lovegrass, and sedge. All but the woody plants are grazed by cattle. Sheep and goats readily utilize the woody species.

If the site is overgrazed by cattle, blackberry, sumac, broomsedge, and purple lovegrass increase, and annual brome, annual three-awn, annual broomweed, lanceleaf ragweed, and purpletop invade. As grazing pressure continues, the plant cover degenerates to woody shrubs, broomsedge bluestem, purpletop, annual grasses, and some forb increasers.

Overgrazing by sheep and goats eliminates forbs and woody species, and only broomsedge bluestem, purple lovegrass, purpletop, and annual grasses remain. Using mechanical equipment is difficult because small sandstone rocks are on the surface and in the soil. In most places brush control and deferred grazing during the growing season restore a site in poor or fair condition to good or excellent condition.

SHALLOW SAVANNAH RANGE SITE

This range site consists only of Darnell soils, which are shallow over sandstone. Many sandstone rocks are at or near the surface, and large boulders occur in some areas. This site produces approximately 3,500 pounds of air-dry forage in favorable years and 1,500

pounds in unfavorable years. Yields are highly variable.

The climax plant community is approximately 35 percent little bluestem, 20 percent post oak and black oak, and 10 percent big bluestem; about 5 percent each of indiangrass, forb decreaseers, forb increaseers, and woody increaseers; and no more than 3 percent each of switchgrass, Virginia wildrye, Canada wildrye, tall dropseed, rosette panicum, and sedge. In climax condition, about 75 percent of the forage is grazed by cattle. Post oak, black oak, and the woody increaseers are seldom grazed by cattle. Oak sprouts are lightly browsed by deer but are readily grazed by sheep and goats. Woody species decrease if grazed by sheep and goats.

Under heavy grazing by cattle, little bluestem, big bluestem, indiangrass, switchgrass, and forb decreaseers are replaced by blackberry, sumac, buckbrush, broomsedge bluestem, purpletop, and annuals. Under continued heavy grazing, post oak and blackjack oak form a dense canopy, and very small amounts of sedge, buckbrush, purpletop, and shade tolerant annuals are in the understory. Overgrazing by sheep and goats eliminates oak sprouts, most forbs, and many climax grasses.

If the site is grazed only by cattle, brush control is needed to maintain the vegetation near climax. A combination of light summer grazing by sheep and goats and moderate grazing by cattle in the dormant season is effective in keeping the site near climax. Brush control is needed to restore sites in poor to fair condition to excellent condition.

The following comparisons of herbage yields of trees and shrubs and of grasses and forbs, according to percent canopy coverage, are based on limited clipping data. Herbage on trees and shrubs consists of leaves, twigs, and floral parts produced during a growing season.

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

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

Under 51 to 75 percent canopy, the yield is 60 to 90 percent for trees and shrubs and 10 to 35 percent for grasses and forbs.

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

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

UPLAND SLICKSPOTS RANGE SITE

This range site consists only of slickspots mapped with Dennis and Martin soils. It produced approximately 4,000 pounds of air-dry forage per acre in years of favorable moisture and 1,500 pounds in years of unfavorable moisture.

The climax plant community is approximately 20 percent switchgrass, 15 percent side-oats grama, 15 percent little bluestem, 10 percent tall dropseed, and 10 percent western wheatgrass; 5 percent each of blue grama, buffalograss, sedges, forb decreaseers, and forb

increaseers; and no more than 3 percent each of Virginia wildrye and Canada wildrye. In places buffalograss and blue grama are not part of the climax vegetation. All areas are accessible.

Species composition is mainly affected by the various degrees of alkalinity and salinity. Livestock frequently concentrate in the alkali- and saline-affected areas.

Under heavy grazing, degeneration is rapid. Little bluestem, switchgrass, and side-oats grama are replaced by blue grama and buffalograss, and tall dropseed, western ragweed, and annual grasses invade. Tall dropseed, annual three-awn, annual brome, annual dropseed, and lanceleaf ragweed are dominant on severely overgrazed sites.

This range site responds slowly to management, but it provides excellent forage under a planned grazing system.

Management of Soils for Crops

The management needed for cultivated crops on the soils of Chautauqua County consists of maintaining or improving the organic-matter content, soil tilth, and subsoil permeability; supplying essential nutrients for plant growth; preventing soil compaction and increasing water infiltration at the soil surface; and removing excessive surface water.

Growing crops in a proper sequence or rotation maintains or increases the supply of organic matter and improves soil tilth and water infiltration into the soil. Including a legume that has a strong tap root, for example, alfalfa or sweetclover, increases permeability of the subsoil.

The application of lime and fertilizer adjusts the soil acidity and provides the essential nutrients for plant growth. The kind and amount are determined by accepted field sampling and soil testing.

Minimum tillage reduces the amount of fieldwork needed and avoids compaction of the surface layer. Keeping a protective cover of crop residue on the soil surface during critical erosion periods and farming on the contour increase water intake at the soil surface.

Diversions, gradient terraces, land smoothing, and field ditches remove excess surface water. Diversions and gradient terraces are used on sloping uplands to intercept and divert runoff from higher areas and reduce the risk of erosion. Land smoothing and drainage field ditches are needed in removing the excess water from poorly drained alluvial soils. Drainage allows the soil to dry out and favors fieldwork.

Grade stabilization structures are used on stream-banks and terrace escarpments to lower surface water into natural channels and prevent the formation of gully heads caused by concentration of surface water.

The proper combination of practices conserves the maximum amount of moisture and helps control erosion. The characteristics of the soil determine the kinds of practices needed for each mapping unit.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops.

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

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

In the capability system, all kinds of soil are grouped at three levels: the class, the subclass, and the unit. The broadest grouping, the capability class, is designated by Roman numerals I to VIII. In class I are the soils that have the fewest limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products. The subclass indicates major kinds of limitations within the classes. Within most of the classes there can be up to four subclasses. The subclasses are indicated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter "e" shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; "w" means that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); "s" shows that the soil is limited mainly because it is shallow, droughty, or stony; and "c" indicates that the chief limitation is climate that is too cold or too dry.

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

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 IIIs-4.

For a complete explanation of the capability classification, see Department of Agriculture Handbook 210 (5).

The eight classes in the capability system and the subclasses and units in Chautauqua County are described in the list that follows. The unit designation is given in the Guide to Mapping Units. Management for each soil in the county is suggested in the mapping unit descriptions.

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

Unit I. Deep, nearly level, well-drained soils that are loamy throughout; on 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. Moderately deep, gently sloping, well-drained soils that are loamy throughout; on uplands.

Unit IIe-2. Moderately deep to deep, gently sloping, moderately well drained and well drained soils that have a loamy surface layer and a clayey subsoil; on uplands.

Unit IIe-3. Deep, nearly level to gently sloping, well-drained soils that are loamy throughout; on uplands.

Subclass IIw. Soils moderately limited by excess water.

Unit IIw-1. Deep, nearly level to gently sloping, moderately well drained and well drained soils that are loamy throughout; on bottom lands.

Unit IIw-2. Deep, nearly level, somewhat poorly drained soils that are clayey throughout; on stream terraces.

Subclass IIIs. Soils moderately limited by a restricted root zone.

Unit IIIs-1. Deep, nearly level, moderately well drained soils that have a loamy surface layer and a clayey subsoil; on uplands.

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

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

Unit IIIe-1. Deep, sloping, moderately well drained soils that have a loamy surface layer and a clayey subsoil; on uplands.

Unit IIIe-2. Deep, sloping, moderately well drained, eroded soils that have a loamy surface layer and a clayey subsoil; on uplands.

Unit IIIe-3. Deep, gently sloping, well-drained, eroded soils that have a loamy surface layer and a clayey subsoil; on uplands.

Subclass IIIw. Soils severely limited by excess water.

Unit IIIw-2. Deep, nearly level, poorly drained soils that are clayey throughout; on bottom lands.

Subclass IIIIs. Soils severely limited by a restricted root zone.

Unit IIIIs-1. Moderately deep, nearly level to gently sloping, well-drained soils that have a loamy surface layer and a stony, clayey subsoil; on uplands.

Unit IIIIs-2. Deep, nearly level, well-drained soils mapped with slickspots; on stream terraces.

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

Subclass IVs. Soils very severely limited by a restricted root zone.

Unit IVs-1. Deep, gently sloping, moderately well drained soils mapped with slickspots; on uplands.

Unit IVs-2. Deep, nearly level, somewhat poorly drained soils mapped with slickspots; on stream terraces.

Class V. Soils 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 food and cover. (None in Chautauqua County.)

Class VI. Soils have severe limitations that make them generally unsuitable for cultivation and restrict their use largely to grazing, woodland, or wildlife.

Subclass VIe. Soils severely limited by erosion.

Unit VIe-1. Moderately deep and shallow, gently sloping to steep, moderately well drained to excessively drained soils that have a loamy surface layer and a loamy or clayey subsoil; on uplands.

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

Subclass VIIs. Soils very severely limited by a restricted root zone.

Unit VIIs-1. Moderately deep and shallow, strongly sloping, somewhat poorly drained and excessively drained soils that have a cobbly and stony loamy surface layer and a loamy or clayey subsoil; on uplands.

Unit VIIs-2. Shallow, gently sloping, somewhat excessively drained loamy soils that have stones and exposed bedrock on the surface; on uplands.

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

Predicted yields

The predicted average yields per acre that can be expected from the principal crops grown in the county are shown in table 2. They do not apply to any specific field in any particular year. They indicate the expected average yield over a period of years. The predictions in the table were based on information obtained from local farmers, various agricultural agencies, demonstration plots, and research data. Only the soils commonly used for crops are listed in the table.

The yields predicted are those to be expected under improved management. This kind of management consists of—

1. Planting crop varieties that are suited to the area.
2. Seeding at the proper rates and using suitable and timely methods of planting and harvesting.

3. Controlling weeds, diseases, and insects.
4. Timely tillage.
5. Applying fertilizer in amounts based on requirements for optimum yields.
6. Establishing terraces and grassed waterways, farming on the contour, and using stubble-mulch tillage and summer fallow to conserve moisture and control runoff.
7. Choosing cropping systems and managing crop residue to control water erosion and soil blowing and to keep the soil in good tilth.

Management of Soils for Woodland³

In 1970, about 22 percent of the county, or 91,300 acres, in Chautauqua County was wooded. More than 80 percent of this wooded acreage is used for grazing.

About 71,300 acres of woodland is on uplands throughout the eastern half of the county. The rest is on bottom land along all the streams in the county. These bottom-land tracts are small, but are well suited to trees (fig. 16).

The upland woodland consists of oak and hickory and an understory of grasses, commonly referred to as savannah type vegetation. Blackjack and post oaks produce more than 90 percent of the annual wood crops. All the rest is from hickory and red oak. Little and big bluestem produce 75 percent of the annual grass yield. The rest is from indiagrass, sedges, switchgrass, Virginia wildrye, rosette panicum, and a wide variety of lesser species.

Total herbage yields, by types of vegetation, vary according to the canopy coverage. If the canopy coverage is between 0 and 25 percent, trees produce 5 to 30 percent of the total herbage yield. If the canopy coverage is 76 to 100 percent, they produce 90 to 95 percent of the total herbage yield. More detailed information about canopy coverage is in the section on range management under the Savannah and the Shallow Savannah range sites.

The soils in Chautauqua County have been assigned to five woodland groups. 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.

Table 3 shows, by woodland groups, the potential productivity of specified trees and soil-related limitations in management. The woodland group designation for each soil is shown in the Guide to Mapping Units at the back of this survey.

Some of the terms used in table 3 are defined as follows.

