United States
Department of
Agriculture

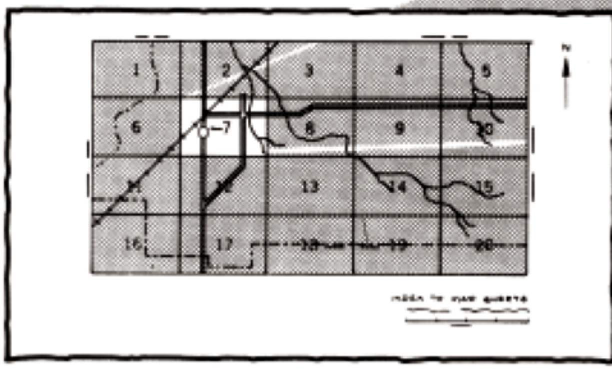
Soil
Conservation
Service

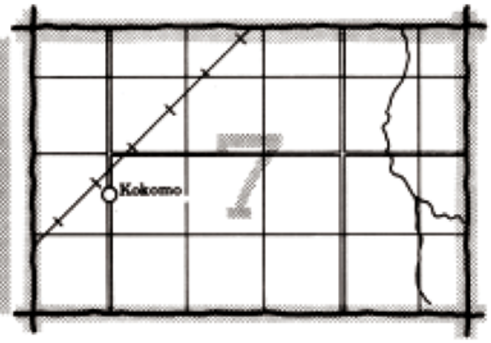
In cooperation with
Oklahoma
Agricultural
Experiment
Station

Soil Survey of Cleveland County, Oklahoma

HOW TO USE

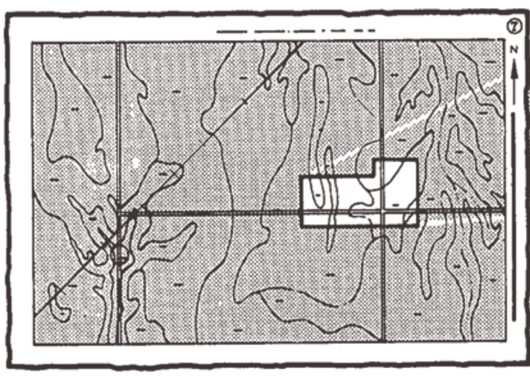
1. Locate your area of interest on the "Index to Map Sheets"

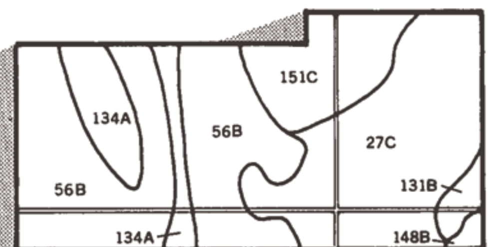




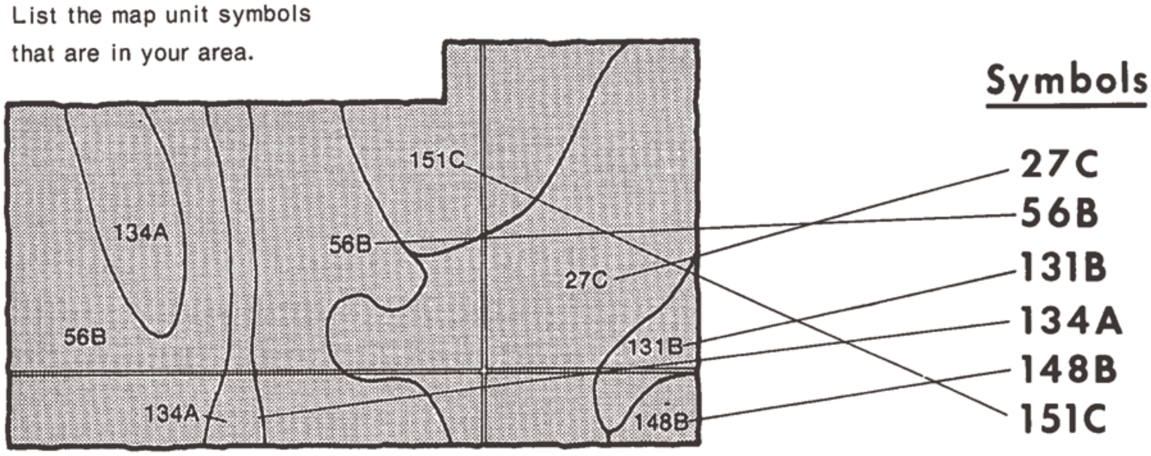
2. Note the number of the map sheet and turn to that sheet.