Potential productivity for wood crops is expressed as *site index*, which is the average height, in feet, of the dominant and codominant species at the age of 50 years. The site indexes shown in table 3 were evaluated on only a few sites for each group.

Seedling mortality refers to the expected degree of mortality of naturally occurring or planted seedlings as influenced by soil texture, depth, drainage, flooding, water table, and degree of erosion. Mortality is *slight*

³ Prepared by LEONARD J. JURGENS, range conservationist, Soil Conservation Service.

TABLE 2.—Predicted average yields per acre of principal crops grown under improved management

[Absence of figure indicates that the soil is not suited to the crop or that the crop is not commonly grown.
Only the soils suitable for crops and pasture are listed]

Soil name	Wheat	Alfalfa	Grain sorghums	Tall fescue	Brome-grass	Bermuda-grass
	Bu	Tons	Bu	AUD ¹	AUD ¹	AUD ¹
Bates fine sandy loam, 1 to 4 percent slopes.....	38	3.1	55	165	165	195
Clareson silty clay loam, 0 to 2 percent slopes.....	22			150		150
Cleora fine sandy loam.....	34	4.4		240	240	255
Dennis silt loam, 1 to 3 percent slopes.....	42	3.9	75	195	180	225
Dennis silt loam, 3 to 7 percent slopes.....	38	3.5	70	180	165	210
Dennis silty clay loam, 3 to 7 percent slopes, eroded.....	28	3.1	55	150		150
Dennis-Slickspots complex.....	25			105		120
Eram silty clay loam, 1 to 3 percent slopes.....	28	2.6	50	180	150	195
Ivan silt loam.....	44	5.0		240	240	240
Kenoma silt loam.....	34	3.0	56	180		150
Longford silty clay loam, bedrock substratum, 1 to 4 percent slopes.....	32	2.6	57	180	165	180
Longford silty clay loam, bedrock substratum, 1 to 4 percent slopes, eroded.....	30	2.4	45	150		150
Lula silt loam, 0 to 2 percent slopes.....	33	3.0	65	180	180	210
Martin silty clay loam, 0 to 1 percent slopes.....	44	3.4	80	225		225
Martin silty clay loam, 1 to 4 percent slopes.....	40	3.3	79	225	180	225
Martin silty clay loam, 4 to 7 percent slopes.....	33	3.2	74	210	165	210
Martin silty clay loam, 3 to 7 percent slopes, eroded.....	23	2.7	52	150		120
Martin-Slickspots complex.....	32			105		120
Mason silt loam.....	44	4.5	80	220	220	240
Mason-Slickspots complex.....	35		58	150		180
Osage silty clay loam.....	39	4.0	70	165	150	210
Osage silty clay.....	34		58	135		165
Osage-Slickspots complex.....	33			105		120
Stephenville fine sandy loam, 1 to 4 percent slopes.....	34	2.7	58	165	165	195
Verdigris silt loam.....	41	4.6		240	240	240

¹ Animal-unit-day. The figures represent the number of days that 1 acre will provide grazing for one animal (1,000 pounds live weight).

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 in woodland where normal practices are used in management and harvesting trees. It is *slight* if erosion control is not an important concern; *moderate* if some attention must be given to check soil losses; and *severe* if special management is needed.

Windthrow hazard depends on the development of roots and the capacity of soil to hold trees firmly. The hazard is *slight* if windthrow is no special concern; *moderate* if roots hold the trees firmly, except when soil is excessively wet; and *severe* if many trees may be blown over because 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 management is intensive.

The rating for *equipment limitations* is based on the degree that soils and topographic features restrict or prohibit the use of equipment normally used 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 equipment 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 needed or if the use of such equipment is severely restricted by one or more unfavorable soil characteristics.

Management of Soils for Wildlife⁴

A significant concept now commonly accepted is multiple use of land. This policy was first applied mainly to public property, such as the national forests. Its application to other types of ownership, however, has become progressively evident. Wildlife is a resource, commonly of secondary value in land-use economics, and its status and utilization as a land and water product generally depend on effective multiple use.

Many species of wildlife, for example, deer, rabbits, turkeys, and grouse, require variety in their ranges. They make extensive use of openings in the forest canopy and benefit from a suitable combination of plants, topography, soil, and climate. The need for interspersed habitat among areas used for other purposes is an accepted principle among wildlife managers. Meeting this need is a basic objective in developing productive land-use practices.

Table 4 rates the potential of each of the six soil associations for producing food and cover for various kinds of wildlife in the county. The soil associations, shown on a map at the back of this survey, are described in the section "General Soil Map."

⁴ JACK W. WALSTROM, biologist, Soil Conservation Service.

TABLE 3.—Woodland suitability groups,
[Only soils suitable]

Woodland suitability group and map symbols	Potential productivity		Hazards or limitations	
	Species	Site index range	Seedling mortality	Erosion hazard
Group 1: Deep, well drained and moderately well drained, gently sloping soils on flood plains; subject to annual flooding. Ct, Iv, Ve.	Black walnut.....	71-85	Slight.....	Slight.....
	Bur oak.....	56-70		
	Red oak.....	56-70		
	Green ash.....	71-85		
	Cottonwood.....	71-85		
	Pecan.....	71-85		
Group 2: Deep, poorly drained, nearly level soils on flood plains; subject to annual flooding. Oa, Oc, Os.	Pecan.....	71-85	Moderate.....	Slight.....
	Bur oak.....	40-55		
	Green ash.....	56-70		
Group 3: Deep, well-drained, nearly level soils on terraces. Mt, Mx.....	Black walnut.....	56-70	Slight.....	Slight.....
	Bur oak.....	40-55		
	Green ash.....	56-70		
	Cottonwood.....	56-70		
Group 4: Moderately deep, well-drained and somewhat poorly drained, gently to strongly sloping soils on uplands. Niotaze soil in Nd; Sv; Stephenville soil in Sx.	Post oak.....	40-55	Slight.....	Moderate.....
	Blackjack oak.....	40-55		
	Red oak.....	40-55		
	Hickory.....	40-55		
Group 5: Shallow, excessively drained, sloping soils on uplands. Darnell soil in Nd and Sx.	Post oak.....	40-55	Severe.....	Moderate.....
	Blackjack oak.....	40-55		
	Hickory.....	40-55		

The bobwhite quail is the most popular upland game bird in the county. The highest population of these birds occurs on the Osage-Mason, Verdigris-Mason, and Mason-Ivan soil associations. The areas of field crops interspersed with areas of riparian timber and areas of brush and shelterbelts provide year-round habitat.

The white-tailed deer is increasing in number throughout the county. It finds habitat on the same soil associations as the bobwhite quail. Also density is fairly high on the Niotaze-Stephenville-Darnell soil association. These associations also provide suitable habitat for fox, grey and flying squirrels, coyote, rabbit, skunk, raccoon, and opossum, as well as large numbers and varieties of songbirds and insectivorous birds.

Prairie chickens are plentiful on the Steedman-Dennis-Eram and Clime-Martin-Sogn soil associations, along with meadowlarks, prairie hawks, badgers, and prairie dogs.

Waterfowl, beaver, muskrats, mink, and raccoon are abundant on the Verdigris-Mason, Mason-Ivan, Osage-Slickspot-Verdigris, and Osage-Mason soil associations. They are also common near sites of watershed flood control structures on various soil associations throughout the county. These ponds and reservoirs and all permanent streams and rivers also provide good to excellent fishing and other forms of recreational opportunities. Information and assistance in planning and developing wildlife habitat can be obtained from the local office of the Soil Conservation Service; the Forestry, Fish and Game Commission; the Fish and Wild-

life Service; and the County Extension Service.

Openland wildlife are birds and mammals that normally frequent croplands, pastures, meadows, lawns, and areas overgrown with grasses, herbs, and shrubby growth. Examples are quail, prairie chicken, pheasants, meadowlarks, field sparrows, redwing blackbirds, cottontail rabbits, red foxes, ground squirrel, and marmots.

Woodland wildlife are birds and mammals that normally frequent wooded areas or hardwood trees and shrubs, coniferous trees and shrubs, or mixtures of such plants. Examples of woodland wildlife are thrushes, vireos, fox squirrel, red fox, white-tailed and mule deer, and raccoons.

Wetland wildlife are birds and mammals that normally frequent wet areas, such as ponds, streams or ditches, marshes, and swamps. Examples are wood ducks, herons, shore birds, mallards, pintails, mink, muskrats, and beavers.

Management of Soils for Recreational Purposes⁵

The small watershed program in Chautauqua County has created approximately 50 pond and reservoir sites ranging from 6 to 472 surface acres in size. Several of these were designed as multipurpose sites to furnish water supplies for the cities of Sedan and Caney. A

⁵ By JACK W. WALSTROM, biologist, Soil Conservation Service, Salina, Kans.

wood crops, and factors in management

for trees are listed]

Hazards or limitations—Continued			Species to be—	
Windthrow hazard	Plant competition	Equipment limitations	Favored in existing stands	Used for planting
Slight.....	Moderate....	Slight.....	Black walnut, cottonwood, pecan, green ash, hackberry, soft maple, sycamore, bur oak, and red oak.	Black walnut, green ash, hackberry, pecan, sycamore, and soft maple.
Slight.....	Severe.....	Moderate....	Pecan, green ash, soft maple, bur oak and red oak.	Pecan, green ash, and hackberry.
Slight.....	Moderate....	Slight.....	Black walnut, pecan, green ash, hackberry, soft maple, bur oak, and red oak.	Black walnut, green ash, hackberry, pecan, and soft maple.
Slight.....	Moderate....	Moderate....	Post oak, and red oak.....	Shortleaf pine, green ash, Scotch pine, and pin oak.
Moderate....	Slight.....	Moderate....	Post oak.....	Shortleaf pine.

few of the watershed reservoirs have been developed by private interests for public and private recreation (fig. 17).

The Quivera Scout Ranch, 10 miles north of Sedan, is a 2,900-acre wilderness camp around a 472-acre lake. A 985-acre tract, Oakridge, provides a scenic recreation area of several ponds, vacation homes, and lodges. Another recreational opportunity in the county is provided by the scenic and historic trail of the Redbud Tour.

The degree and kind of limitation to be considered in planning specified recreational facilities are shown in table 5.

The ratings for picnic areas in table 5 are based on the features of the soil. Lakes, trees, and scenic beauty, all of which affect the desirability of the site, were also considered.

Playgrounds are for organized games, such as baseball, football, and badminton. A playground should have good drainage and a nearly level, rock-free surface. It is assumed that good plant cover can be established and maintained where needed.

Trails and paths refer to trails for cross-country hiking, bridle paths, and other nonintensive activities. The need for grading and shaping to any great extent is not anticipated. The ratings are based on soil features only. Other factors important in selecting a site were not considered.

Engineering Uses of Soils⁶

This section provides information of special interest to engineers, contractors, farmers, and others who use soil as structural material or as foundation material upon which structures are built. Some soil properties are of special interest to engineers because they affect construction and maintenance of roads and airports, pipelines, building foundations, water storage facilities, erosion control structures, drainage systems, and sewage disposal systems. Among the soil properties most important in engineering are permeability, shear strength, density, shrink-swell potential, available water capacity, grain-size distribution, plasticity, and reaction.

Information concerning these and related soil properties is given in tables 6, 7, and 8. The estimates and interpretations of soil properties in these tables can be used in—

1. Planning and designing farm drainage systems, farm ponds, irrigation systems, terraces, and other structures for controlling water and conserving soil.
2. Selecting potential locations for highways, airports, pipelines, and underground cables.
3. Locating probable sources of sand, gravel, or rock suitable for use as construction material.

⁶ By ROY N. SELBY and CHARLES D. CHEEK, civil engineers, and ELBERT L. BELL, soil scientist, Soil Conservation Service.



Figure 16.—Black walnut sawlogs ready for shipment to a mill. The logs were sawed from trees on Verdigris silt loam along the Little Caney River.

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

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

Some terms have special meanings in soil science that may not be familiar to engineers. Such terms are defined in the Glossary.

Engineering classification systems

The two systems most commonly used in classifying soil horizons for engineering are the AASHO system (1) adopted by the American Association of State Highway Officials and the Unified system (11) used by the SCS engineers, the Department of Defense, and others. The explanations that follow are largely from the PCA Soil Primer (7).

In the AASHO system all soil material is classified

in seven basic groups according to those properties that affect use in highway construction. The groups range from A-1 through A-7, based on grain-size distribution, liquid limit, and plasticity index. In group A-1 are soils that have the highest bearing strength and are the best soils for subgrade, or foundation. In group 7 are soils that have the lowest strength when wet. 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; and A-7-5, A-7-6. If soil material is near a classification boundary, it is given a symbol showing both classes, for example, A-2 or A-4. Within each group, the relative engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 for the poorest. The AASHO classification for tested soils, index numbers in parentheses, is shown in table 8. The estimated classification for all soils mapped in the survey area is shown in table 6.

In the Unified system, soils are identified according to particle-size distribution, liquid limit, plasticity index, and organic matter. Soils are grouped into 15 classes. There are four classes of coarse-grained soils,



Figure 17.—Bee Creek Lake, first of the watershed reservoirs in Chautauqua County, provides excellent recreation.

GW, GP, SW, SP; four classes of fine-grained soils, CL, ML, CH, MH; four combinations of coarse- and fine-grained soils, GC, GM, SC, SM; and three classes of organic soils, OL, OH, and Pt. Soils on the borderline between two classes are designated by the symbol for both classes; for example, CL-ML.

Soil properties significant in engineering

Table 6 provides estimates of soil properties important in engineering. The estimates are based on laboratory data in table 8, on field descriptions, on test data from similar soils in adjacent areas, and on detailed experience in working with the individual kinds of soil in the survey area.

Following are explanations of some of the columns in table 6.

Depth to bedrock is measured from the surface of the soil to the upper surface of the rock layer.

USDA texture is determined by the relative proportions of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Sand," "silt," "clay," and some of the other terms used in the USDA textural classification are defined in the Glossary.

Permeability relates only to the movement of water downward through uncompacted soil, not to lateral

seepage. The estimates are based on structure and porosity of the soil. Plowpans, surface crusts, and other properties resulting from use of the soils are not considered.

Available water capacity is the capacity of a soil to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants.

Reaction is the degree of acidity or alkalinity of a soil, expressed as a pH value. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential indicates the change in volume to be expected in soil material with changes in moisture content. Shrinking and swelling cause much damage to building foundations, roads, and other structures. A *high* shrink-swell potential indicates a hazard to the maintenance of structures built in, on, or with such materials.

Engineering interpretations

Table 7 contains information useful to engineers and others who plan to use soil material in constructing highways, farm facilities, buildings, and sewage dis-

TABLE 4.—Potential of soil associations for providing wildlife habitat

Soil association	Wildlife	Potential for producing kinds of habitat			
		Woody	Herbaceous	Aquatic	Food
Steedman-Dennis-Eram	Upland	Fair	Good	Fair	Good.
	Woodland	Fair	Good	Fair	Good.
	Wetland	Fair	Good	Fair	Fair.
Niotaze-Stephenville-Darnell	Upland	Fair	Fair	Fair	Good.
	Woodland	Good	Fair	Fair	Good.
	Wetland	Fair	Fair	Fair	Good.
Clime-Martin-Sogn	Upland	Good	Good	Fair	Good.
	Woodland	Fair	Good	Fair	Fair.
	Wetland	Fair	Good	Fair	Fair.
Osage-Mason	Upland	Good	Good	Good	Good.
	Woodland	Good	Good	Good	Good.
	Wetland	Good	Good	Good	Good.
Verdigris-Mason	Upland	Good	Good	Good	Good.
	Woodland	Good	Good	Good	Good.
	Wetland	Good	Good	Good	Good.
Mason-Ivan	Upland	Good	Good	Good	Good.
	Woodland	Good	Good	Good	Good.
	Wetland	Good	Good	Good	Good.

posal systems. Detrimental or undesirable features are emphasized, but important desirable features are also mentioned. The interpretations in this table are based on the estimates of soil properties in table 6; on available test data, including those in table 8; and on field experience.

The degree of limitation of the soil for sewage disposal, shallow excavations, foundations, and sanitary landfill is defined as *slight*, *moderate*, or *severe*. Septic tank absorption fields are generally affected by permeability, height of the water table, and susceptibility of the undisturbed soil to flooding.

Sewage lagoons are influenced chiefly by permeability, height of the water table, and slope.

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

Foundations for low buildings are affected chiefly by features of the undisturbed soil that influence its capacity to support low buildings of normal foundation loads. Specific values of bearing strength are not assigned. Cleora, Ivan, and Verdigris soils have a seasonal high water table and are subject to flooding.

Sanitary landfills trench type and area type, are methods of handling refuse. The trench type is a dug trench in which refuse is buried. In the area type the refuse is placed in successive layers on the surface of the soil and then covered with a layer of soil material. Limitations are based on soil qualities and characteristics that affect such use. The suitability of a soil as sanitary landfill cover material is based on soil properties that reflect workability and ease of digging, moving, and spreading the soil material over the refuse daily.

Topsoil is a term used to designate a fertile soil or soil material, ordinarily rich in organic matter, used as topdressing for lawns, gardens, roadbanks, and the like. Only the surface layer is considered, unless otherwise stated.

Ratings for sand and gravel are based on the probability that delineated areas of the soil contain deposits of sand and gravel. The ratings in table 7 indicate source, not the quality or the size of the deposits.

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

Road fill is material used to build the embankment that supports the subgrade of a highway. Suitability is based on the performance of the soil material when excavated and used for road fill.

Highway location is influenced by features of the undisturbed soil that affect construction and maintenance of highways. Both favorable and unfavorable features affecting geographic location of highways are considered. It should be assumed that the surface layer in which the content of organic matter is high will be removed in construction.

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

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

TABLE 5.—*Degree and kind of limitations for recreational facilities*

Soil series and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Bates: Ba.....	None to slight.....	None to slight.....	Slight to moderate: slopes of 1 to 4 percent.	None to slight.
Clareson: Ca, Cs..... For Sogn part of Cs, see Sogn series.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Cleora: Ct.....	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.
Clime: Cx..... For Sogn part of Cx, see Sogn series.	Severe: slopes of 8 to 30 percent; silty clay surface layer.	Severe: slopes of 8 to 30 percent; silty clay surface layer.	Severe: slopes of 8 to 30 percent; silty clay surface layer.	Severe: slopes of 8 to 30 percent; silty clay surface layer.
Collinsville..... Mapped only with Eram soils.	Severe: 10 percent of surface area is sandstone outcrop.	Severe: 10 percent of surface area is sandstone outcrop.	Severe: 10 percent of surface area is sandstone outcrop.	Severe: 10 percent of surface area is sandstone outcrop.
Darnell..... Mapped only with Stephenville and Niotaze soils.	Severe: 10 to 15 percent of surface area is sandstone outcrop.	Severe: 10 to 15 percent of surface area is sandstone outcrop.	Severe: 10 to 15 percent of surface area is sandstone outcrop.	Severe: 10 to 15 percent of surface area is sandstone outcrop.
Dennis: Db, Dc, Dø, Ds.....	Moderate: moderately well drained; slow permeability.	Moderate: moderately well drained.	Moderate: moderately well drained; slow permeability; slopes of 1 to 7 percent.	None to slight.
Eram: Ea, Ec..... For Collinsville part of Ec, see Collinsville series.	Moderate: moderately well drained; slow permeability; silty clay loam surface layer.	Moderate: moderately well drained; silty clay loam surface layer.	Moderate: moderately well drained; slow permeability; slopes of 1 to 7 percent.	Moderate: silty clay loam surface layer.
Ivan: Iv.....	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.
Kenoma: Ke.....	Severe: very slow permeability.	Moderate: moderately well drained.	Severe: very slow permeability.	Moderate: moderately well drained.
Longford: Ln, Lo.....	Moderate: moderately slow permeability; silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: moderately slow permeability; slopes of 1 to 4 percent; silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Lula: Lu.....	None to slight.....	None to slight.....	None to slight.....	None to slight.
Martin: Ma, Mb, Mc, Me, Ms.....	Moderate: moderately well drained; slow permeability; silty clay loam surface layer.	Moderate: moderately well drained; silty clay loam texture.	Moderate: moderately well drained; slow permeability; slopes of 0 to 7 percent; silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Mason: Mt, Mx.....	None to slight.....	None to slight.....	None to slight.....	None to slight.
Niotaze: Nd..... For Darnell part, see Darnell series.	Severe: slopes of 8 to 20 percent; 40 percent of surface layer is stones.	Severe: slopes of 8 to 20 percent; 40 percent of surface layer is stones.	Severe: slopes of 8 to 20 percent; 40 percent of surface layer is stones.	Severe: 40 percent of surface layer is stones.
Osage: Oa, Oc, Os.....	Severe: poorly drained; subject to flooding; silty clay surface layer.	Severe: poorly drained; subject to flooding; silty clay surface layer.	Severe: poorly drained; subject to flooding; silty clay surface layer.	Severe: poorly drained; subject to flooding; silty clay surface layer.
Sogn: So.....	Moderate: silty clay surface layer; 15 percent of surface area is limestone bedrock.	Moderate: silty clay surface layer; 15 percent of surface area is limestone bedrock.	Moderate: silty clay surface layer; 15 percent of surface area is limestone bedrock.	Moderate: silty clay surface layer; 15 percent of surface area is limestone bedrock.
Steedman: St.....	Severe: slopes of 8 to 20 percent; 40 percent of surface layer is stones.	Severe: slopes of 8 to 20 percent; 40 percent of surface layer is stones.	Severe: slopes of 8 to 20 percent; 40 percent of surface layer is stones.	Severe: 40 percent of surface layer is stones.

TABLE 5.—Degree and kind of limitations for recreational facilities—Continued

Soil series and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Stephenville: Sv, Sx..... For Darnell part of Sx, see Darnell series.	None to slight.....	None to slight.....	Moderate: slopes of 1 to 4 percent.	None to slight.
Verdigris: Ve.....	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.

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

Factors that affect the suitability of a soil for irrigation are available water capacity, depth, water-intake rate, drainage, and flooding.

Salinity, shown by a white salt crust on the surface, occurs in small areas or in spots on some soils in Chautauqua County during wet periods. Saline areas are numerous in the areas of slickspots mapped with Dennis, Martin, Mason, and Osage soils. The origin of soluble salts is explained under "Parent material" in the section Factors of Soil Formation in this survey.

The degree of salinity is based on the electrical conductivity of the saturated soil extract. It is expressed in millimhos per centimeter (mmhos/cm) at 25° C. According to the extensive testing during this survey, salinity in the areas having a white salt crust ranged from low, 2.0 to 4.0 millimhos per centimeter, to high, 8.0 to 16.0 millimhos per centimeter.

Corrosion of uncoated steel is a problem in some soils in Chautauqua County. Oil transportation lines, buried or on the soil surface, often deteriorate rapidly, frequently in the transition zone between normal soils and slickspots. Areas of slickspots mapped with Dennis, Martin, Mason, and Osage soils should be examined before laying uncoated steel pipelines or building other steel structures in contact with the soil.