3. Locate your area of interest on the map sheet.



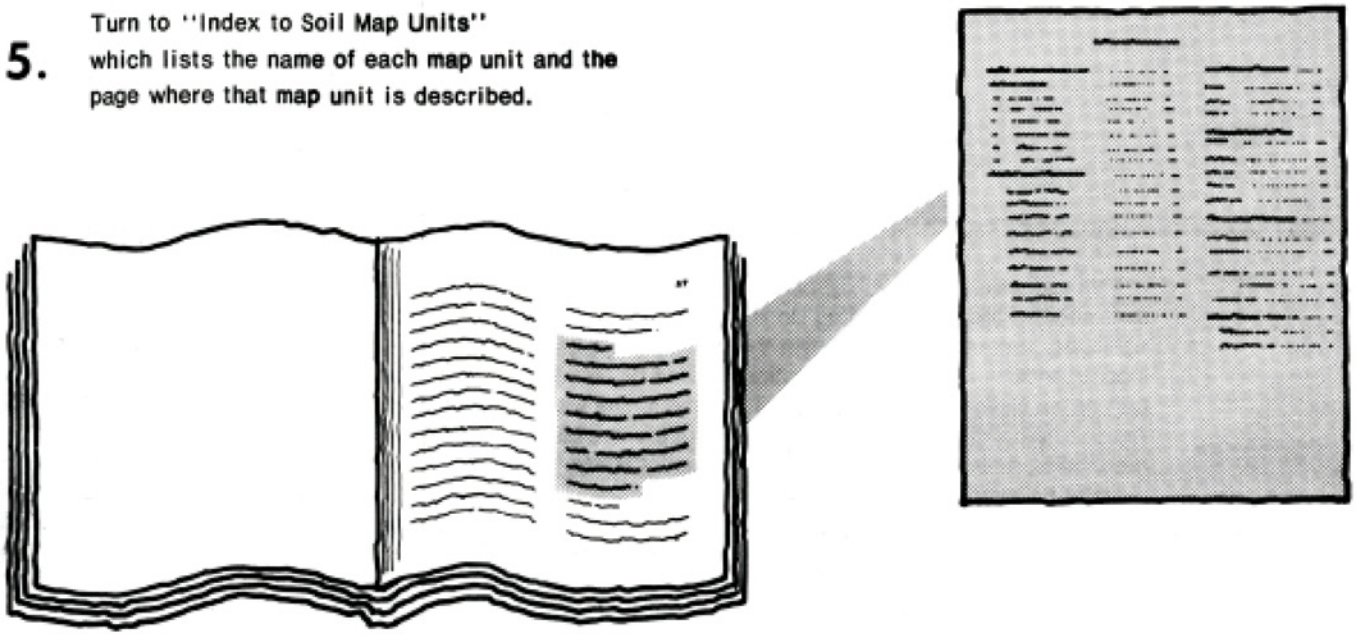


4. List the map unit symbols that are in your area.

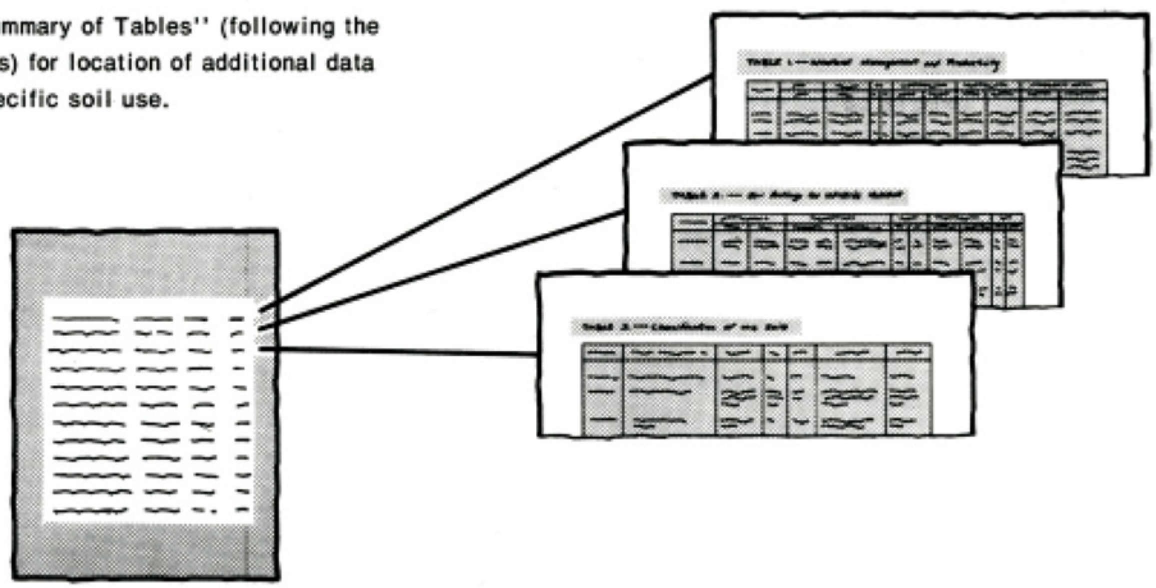


THIS SOIL SURVEY

5. Turn to "Index to Soil Map Units" which lists the name of each map unit and the page where that map unit is described.