Engineering test data

Table 8 contains the results of engineering tests performed by the Kansas State Highway Commission on six important soils in Chautauqua County. The table shows the specific location from which the samples were taken, the depth to which sampling was done, and the results of tests to determine particle-size distribution and other properties significant in soil engineering.

Maximum dry density is the maximum unit dry weight of the soil when it has been compacted with optimum moisture by the prescribed method of compaction. The moisture content which gives the highest dry unit weight is called the *optimum moisture content* for the specific method of compaction.

Mechanical analysis shows the percentages, by weight, of soil particles that would pass specified sieve sizes. The coarse fraction, sand and gravel, is the size that passes a 3-inch sieve and is retained on the No. 200 sieve. The fine fraction is the material passing the

No. 200 sieve. The fine fraction is classified as plastic (clay) and nonplastic (silt), and the classification is based on the Atterberg limits, not on particle size, as is the textural classification. The gradation of the fines was determined by the hydrometer method.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material changes from semisolid to plastic. The liquid limit is the moisture content at which the material changes from plastic to liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic.

Formation and Classification of the Soils

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

Factors of Soil Formation

Soil forms through the physical and chemical weathering of parent 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 is formed, and in extreme cases, determines it almost entirely. Finally, time is needed for changing the par-

ent 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 development of distinct horizons.

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

Parent material.—About 60 percent of the soils in Chautauqua County formed in material weathered from shale, 15 percent from limestone, 13 percent from alluvium, and 12 percent from sandstone.

Shale crops out throughout the uplands. It is interbedded with limestone in the western half of the county and with sandstone in the eastern half. Reaction ranges from strongly acid to moderately alkaline in the surface layer of soils formed in material weathered from shale. Clime, Dennis, Eram, Kenoma, Martin, Niotaze, and Steedman soils, for example, formed in material weathered from shale.

Limestone is the parent material for Clareson, Lula, and Sogn soils. Martin and Clime soils, which are closely associated with limestone, have a slightly acid to moderately alkaline surface layer. As the landscape is eroded, the limestone releases calcium carbonate, which supplies these soils with lime.

Alluvium consists of gravel, sand, silt, and clay deposited by streams. The Cleora, Ivan, Mason, Osage, and Verdigris soils, in valleys and on bottom land, formed in alluvium. The properties of alluvium are influenced by the nature of the geological material within the drainage area along its stream. Ivan soils, on the flood plain of streams that drain a limestone-shale landscape, contain free lime and are moderately alkaline in the solum. Verdigris soils, on the flood plain of streams that drain a sandstone-shale landscape, have a slightly acid to neutral solum.

Sandstone is the parent material for Bates, Collinsville, Darnell, and Stephenville soils. These soils are medium acid to strongly acid in the surface layer.

Soil material that contains soluble salts or exchangeable sodium sufficient to affect growth of plants and the physical properties of the material occurs throughout Chautauqua County. This material, commonly called slickspots, is associated with Dennis and Martin soils on the uplands and with the Mason and Osage soils on bottom land. The source of salts in slickspots is related to geological formations that weathered during the time soil-forming processes have been active. These formations contained salt that was trapped in their layers when they were laid down by saltwater seas millions of years ago. Later the formations were elevated above sea level and began to weather and erode. The salts are released by weathering processes and accumulate in the soils.

Marked differences in chemical composition occur within adjacent slickspots. The composition cannot be predicted. Separate analysis is required to properly classify each salt-affected area.

Special soil amendments, such as calcium sulfate, are effective in treating soils that have an excess of exchangeable sodium. Incorporating large amounts of

organic matter is also helpful. A legume having a strong tap root should be planted after some improvement in the soil is evident. Barley and bermudagrass are the more salt-tolerant crops grown in the county.

Climate.—Climate influences both the chemical and physical weathering and the biological processes at work in the parent material. Soil-forming processes are most active when the soil is warm and moist. Water plays a major role in the weathering of soils. Alternate wetting and drying, along with freezing and thawing, contribute to physical weathering of soils and parent material. Detailed information on the climate of Chautauqua County is given in the section Additional Facts About the County.

The difference in climate as it is reflected in the formation of soils within Chautauqua County is not clearly evident.

Plants and animals.—Plants and animals furnish organic matter to the soil and bring plant nutrients from the lower layers to the surface. Trunks, stems, leaves, and roots are the principal sources of organic matter. The organic matter modifies the color, structure, and other chemical and physical properties of the soil. Burrowing animals mix the soil horizons. Earthworms feed on the organic matter and channel through the soil.

The upland soils of Chautauqua County formed under the influence of a tall-grass prairie and an oak-hickory plant cover. The influence of the plant cover is evident in detailed comparisons of the chemical properties of Darnell and Collinsville soils and of Stephenville and Bates soils.

Relief.—Relief influences soil formation through the effects of water and erosion. Runoff is slow in level areas where most of the rainfall enters the soil. Generally, less water enters steep soils and more soil material is lost through erosion. Slope exposure influences the natural plant cover in the Chautauqua Hills area. Where the hilltops are covered with oak and hickory, the north- and east-facing slopes are generally wooded and the south- and west-facing slopes mostly in tall prairie grasses.

Time.—Time influences the morphological effects of the active soil-forming factors. Ivan and Clime soils, for example, are young soils in terms of morphological change. Their surface layer is not leached of soluble carbonates, and the lower horizons have no illuviated clay. Mason and Martin soils, in contrast, are older and more advanced in morphological change.

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 understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

Thus in classification, soils are placed in narrow categories that are used in detailed soil surveys so that

TABLE 6.—*Estimates of soil*

[An asterisk in the first column indicates that at least one mapping unit in this series different properties and limitations, and for this reason it is necessary to follow carefully the instructions for

Soil series and map symbols	Depth to bedrock	Depth from surface	Classification		
			USDA texture	Unified	AASHO
	<i>Feet</i>	<i>Inches</i>			
Bates: Ba.....	2-3	0-16 16-34 34	Fine sandy loam..... Sandy clay loam..... Sandstone.	ML or SM CL or ML-CL	A-4 A-6
*Clareson: Ca, Cs..... For Sogn part of Cs, see Sogn series.	2-3	0-17 17-35 35	Silty clay loam..... Flaggy silty clay..... Limestone.	CL CL or CH	A-7 A-7
Cleora: Ct.....	>5	0-60	Fine sandy loam.....	ML or SM	A-4
*Clime: Cx..... For Sogn part of Cx, see Sogn series.	2-3	0-28 28	Silty clay..... Shale.	CH	A-7
Collinsville..... Mapped only with Eram soils.	0.5-1.5	0-12 12	Loam..... Sandstone.	ML	A-4
Darnell..... Mapped only with Stephenville and Niotaze soils.	0.5-1.5	0-14 14	Fine sandy loam..... Sandstone.	ML-SM	A-4
Dennis: Db, Dc, De, Ds..... No valid estimates can be made for Slickspots part of Ds.	5-7	0-14 14-60	Silt loam..... Silty clay loam.....	ML-CL CL	A-4 A-6
*Eram: Ea, Ec..... For Collinsville part of Ec, see Collinsville series.	2-3	0-12 12-36 36	Silty clay loam..... Silty clay..... Shale.	ML or CL CH	A-7 A-7
Ivan: Iv.....	>5	0-60	Silty clay loam.....	ML or CL	A-6
Kenoma: Ke.....	4-8	0-11 11-60	Silt loam..... Silty clay.....	ML or CL CH	A-4 or A-6 A-7
Longford: Ln, Lo.....	3-5	0-13 13-54 54	Silty clay loam..... Silty clay..... Limestone.	CL CL or CH	A-7 A-7
Lula: Lu.....	3-4	0-10 10-46 46	Silt loam..... Silty clay loam..... Limestone.	ML or ML-CL CL or CH	A-4 or A-6 A-7
Martin: Ma, Mb, Mc, Me, Ms..... No valid estimates can be made for Slickspots part of Ms.	3-6	0-12 12-54 54	Silty clay loam..... Silty clay..... Shale.	CL CH	A-7 A-7
Mason: Mt, Mx..... No valid estimates can be made for Slickspots part of Mx.	>10	0-12 12-60	Silt loam..... Silty clay loam.....	CL CL	A-4 or A-6 A-6
*Niotaze: Nd..... For Darnell part, refer to Darnell series.	2-3	0-10 10-18 18-28 28	Stony fine sandy loam ¹ Silty clay..... Silty clay loam..... Shale.	SM CH CL	A-2 or A-4 A-7 A-7
Osage: Oa, Os..... No valid estimates can be made for Slickspots part of Os.	>10	0-24 24-60	Silty clay loam..... Silty clay.....	CL or CH CH	A-7 A-7
Oc.....	>10	0-60	Silty clay.....	CH	A-7
Sogn: So.....	0.5-1.5	0-10 10	Silty clay loam..... Limestone.	CL	A-7
Steedman: St.....	2-3	0-6 6-30 30	Stony clay loam ² Silty clay..... Shale.	ML-CL CH	A-6 A-7

See footnotes at end of table.

properties significant in engineering

is made up of two or more kinds of soil. The soils in such mapping units may have referring to other series that appear in the first column of this table. > means more than; < means less than]

Percentage less than 3 inches passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4	No. 10	No. 40	No. 200				
				<i>Inches per hour</i>	<i>Inches per inch of soil</i>	<i>pH</i>	
100	100	70-85	40-55	2.00-6.00	0.12-0.14	5.6-6.0	Low.
100	100	80-90	50-65	0.60-2.00	0.15-0.17	5.6-6.5	Low.
90-100	90-100	85-95	85-95	0.60-2.00	0.17-0.19	6.1-6.5	Moderate.
85-100	85-100	80-95	80-95	0.06-0.20	0.18-0.20	5.6-7.3	Moderate.
100	100	70-85	40-55	2.00-6.00	0.12-0.14	5.6-7.3	Low.
100	100	95-100	90-95	0.06-0.20	0.17-0.19	7.4-8.4	High.
90-100	85-100	85-95	60-75	2.00-6.00	0.16-0.18	5.6-6.5	Low.
90-100	85-100	70-85	40-55	2.00-6.00	0.11-0.13	5.1-6.5	Low.
100	100	95-100	85-95	0.60-2.00	0.17-0.19	5.6-6.0	Low.
100	100	95-100	85-95	0.06-0.20	0.18-0.20	5.6-6.5	Moderate.
100	100	95-100	85-95	0.60-2.00	0.17-0.19	5.6-6.5	Moderate.
100	100	95-100	90-95	0.06-0.20	0.18-0.20	5.6-7.3	High.
100	100	95-100	85-95	0.60-2.00	0.17-0.19	7.4-8.4	Moderate.
100	100	90-100	70-90	0.60-2.00	0.17-0.19	5.6-6.5	Moderate.
100	100	95-100	90-95	< 0.06	0.18-0.20	6.1-7.8	High.
95-100	90-100	90-100	85-95	0.20-0.60	0.17-0.19	5.6-6.5	Moderate.
90-100	85-100	85-95	80-90	0.06-0.20	0.18-0.20	6.1-8.4	High.
100	100	90-100	70-90	0.60-2.00	0.17-0.19	5.6-6.5	Moderate.
100	100	95-100	85-95	0.60-2.00	0.18-0.20	5.6-7.3	High.
100	100	95-100	85-95	0.20-0.60	0.17-0.19	6.1-7.3	Moderate.
100	100	95-100	90-95	0.06-0.20	0.18-0.20	6.1-7.8	High.
100	100	100	90-95	0.60-2.00	0.17-0.19	5.6-6.5	Moderate.
100	100	100	90-100	0.20-0.60	0.17-0.19	5.6-6.5	Moderate.
95-100	95-100	95-100	30-50	2.00-6.00	0.11-0.13	5.1-6.0	Low.
100	100	95-100	90-100	0.06-0.20	0.18-0.20	4.5-6.0	High.
100	100	95-100	90-100	0.60-2.00	0.17-0.19	5.6-7.3	Moderate.
100	100	95-100	90-100	0.06-0.20	0.17-0.19	6.1-7.3	High.
100	100	95-100	90-100	> 0.06	0.18-0.20	6.1-7.8	Very high.
100	100	95-100	90-100	> 0.06	0.18-0.20	6.1-7.8	Very high.
100	100	95-100	85-95	0.6-2.0	0.17-0.19	6.6-8.4	Moderate.
85-90	75-85	65-75	55-65	0.60-2.00	0.17-0.19	5.6-6.5	Moderate.
100	100	95-100	90-95	0.06-0.20	0.18-0.20	5.6-7.8	High.

TABLE 6.—*Estimates of soil*

Soil series and map symbols	Depth to bedrock	Depth from surface	Classification		
			USDA texture	Unified	AASHO
	<i>Feet</i>	<i>Inches</i>			
*Stephenville: Sv, Sx..... For Darnell part of Sx, see Darnell series.	2-3	0-12 12-26 26-34 34	Fine sandy loam..... Sandy clay loam..... Sandy clay loam..... Sandstone.	SM SC or CL CL or SC	A-2 or A-4 A-6 A-6
Verdigris: Ve.....	>5	0-38 38-60	Silt loam..... Silty clay loam.....	CL-ML CL	A-6 A-4

¹ Layer is 60 percent, by weight, sandstone fragments greater than 3 inches in diameter.

properties significant in engineering—Continued

Percentage less than 3 inches passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4	No. 10	No. 40	No. 200				
				<i>Inches per hour</i>	<i>Inches per inch of soil</i>	<i>pH</i>	
100	100	95-100	30-40	2.00-6.00	0.11-0.13	5.1-6.0	Low.
100	100	95-100	40-55	0.60-2.00	0.16-0.18	5.1-6.5	Moderate.
100	100	95-100	45-55	0.60-2.00	0.15-0.17	5.6-6.5	Low.
100	100	100	90-100	0.60-2.00	0.17-0.19	5.6-7.3	Moderate.
100	100	100	55-65	0.60-2.00	0.17-0.19	5.6-6.5	Moderate.

² Layer is 55 percent, by weight, sandstone fragments greater than 3 inches in diameter.

TABLE 7.—Engineering

[An asterisk in the first column indicates that at least one mapping unit in this series is made up and for this reason it is necessary to follow carefully the instructions for

Soil series and map symbols	Degree and kind of limitation for—							Suitability as a source of
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings	Local roads and streets	Sanitary landfill ¹		Sanitary landfill, cover material
						Trench type	Area type	
Bates: Ba-----	Severe: 20 to 40 inches to bedrock.	Severe: 20 to 40 inches to bedrock.	Severe: 20 to 40 inches to rippable bedrock.	Moderate: 20 to 40 inches to rippable bedrock.	Slight-----	Severe: 20 to 40 inches to bedrock.	Slight-----	Fair: 20 to 40 inches to bedrock.
*Clareson: Ca, Cs. For Sogn part of Cs, see Sogn series.	Severe: 20 to 40 inches to bedrock; coarse fragments in subsoil.	Severe: 20 to 40 inches to bedrock; coarse fragments in subsoil.	Severe: 20 to 40 inches to bedrock; coarse fragments in subsoil.	Severe: 20 to 40 inches to bedrock; coarse fragments in subsoil; moderate shrink-swell potential.	Moderate: 20 to 40 inches to bedrock; coarse fragments in subsoil.	Severe: 20 to 40 inches to bedrock; coarse fragments in subsoil; silty clay texture below 17 inches.	Slight-----	Poor: silty clay loam in top 17 inches; coarse fragments in subsoil.
Cleora: Ct-----	Severe: subject to flooding; moderately rapid permeability.	Severe: subject to flooding; moderately rapid permeability.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding; moderately rapid permeability.	Severe: subject to flooding; moderately rapid permeability.	Good-----
*Clime: Cx----- For Sogn part of Cx, see Sogn series.	Severe: 20 to 40 inches to shale; slow permeability; steep slopes.	Severe: 20 to 40 inches to shale; steep slopes.	Severe: 20 to 40 inches to shale; silty clay texture; steep slopes.	Severe: high shrink-swell potential; steep slopes; 20 to 40 inches to shale.	Severe: high shrink-swell potential; steep slopes.	Severe: 20 to 40 inches to shale; steep slopes; silty clay texture.	Severe: 20 to 40 inches to shale; steep slopes; silty clay texture.	Poor: silty clay texture; steep slopes.
Collinsville----- Mapped only with Eram soils.	Severe: less than 20 inches to bedrock.	Severe: less than 20 inches to bedrock; moderately rapid permeability.	Severe: less than 20 inches to bedrock; rocks in surface layer.	Severe: less than 20 inches to bedrock; moderate potential frost action.	Severe: less than 20 inches to bedrock.	Severe: less than 20 inches to bedrock; moderately rapid permeability; rocks in surface layer.	Severe: less than 20 inches to bedrock; moderately rapid permeability; rocks in surface layer.	Poor: less than 20 inches of material; rocks in surface layer.
Darnell----- Mapped only with Stephenville and Niotaze soils.	Severe: less than 20 inches to bedrock.	Severe: less than 20 inches to bedrock; moderately rapid permeability.	Severe: less than 20 inches to bedrock; rocks on surface.	Severe: less than 20 inches to bedrock; moderate potential frost action.	Severe: less than 20 inches to bedrock.	Severe: less than 20 inches to bedrock; moderately rapid permeability; rocks on surface.	Severe: less than 20 inches to bedrock; moderately rapid permeability; rocks on surface.	Poor: less than 20 inches of material; rocks on surface.

See footnotes at end of table.

interpretations

of two or more kinds of soil. The soils in such mapping units may have different properties and limitations, referring to other series that appear in the first column of this table]

Suitability as a source of—Continued					Soil features affecting—			
Topsoil	Sand and gravel	Road subgrade ²	Road fill ²	Highway location ²	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation
Good: fair in subsoil.	Not suitable..	Poor: low soil support.	Fair: fair shear strength.	20 to 40 inches to bedrock.	20 to 40 inches to bedrock; some seepage.	Fair to poor stability and compaction in upper 16 inches.	Features favorable.	20 to 40 inches to bedrock; low available water capacity; slopes of 1 to 4 percent.
Fair: silty clay loam in top 17 inches; coarse fragments in subsoil.	Not suitable..	Poor: poor soil compaction.	Fair: fair workability.	20 to 40 inches to bedrock; coarse fragments in subsoil.	20 to 40 inches to bedrock; moderately slow permeability.	Fair to poor stability and compaction; moderate shrink-swell potential.	Coarse fragments in subsoil.	20 to 40 inches to bedrock; coarse fragments in subsoil; low available water capacity; slopes of 0 to 3 percent.
Good.....	Poor: improbable source of sand; unsuitable for gravel.	Good.....	Fair: ML material probable.	Subject to flooding.	Moderately rapid permeability.	Moderate permeability when compacted; poor resistance to piping.	Nearly level to gently sloping; subject to flooding.	Subject to flooding; moderately rapid permeability.
Poor: silty clay texture; steep slopes.	Not suitable..	Fair: medium soil support.	Good when protected from erosion.	20 to 40 inches to shale.	20 to 40 inches to shale; steep slopes.	Fair to poor stability and compaction; high shrink-swell potential.	20 to 40 inches to shale; steep slopes.	Slopes of 8 to 30 percent; slow permeability; 20 to 40 inches to shale.
Fair to poor: less than 20 inches of material; rocks in surface layer.	Not suitable..	Good.....	Good.....	Less than 20 inches to bedrock.	Less than 20 inches to bedrock; moderately rapid permeability.	Shallow, stony soil; poor resistance to piping.	Less than 20 inches to bedrock; rocks on surface.	Shallow soil; very low available water capacity; slopes of 1 to 7 percent.
Fair to poor: less than 20 inches of material; rocks on surface.	Not suitable..	Good.....	Good.....	Less than 20 inches to bedrock.	Less than 20 inches to bedrock; moderately rapid permeability.	Poor stability and compaction; poor resistance to piping; shallow, stony soils.	Less than 20 inches to bedrock; rocks on surface.	Shallow soil; low available water capacity; slopes of 1 to 20 percent.

TABLE 7.—Engineering

Soil series and map symbols	Degree and kind of limitation for—							Suitability as a source of
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings	Local roads and streets	Sanitary landfill ¹		Sanitary landfill, cover material
						Trench type	Area type	
Dennis: Db, Dc, De, Ds. No interpretations for Slickspots part of Ds. Material too variable.	Severe: slow permeability.	Moderate: slopes of 1 to 7 percent.	Moderate: silty clay loam texture below depth of 14 inches.	Moderate: moderate shrink-swell potential.	Moderate: moderate shrink-swell potential.	Moderate: silty clay loam texture below 14 inches.	Slight-----	Fair: silty clay loam texture below depth of 14 inches.
*Eram: Ea, Ec. For Collinsville part of Ec, see Collinsville series.	Severe: 20 to 40 inches to shale; slow permeability.	Severe: 20 to 40 inches to shale.	Severe: 20 to 40 inches to shale; silty clay texture below depth of 12 inches.	Severe: 20 to 40 inches to shale; high shrink-swell potential.	Severe: high shrink-swell potential.	Severe: 20 to 40 inches to shale; silty clay texture below 12 inches.	Slight-----	Poor: silty clay texture below depth of 12 inches.
Ivan: Iv-----	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Fair: silty clay loam texture.
Kenoma: Ke--	Severe: very slow permeability.	Moderate: 4 to 8 feet to bedrock.	Severe: silty clay texture below depth of 12 inches.	Severe: high shrink-swell potential.	Severe: high shrink-swell potential.	Severe: 4 to 8 feet to bedrock; silty clay texture below depth of 12 inches.	Slight-----	Poor: silty clay texture below depth of 12 inches.
Longford: Ln, Lo.	Moderate to severe: 40 to 60 inches to bedrock; moderately slow permeability.	Moderate: 40 to 60 inches to bedrock; slopes of 1 to 4 percent.	Moderate to severe: 40 to 60 inches to bedrock; silty clay below depth of 13 inches.	Moderate to severe: 40 to 60 inches to bedrock; high shrink-swell potential.	Severe: high shrink-swell potential.	Severe: 40 to 60 inches to bedrock; silty clay texture below depth of 13 inches.	Slight-----	Poor: silty clay texture below depth of 13 inches.
Lula: Lu-----	Severe: 40 to 50 inches to bedrock.	Moderate: 40 to 50 inches to bedrock; moderate permeability.	Moderate: 40 to 50 inches to bedrock.	Moderate to severe: 40 to 50 inches to bedrock; high shrink-swell potential.	Severe: high shrink-swell potential.	Severe: 40 to 50 inches to bedrock.	Slight-----	Fair: silty clay loam texture below depth of 10 inches.
Martin: Ma, Mb, Mc, Me, Ms. No interpretations for Slickspots part of Ms. Material too variable.	Severe: 40 to 70 inches to shale; slow permeability.	Moderate: 40 to 70 inches to shale.	Severe: silty clay texture below depth of 12 inches; 40 to 70 inches to shale.	Severe: high shrink-swell potential; 40 to 70 inches to shale.	Severe: high shrink-swell potential.	Severe: 40 to 70 inches to shale; silty clay texture below depth of 12 inches.	Slight-----	Poor: silty clay texture below depth of 12 inches.

See footnotes at end of table.

interpretations—Continued

Suitability as a source of—Continued				Soil features affecting—				
Topsoil	Sand and gravel	Road subgrade ²	Road fill ²	Highway location ²	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation
Fair: silty clay loam texture below depth of 14 inches.	Not suitable..	Fair: medium soil support.	Good.....	Features favorable.	Features favorable.	Fair to good stability and compaction; moderate shrink-swell potential.	Features favorable.	Slow water-intake rate; slopes of 1 to 7 percent.
Fair: silty clay loam texture to depth of 12 inches.	Not suitable..	Poor: low soil support.	Fair: fair shear strength.	20 to 40 inches to shale.	20 to 40 inches to shale.	Fair to poor stability and compaction; high shrink-swell potential.	Features favorable.	Slow water-intake rate; slopes of 1 to 7 percent.
Fair: silty clay loam texture.	Not suitable..	Fair: medium soil support.	Good.....	Subject to flooding.	Moderate permeability; nearly level.	Fair stability and compaction.	Nearly level to gently sloping; subject to flooding.	Subject to flooding.
Fair: silt loam to depth of 12 inches.	Not suitable..	Poor: low soil support.	Fair: fair shear strength.	High shrink-swell potential.	Nearly level..	Fair to poor stability and compaction; high shrink-swell potential.	Features favorable.	Slow water-intake rate.
Fair: silty clay loam to 13 inches.	Not suitable for sand; poor source of gravel; mixed with CL material. *	Poor: low soil support.	Fair: fair shear strength.	Features favorable.	Features favorable.	Fair to poor stability and compaction; moderate to high shrink-swell potential.	Features favorable.	Slow water-intake rate; slopes of 1 to 4 percent.
Fair: silt loam to 10 inches; silty clay loam below depth of 10 inches.	Not suitable..	Poor: low soil support.	Fair: fair shear strength.	40 to 50 inches deep over bedrock.	Moderate permeability; 40 to 50 inches deep over bedrock.	Fair to poor stability and compaction; high shrink-swell potential.	Features favorable.	High available water capacity; moderate rooting depth.
Fair: silty clay loam to depth of 12 inches.	Not suitable..	Poor: low soil support.	Fair: fair shear strength.	High shrink-swell potential.	Features favorable.	Fair to poor stability and compaction; high shrink-swell potential.	Features favorable.	Slow water-intake rate; slopes of 0 to 7 percent.

TABLE 7.—*Engineering*

Soil series and map symbols	Degree and kind of limitation for—							Suitability as a source of
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings	Local roads and streets	Sanitary landfill ¹		Sanitary landfill, cover material
						Trench type	Area type	
Mason: Mt, Mx. No interpretations for Slick-spots part of Mx. Material too variable.	Moderate: moderately slow permeability.	Moderate: moderately slow permeability.	Slight.....	Moderate: moderate shrink-swell potential; CL material.	Moderate: moderate shrink-swell potential.	Moderate: silty clay loam below depth of 12 inches.	Slight.....	Fair: silty clay loam below depth of 12 inches.
*Niotaze: Nd.. For Darnell part, see Darnell series.	Severe: 20 to 40 inches to shale; slow permeability; slopes of 8 to 20 percent.	Severe: 20 to 40 inches to shale; coarse fragments in surface layer; slopes of 8 to 20 percent.	Severe: 20 to 40 inches to shale; slopes of 8 to 20 percent; silty clay texture; stones in surface layer.	Severe: 20 to 40 inches to shale; slopes of 8 to 20 percent; high shrink-swell potential.	Severe: high shrink-swell potential; slopes of 8 to 20 percent.	Severe: 20 to 40 inches to shale; silty clay texture below depth of 10 inches; stones in surface layer.	Severe: 20 to 40 inches to shale; silty clay texture below depth of 10 inches; stones in surface layer.	Poor: silty clay texture below depth of 10 inches; slopes of 8 to 20 percent; stones in surface layer.
Osage: Oa, Os..... No interpretations for Slick-spots part of Os. Material too variable.	Severe: slow permeability; possible flooding.	Slight.....	Severe: somewhat poorly drained; silty clay texture below 24 inches; possible flooding.	Severe: somewhat poorly drained; high shrink-swell potential below depth of 24 inches; possible flooding.	Severe: high shrink-swell potential; possible flooding.	Moderate to severe: somewhat poorly drained; slow permeability; high shrink-swell potential below depth of 24 inches; possible flooding.	Moderate to severe: somewhat poorly drained; slow permeability; high shrink-swell potential below depth of 24 inches; possible flooding.	Fair to poor: silty clay loam texture to depth of 24 inches; silty clay texture below depth of 24 inches.
Oc.....	Severe: very slow permeability; subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding; poorly drained; clay texture.	Severe: subject to flooding; poorly drained; very high shrink-swell potential.	Severe: high shrink-swell potential; subject to flooding.	Severe: subject to flooding; poorly drained; clay texture.	Severe: subject to flooding; poorly drained; clay texture.	Poor: clay texture; poorly drained; very firm consistency.
Sogn: So.....	Severe: less than 20 inches to bedrock.	Severe: rocks on surface; less than 20 inches to bedrock.	Severe: rocks on surface; less than 20 inches to bedrock.	Severe: rocks on surface; less than 20 inches to bedrock.	Severe: less than 20 inches to bedrock.	Severe: rocks on surface; less than 20 inches to bedrock.	Slight: possible pollution.	Poor: rocks on surface; less than 20 inches to bedrock.

See footnotes at end of table.

interpretations—Continued

Suitability as a source of—Continued				Soil features affecting—				
Topsoil	Sand and gravel	Road subgrade ²	Road fill ²	Highway location ²	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation
Fair: silt loam to depth of 12 inches.	Not suitable..	Fair: medium soil support.	Good.....	Features favorable.	Moderately slow permeability; gently sloping.	Fair to good stability and compaction; moderate shrink-swell potential.	Features favorable.	Features favorable.
Poor: silty clay texture below depth of 10 inches; slopes of 8 to 20 percent; stones in surface layer.	Not suitable..	Fair: medium soil support and soil plasticity.	Good.....	20 to 40 inches to shale; slopes of 8 to 20 percent.	20 to 40 inches to shale; stones in surface layer.	Fair to poor stability and compaction; high shrink-swell potential.	20 to 40 inches to shale; stones in surface layer; slopes of 8 to 20 percent.	Slow water-intake rate; stones in surface layer; slopes of 8 to 20 percent.
Fair: silty clay loam texture in upper 24 inches.	Not suitable..	Poor: high plasticity.	Fair: fair shear strength.	Possible flooding.	Nearly level; possible flooding; slow permeability.	Fair to poor stability and compaction; high shrink-swell potential.	Nearly level; clay texture.	Slow water-intake rate; slow permeability; somewhat poorly drained.
Poor: clay texture; very firm consistency; poorly drained.	Not suitable..	Poor: high plasticity.	Fair: fair shear strength.	Subject to flooding.	Subject to flooding; nearly level; very slow permeability.	Fair to poor stability and compaction; very high shrink-swell potential.	Nearly level; clay texture.	Subject to flooding; poorly drained; very slow intake rate.
Fair to poor: silty clay loam to depth of 10 inches; rocks on surface.	Not suitable..	Poor: less than 20 inches to bedrock.	Fair: less than 20 inches to bedrock.	Less than 20 inches to bedrock.	Less than 20 inches to bedrock; slopes of 1 to 30 percent.	Less than 20 inches to bedrock; fair to good stability and compaction; moderate shrink-swell potential.	Less than 20 inches to bedrock; rocks on surface; slopes of 1 to 30 percent.	Low available water capacity; shallow rooting depth; rocks on surface; slopes of 1 to 30 percent.

TABLE 7.—Engineering

Soil series and map symbols	Degree and kind of limitation for—							Suitability as a source of
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings	Local roads and streets	Sanitary landfill		Sanitary landfill, cover material
						Trench type	Area type	
Steedman: St.	Severe: 20 to 40 inches to shale; slow permeability; slopes of 8 to 20 percent.	Severe: 20 to 40 inches to shale; stones on surface; slopes of 8 to 20 percent.	Severe: 20 to 40 inches to shale; slopes of 8 to 20 percent; silty clay subsoil; stones on surface.	Severe: slopes of 8 to 20 percent; high shrink-swell potential; stones on surface.	Severe: high shrink-swell potential; slopes of 8 to 20 percent; 20 to 40 inches to shale.	Severe: silty clay texture; 20 to 40 inches to shale; stones on surface.	Moderate to severe: slopes of 8 to 20 percent.	Poor: 20 to 40 inches to shale; slopes of 8 to 20 percent; stones on surface; silty clay texture.
*Stephenville: Sv, Sx. For Darnell part of Sx, see Darnell series.	Severe: 20 to 40 inches to bedrock.	Severe: moderate permeability; 20 to 40 inches to bedrock.	Severe: 20 to 40 inches to bedrock.	Moderate to severe: moderate shrink-swell potential; 20 to 40 inches to bedrock.	Moderate: 20 to 40 inches to bedrock.	Severe: 20 to 40 inches to bedrock.	Slight-----	Fair: 20 to 40 inches to bedrock.
Verdigris: Ve.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Good-----

¹ Onsite study is needed of the underlying strata and water table to determine the hazard of aquifer pollution and drainage into ground water in landfill deeper than 5 or 6 feet.

interpretations—Continued

Suitability as a source of—Continued				Soil features affecting—				
Topsoil	Sand and gravel	Road subgrade ²	Road fill ²	Highway location ²	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions, and waterways	Irrigation
Poor: silty clay below depth of 6 inches; stones on surface; slopes of 8 to 20 percent.	Not suitable.	Poor: low soil support.	Fair: fair shear strength.	20 to 40 inches to shale; slopes of 8 to 20 percent.	20 to 40 inches to shale; strongly sloping; stones on surface.	Fair to poor stability and compaction; high shrink-swell potential; stones on surface.	20 to 40 inches to shale; stones on surface; slopes of 8 to 20 percent.	Slow permeability; stones on surface; slopes of 8 to 20 percent.
Good to fair: fine sandy loam to depth of 12 inches; sandy clay loam below depth of 12 inches.	Not suitable.	Fair: medium soil support.	Good	20 to 40 inches to bedrock.	20 to 40 inches to bedrock; probable seepage.	Fair to good stability and compaction; moderate shrink-swell potential; some piping.	Low fertility.	20 to 40 inches to bedrock; low available water capacity; slopes of 1 to 5 percent.
Good	Not suitable.	Fair: medium soil support.	Good	Subject to flooding.	Subject to flooding; nearly level.	Fair to good stability and compaction; moderate shrink-swell potential.	Nearly level to gently sloping; subject to flooding.	Subject to flooding.

² By Norman Clark, soils engineer, and Herbert E. Worley, soils research engineer, Kansas State Highway Commission.

TABLE 8.—Engineering

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

Soil name and location	Parent material	Kansas report number S-70	Depth	Moisture density ¹	
				Maximum dry density	Optimum moisture
			<i>In</i>	<i>Lb/cuft</i>	<i>Pct</i>
Dennis silt loam: 1,650 feet west of east quarter corner sec. 22, T. 34 S., R. 12 E., on north side of Kansas State Highway No. 166. (Modal)	Predominantly shale with thin lenses of sandstone.	10-4-1	0-14	109	15
		10-4-2	19-35	109	16
		10-4-3	64-76	108	16
Martin silty clay loam: 550 feet south, 12 feet east of west quarter corner sec. 32, T. 33 S., R. 9 E. (Modal)	Shale with lenses of limestone.	10-5-1	0-12	97	22
		10-5-2	18-40	96	24
		10-5-5	40-54	98	24
Mason silt loam: One-fourth mile north of the center of sec. 1, T. 35 S., R. 9 E., and 0.1 mile east and 100 feet north in large cultivated field. (Modal)	Alluvium.	10-6-1	0-12	108	16
		10-6-2	12-42	103	18
		10-6-3	58-72	108	16
Niotaze stony fine sandy loam: NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 14, T. 35 S., R. 11 E., 850 feet south of county road along an oilfield road to crude oil tank battery on side of hill. (Modal)	Shale interbedded with lenses of sandstone.	10-2-1	3-10	115	12
		10-2-2	10-18	101	22
		10-2-3	28-40	108	18
Stephenville fine sandy loam: 220 feet north and 20 feet west of east quarter corner sec. 12, T. 35 S., R. 11 E. About 1 $\frac{1}{2}$ miles east and $\frac{1}{4}$ mile south of the town of Chautauqua. (Modal)	Sandstone and sandy shale.	10-1-1	4-12	119	9
		10-1-2	12-26	117	12
		10-1-3	26-34	112	16
Verdigris silt loam: South side of county road, 100 feet east of northwest corner of cultivated field in SE $\frac{1}{4}$ sec. 1, T. 34 S., R. 11 E. (Modal)	Recently deposited alluvium.	10-3-1	12-38	104	19
		10-3-2	38-68	114	15
		10-3-3	68-84	113	14

¹ Based on AASHTO Designation T 99-61, Method A (1) with the following variations: (1) All material is oven-dried at 230°F and crushed in a laboratory crusher, and (2) no time is allowed for dispersion of moisture after mixing with the soil material.

² Mechanical analyses according to 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 Soil Conservation Service (SCS). In the AASHTO procedure, the fine material

test data

standard procedures of the American Association of State Highway Officials (AASHO) (1)]

Mechanical analysis ³							Liquid limit	Plasticity index	Classification	
Percentage less than 3 inches passing sieve—			Percentage smaller than—						AASHO ³	Unified
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.				
							<i>Pct</i>			
100	99	86	73	40	19	12	26	5	A-4(8)	ML-CL
-----	100	94	87	67	45	37	38	20	A-6(12)	CL
100	99	92	88	69	47	39	39	19	A-6(12)	CL
100	99	91	85	68	45	37	41	14	A-7-6(10)	ML-CL
-----	100	96	93	81	60	52	56	30	A-7-6(19)	CH
100	98	94	90	79	58	51	56	29	A-7-6(19)	CH
-----	100	94	86	63	34	26	30	10	A-4(8)	CL
-----	100	97	92	75	49	41	41	20	A-7-6(12)	CL
-----	100	96	90	72	43	33	38	18	A-6(11)	CL
99	98	31	24	15	9	5	20	2	A-2-4(0)	SM
100	99	95	94	87	71	59	51	26	A-7-6(17)	CH
100	99	98	96	84	57	42	46	23	A-7-6(14)	CL
100	99	33	26	16	7	4	14	⁴ NP	A-2-4(0)	SM
100	99	48	43	34	25	22	25	11	A-6(3)	SC
100	99	51	39	33	28	26	27	11	A-6(4)	CL
-----	100	95	89	70	39	29	36	13	A-6(9)	ML-CL
-----	100	64	56	44	30	25	26	10	A-4(6)	CL
-----	100	58	47	30	21	17	26	8	A-4(5)	CL

is analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

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

⁴ Nonplastic.

TABLE 9.—Soils classified according to the current system of classification¹

Soil series	Family	Subgroup	Order
Bates	Fine-loamy, siliceous, thermic	Typic Argiudolls	Mollisols.
Clareson	Clayey-skeletal, mixed, thermic	Typic Argiudolls	Mollisols.
Cleora	Coarse-loamy, mixed, thermic	Fluventic Hapludolls	Mollisols.
Clime	Fine, mixed, mesic	Udic Haplustolls	Mollisols.
Collinsville	Loamy, siliceous, thermic	Lithic Hapludolls	Mollisols.
Darnell	Loamy, siliceous, thermic, shallow	Udic Ustochrepts	Inceptisols.
Dennis	Fine, mixed, thermic	Aquic Paleudolls	Mollisols.
Eram	Fine, mixed, thermic	Aquic Argiudolls	Mollisols.
Ivan	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Kenoma	Fine, montmorillonitic, thermic	Vertic Argiudolls	Mollisols.
Longford	Fine, montmorillonitic, mesic	Udic Argiustolls	Mollisols.
Lula	Fine-silty, mixed, thermic	Typic Argiudolls	Mollisols.
Martin	Fine, mixed, mesic	Aquic Argiudolls	Mollisols.
Mason	Fine-silty, mixed, thermic	Typic Argiudolls	Mollisols.
Niotaze	Fine, montmorillonitic, thermic	Aquic Paleustalfs	Alfisols.
Osage	Fine, montmorillonitic, thermic	Vertic Haplaquolls	Mollisols.
Sogn	Loamy, mixed, mesic	Lithic Haplustolls	Mollisols.
Steedman	Fine, montmorillonitic, thermic	Vertic Haplustalfs	Alfisols.
Stephenville	Fine-loamy, siliceous, thermic	Ultic Haplustalfs	Alfisols.
Verdigris	Fine-silty, mixed, thermic	Cumulic Hapludolls	Mollisols.

¹ Placement of some soil series in the current system, particularly in families, may change as more precise information becomes available. Soils were classified according to the Soil Taxonomy System of the National Cooperative Soil Survey as of May 6, 1971.

knowledge about the soils can be organized and used in managing farms, fields, and woodland; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. The current system is under continual study. Therefore, readers interested in developments of the current system should search the latest literature available (8, 10). In table 9, the soil series of Chautauqua County are classified in some categories of the current system.

The current system of classification has six categories. Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped together. Most of the classes of the current system are briefly defined in the following paragraphs.

ORDER.—Ten soil orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate these soil orders are those that tend to give broad climatic groupings, of soils. The two exceptions to this are the Entisols and Histosols, which occur in many different kinds of climate. Table 9 shows that the three soil orders in Chautauqua County are Mollisols, Inceptisols, and Alfisols.

Mollisols formed under grass and have a thick, dark-colored surface horizon containing colloids dominated by bivalent cations. The soil material in these soils has not been mixed by shrinking and swelling.

Inceptisols are mineral soils that have weakly expressed genetic horizons. The surface layer is generally lighter colored than in the Mollisols, and they do not

have features which reflect soil mixing caused by shrinking and swelling.

Alfisols are mineral soils that contain horizons of clay accumulation. Unlike the Mollisols, they lack a thick, dark-colored surface layer that contains colloids dominated by bivalent cations, but the base status of the lower horizons is not extremely low.

SUBORDER.—Each order is divided into suborders, based primarily on those characteristics that seem to produce classes that have the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging or soil differences resulting from the climate or vegetation.

GREAT GROUP.—Each suborder is divided into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated or those that contain a pan that interferes with the growth of roots or movement of water. The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown separately in table 9 because it is the last word in the name of the subgroup.

SUBGROUP.—Each great group is divided into subgroups, one representing the central (typic) segment of the group, and others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the great group.

FAMILY.—Families are established within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence.

Additional Facts About the County

Chautauqua County was established in 1875. The population was 11,560 in 1920. It declined sharply after 1940. In 1970 the Federal census reported a total population of 4,642.

In the paragraphs that follow are facts about physiography, relief, and drainage of the county and additional information on the climate, agriculture, natural resources and industry, and transportation and markets. The statistics on population and agriculture are from the Census of Agriculture and Kansas State Board of Agriculture crop and livestock report.

Physiography, Relief, and Drainage

Chautauqua County lies entirely within the Osage Plains, a subdivision of the Central Plains, which is part of the Interior Plains. The Interior Plains is one of the eight major physiographic divisions of the United States.

In the Osage Plains, the underlying rocks dip gently westward, and the surface slopes eastward. Rock formations crop out in parallel strips trending nearly north to south. The stronger beds form *cuestas* that have east-facing escarpments. Some form a belt of hills several miles wide.

The relief of Chautauqua County is steep to rolling. Elevations range from about 1,420 feet in the northwest corner to nearly 705 feet in the southeast corner. The landscape is sharply dissected by narrow ridges and hilltops. Small valleys lie between the rolling hills. Bedrock crops out at the rim of most hilltops, and the hillsides are stony.

All of Chautauqua County is drained by the Caney River, a part of the Verdigris River subbasin within the Arkansas River Basin. The upper reach of the Caney River drains the western part of the county and flows into Oklahoma near the town of Elgin. North and Middle Caney Creeks merge to form the Little Caney River in the eastern part of the county. Little Caney River leaves the county at the southeast corner and joins the Caney River near Bartlesville, Okla.

Climate ⁷

The climate of Chautauqua County is humid continental and is characterized by wide daily and annual variations in temperature. Summers are hot, and winters are fairly mild. The growing season is long and normally has adequate rainfall, considerable sunshine, and moderate temperatures. Facts about the precipita-

tion and temperature in the county are shown in table 10.

PRECIPITATION

The Gulf of Mexico is the principal source of moisture for precipitation in Kansas (2). The southeastern part of the State is frequently in the path of warm, moist air flowing from the Gulf. This air and occasional outbreaks of colder air produce abundant cloudiness and precipitation. Thus, Chautauqua County is in the heaviest rainfall area of the State. Average annual precipitation increases from about 16 inches along the Colorado border to southwestern Kansas to 37 inches in Chautauqua County and reaches 41 inches in the extreme southeastern corner. The bulk of the precipitation falls during the growing season. More than three-fourths of the total annual precipitation occurs during the 7-month period, April through October. This distribution, which coincides with the average freeze-free period, favors the growth of crops and grasses. Winters are usually dry. December, January, and February each average less than 1½ inches precipitation. After winter, monthly moisture gradually increases and reaches a peak late in spring and early in summer; it averages more than 5 inches in both May and June. Rainfall is no more than 3¾ inches during July and August, but increases to 4.25 inches in September.

Precipitation fluctuates greatly from year to year. During the period 1885 to 1971, annual rainfall at Sedan ranged from 17.76 inches in 1910 to 56.61 inches in 1915. An extremely wet year occasionally is followed by a very dry year; for example, annual precipitation was 50.87 in 1951, but only 24.61 inches was recorded the following year. Below average precipitation may occur for several consecutive years, but moisture is usually adequate in most growing seasons. On the average, annual precipitation is less than 30 inches in only 1 year out of 5.

Snowfall is light and averages about 13 inches per year. Seasonal snowfall has been as high as 33½ inches at Sedan, but more than 20 inches in winter is unusual.

TEMPERATURE

Daily and seasonal temperature variations are typical of midlatitude locations (see table 10). Mean monthly temperatures range from 34° F in January to 80½° in July. Winters are usually mild, and summers vary from warm to hot. The maximum yearly temperature is generally above 100°, but in about one-third of the years the lowest minimum is above zero. The average number of days per year with maximum temperatures equal to or higher than 90° is 65. On an average of about 13 days during the year the maximum temperature is 100° or higher. Temperature extremes for the period of record are -27° and 118°.

Probabilities for the last freeze in spring and the first in fall are given for five thresholds in table 11. The freeze-free period is from about April 12 to October 27 (3). It averages 200 days over most of the State and 150 days in the extreme northwest corner.

⁷ By MERLE J. BROWN, State climatologist, National Weather Service.

TABLE 10.—*Temperature and precipitation*

[Data from Sedan, Chautauqua County, Kans.]

Month	Temperature				Precipitation				
	Average daily maximum ¹	Average daily minimum ¹	Two years in 10 will have about 4 days with—		Average total ¹	One year in 10 will have—		Days with snow cover of 1.0 inch or more	Average depth of snow on days that have a snow cover
			Maximum temperature equal to or higher than— ²	Minimum temperature equal to or lower than— ²		Less than— ¹	Greater than— ¹		
	°F	°F	°F	°F	Inches	Inches	Inches	Number	Inches
January	46.0	21.8	66	3	1.28	0.23	2.45	3	2.1
February	50.5	24.9	71	10	1.40	.25	2.71	2	2.5
March	60.7	33.8	80	15	2.32	.73	3.99	2	4.8
April	70.9	45.0	86	28	3.75	1.40	6.38	(³)	2.8
May	78.7	54.4	91	40	5.07	1.84	9.78	0	0
June	87.3	63.6	98	53	5.16	2.11	9.34	0	0
July	93.4	67.7	105	57	3.69	.90	7.06	0	0
August	93.7	66.5	106	54	3.41	.75	7.10	0	0
September	85.3	58.4	98	43	4.25	1.09	8.66	0	0
October	74.3	46.4	90	30	3.11	.55	6.84	0	0
November	60.0	33.9	76	17	1.98	.12	4.54	(³)	1.8
December	48.6	25.1	67	10	1.45	.41	2.74	2	3.6
Year	70.7	45.1	⁴ 105.6	⁵ 4.6	36.87	24.61	49.27	9	3.0

¹ Period 1893–1970.⁴ Average annual highest temperature.² Period 1951–70.⁵ Average annual lowest temperature.³ Less than 0.5 day.

WIND AND STORMS

The prevailing wind direction is southerly. Winds are generally light to moderate in all seasons, but strong winds occur occasionally, especially during spring.

Tornadoes and hail are sometimes reported. They are usually local in extent, are of short duration, and are damaging in a varying and spotted pattern. The frequency of hail is less in Chautauqua County than in the central and western parts of Kansas. In contrast, precipitation increases from west to east across the State.

Agriculture

The agriculture of Chautauqua County is based on grazing of the tall prairie grasses under a ranch type enterprise. Most of the cultivated acreage is farmed to crops that support livestock production. A little cash cropping is done on the alluvial soils in the larger valleys in the county.

Livestock.—Livestock is the major source of income for ranchers and farmers. In 1970, the Kansas State Board of Agriculture (4) reported 600 milk cows on farms in the county, 57,400 other cattle, 8,000 hogs, 900 sheep and lambs, and 2,000 chickens.

Crops.—In 1970 wheat was harvested from 13,000 acres; alfalfa from 6,400 acres; grain sorghum from 4,700 acres; oats from 2,500 acres; barley from 2,470 acres; corn, soybeans, and rye from 1,950 acres; and corn and sorghum for silage from 250 acres (4).

Natural Resources and Industry

Although ranching is the major enterprise in Chautauqua County, the oil industry has contributed substantially to the economy of the county since the early 1900's. There are 1,777 oil wells. Eight major oil companies and 100 independent operators employ about 250 people. A greenhouse and 7 acres under temperature control produce commercial flowers and employ 75 to 100 people during its busiest season. Several small businesses and manufacturing enterprises offer employment to local people.

Transportation and Markets

The county is served by two hard-surfaced highways, U.S. Highway No. 166 and Kansas Highway No. 99. A branch line of a railroad crosses the southern part of the county. A system of crushed rock roads serves the ranches.

Most of the livestock leaves the county in trucks. Wheat is shipped to terminal elevators by way of the railroad.

One livestock sales company is located in Cedar Vale.

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TABLE 11.—Probabilities of last freezing temperatures in spring and first in fall for central Chautauqua County

Temperature probability	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 28	April 5	April 16	April 27
2 years in 10 later than.....	March 17	March 22	March 31	April 11	April 22
5 years in 10 later than.....	March 5	March 12	March 22	April 1	April 12
Fall:					
1 year in 10 earlier than.....	November 16	November 9	October 31	October 21	October 13
2 years in 10 earlier than.....	November 22	November 14	November 4	October 26	October 17
5 years in 10 earlier than.....	December 4	November 25	November 14	November 4	October 27

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Glossary

- Alluvium.** Soil material, such as sand, silt, or clay, that has been deposited on land by streams.
- Calcareous soil.** A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.
- Clay.** As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.
- Clay film.** A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.
- Claypan.** A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.
- Clayey soils.** As used in this survey, soils that contain more than 35 percent clay.
- Concretions.** Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.
- Consistence, soil.** The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—
- Loose.**—Noncoherent when dry or moist; does not hold together in mass.
- Friable.**—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Gravelly soil. A soil that contains a high proportion of rock fragments of gravel size, which are rounded or subangular particles less than 3 inches in diameter.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons.

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Loamy soil. As used in this survey, soil that contains 10 to 70 percent sand, 20 to 80 percent silt, and 15 to 35 percent clay.

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

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: abundance—*few*, *common*, and *many*; size—*fine*, *medium*, and *coarse*; and contrast—*faint*, *distinct*, and *prominent*. The size measurements are these: *fine*, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the

greatest dimension; and *coarse*, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Poorly graded. A soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles in poorly graded soil material, density can be increased only slightly by compaction.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

<i>pH</i>		<i>pH</i>	
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	9.1 and
		alkaline	higher

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Sandy soils. A broad term for soils of the sand and loamy sand classes; soil material with more than 70 percent sand and less than 15 percent clay.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Slickspots. Small areas in a field that are slick when wet because they contain excess exchangeable sodium, or alkali.

Soil textural class. Classification based on the relative proportion of soil separates. The principal classes, in increasing order of the content of finer separates, are as follows: Sand, loamy sand, sandy loam, loam, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Subsurface layer. A transitional soil layer between the surface layer and the subsoil. It is not present in all soils.

Surface layer. A term in nontechnical soil descriptions for one or more upper layers of soil; includes the A horizon.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand*, *loamy sand*, *sandy loam*, *loam*, *silt loam*, *silt*, *sandy clay loam*, *clay loam*, *silty clay loam*, *sandy clay*, *silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Variant, soil. A soil having properties sufficiently different from those of other known soils to suggest establishing a new soil series, but a soil of such limited known area that creation of a new series is not believed to be justified.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. Other information is given in tables as follows:

Acreage and extent, table 1, p. 9.
 Predicted yields, table 2, p. 35.
 Woodland, table 3, p. 36.

Recreation, table 5, p. 41.
 Engineering, tables 6, 7, and 8,
 pp. 44 through 57.

Map symbol	Mapping unit	Page	Capability unit		Page	Woodland suitability group
			Symbol	Range site		
Ba	Bates fine sandy loam, 1 to 4 percent slopes-----	9	IIE-1	Loamy Upland	30	--
Ca	Clareson silty clay loam, 0 to 2 percent slopes-----	10	IIIs-1	Shallow Flats	31	--
Cs	Clareson-Sogn complex-----	10	VIe-1	-----	--	--
	Clareson soil-----	--	-----	Shallow Flats	31	--
	Sogn soil-----	--	-----	Shallow Limy	31	--
Ct	Cleora fine sandy loam-----	11	IIw-1	-----	--	1
Cx	Clime-Sogn complex-----	11	VIe-1	-----	--	--
	Clime soil-----	--	-----	Limy Upland	29	--
	Sogn soil-----	--	-----	Shallow Limy	31	--
Db	Dennis silt loam, 1 to 3 percent slopes----	13	IIE-2	Loamy Upland	30	--
Dc	Dennis silt loam, 3 to 7 percent slopes----	13	IIIE-1	Loamy Upland	30	--
De	Dennis silty clay loam, 3 to 7 percent slopes, eroded-----	13	IIIE-2	Clay Upland	29	--
	Dennis-Slickspots complex-----	13	IVs-1	-----	--	--
	Dennis soil-----	--	-----	Loamy Upland	30	--
	Slickspots-----	--	-----	Upland Slickspots	32	--
Ea	Eram silty clay loam, 1 to 3 percent slopes-----	14	IIE-2	Clay Upland	29	--
Ec	Eram-Collinsville complex-----	15	VIe-1	-----	--	--
	Eram soil-----	--	-----	Clay Upland	29	--
	Collinsville soil-----	--	-----	Shallow Sandstone	31	--
Iv	Ivan silt loam-----	16	IIw-1	-----	--	1
Ke	Kenoma silt loam-----	16	IIs-1	Clay Upland	29	--
Ln	Longford silty clay loam, bedrock substratum, 1 to 4 percent slopes-----	17	IIE-2	Loamy Upland	30	--
Lo	Longford silty clay loam, bedrock substratum, 1 to 4 percent slopes, eroded-----	17	IIIE-3	Loamy Upland	30	--
Lu	Lula silt loam, 0 to 2 percent slopes-----	18	IIE-3	Loamy Upland	30	--
Ma	Martin silty clay loam, 0 to 1 percent slopes-----	18	IIs-1	Loamy Upland	30	--
	Martin silty clay loam, 1 to 4 percent slopes-----	18	IIE-2	Loamy Upland	30	--
Mc	Martin silty clay loam, 4 to 7 percent slopes-----	19	IIIE-1	Loamy Upland	30	--
Me	Martin silty clay loam, 3 to 7 percent slopes, eroded-----	19	IIIE-2	Clay Upland	29	--
	Martin-Slickspots complex-----	19	IVs-1	-----	--	--
	Martin soil-----	--	-----	Loamy Upland	30	--
	Slickspots-----	--	-----	Upland Slickspots	32	--
Mt	Mason silt loam-----	20	I	Loamy Lowland	30	3
Mx	Mason-Slickspots complex-----	20	IIIs-2	-----	--	--
	Mason soil-----	--	-----	Loamy Lowland	30	3
	Slickspots-----	--	-----	Lowland Slickspots	30	--
Nd	Niotaze-Darnell complex-----	22	VIIIs-1	-----	--	--
	Niotaze soil-----	--	-----	Savannah	30	4
	Darnell soil-----	--	-----	Shallow Savannah	31	5
Oa	Osage silty clay loam-----	22	IIw-2	Loamy Lowland	30	2
Oc	Osage silty clay-----	22	IIIW-2	Clay Lowland	29	2

GUIDE TO MAPPING UNITS--Continued

Map symbol	Mapping unit	Page	Capability unit	Range site	Woodland suitability group	
			Symbol	Name	Page	Number
Os	Osage-Slickspots complex-----	23	IVs-2	-----	--	--
	Osage soil-----	--	-----	Loamy Lowland	30	2
	Slickspots-----	--	-----	Lowland Slickspots	30	--
So	Sogn soils-----	24	VIIIs-2	Shallow Limy	31	--
St	Steedman stony clay loam, 8 to 20 percent slopes-----	25	VIe-1	Loamy Upland	30	--
Sv	Stephenville fine sandy loam, 1 to 4 percent slopes-----	26	IIe-1	Savannah	30	4
Sx	Stephenville-Darnell fine sandy loams-----	26	VIe-1	-----	--	--
	Stephenville soil-----	--	-----	Savannah	30	4
	Darnell soil-----	--	-----	Shallow Savannah	31	5
Ve	Verdigris silt loam-----	27	IIw-1	-----	--	1

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