6. See "Summary of Tables" (following the Contents) for location of additional data on a specific soil use.



7. Consult "Contents" for parts of the publication that will meet your specific needs. This survey contains useful information for farmers or ranchers, foresters or agronomists; for planners, community decision makers, engineers, developers, builders, or homebuyers; for conservationists, recreationists, teachers, or students; to specialists in wildlife management, waste disposal, or pollution control.

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other federal agencies, state agencies including the Agricultural Experiment Stations, and local agencies. The Soil Conservation Service has leadership for the federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in 1982. Soil names and descriptions were approved in 1983. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1983. This soil survey was made cooperatively by the Soil Conservation Service and the Oklahoma Agricultural Experiment Station. It is part of the technical assistance furnished to the Cleveland County Conservation District.

Soil maps in this survey may be copied without permission. Enlargement of these maps, however, could cause misunderstanding of the detail of mapping. If enlarged, maps do not show the small areas of contrasting soils that could have been shown at a larger scale.

The first soil survey of Cleveland County, in which the field work was completed in 1942, was published in 1954. This survey updates the first survey and provides additional information.

Cover: An area of Norge silt loam, 3 to 5 percent slopes, converted from agriculture production to small acreage suburban development reflects the rapidly changing land use patterns taking place in Cleveland County.

Contents

Soil Series

Issued April 1987

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Summary of Tables

Foreword

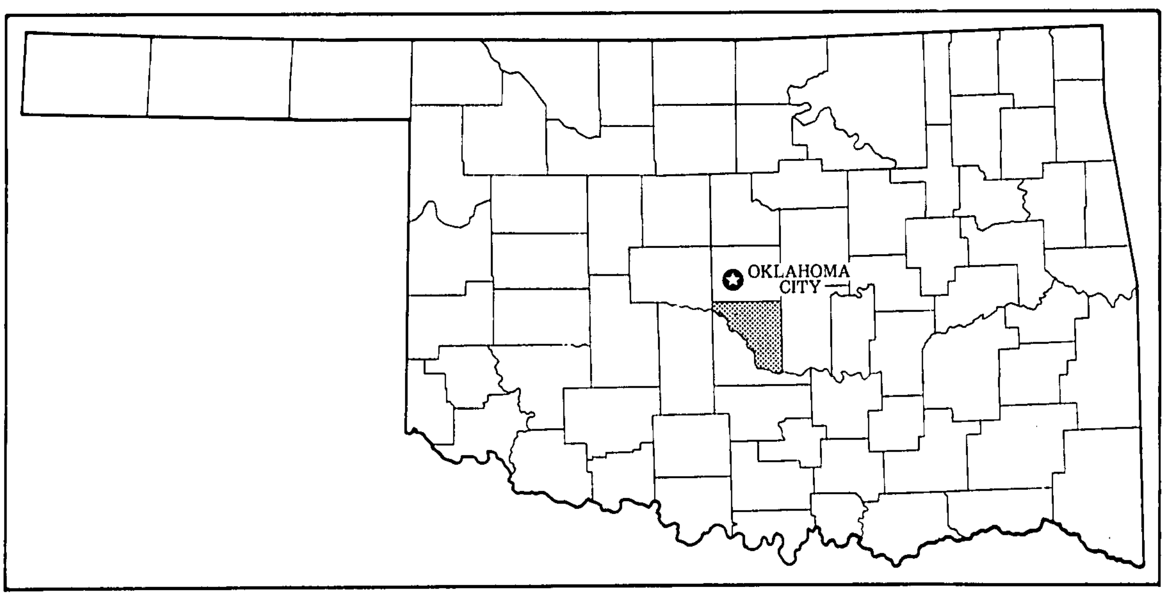
This soil survey contains information that can be used in land-planning programs in Cleveland County. It contains predictions of soil behavior for selected land uses. The survey also highlights limitations and hazards inherent in the soil, improvements needed to overcome the limitations, and the impact of selected land uses on the environment.

This soil survey is designed for many different users. Farmers, ranchers, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food and fiber production. Planners, community officials, engineers, developers, builders, and home buyers can use the survey to plan land use, select sites for construction, and identify special practices needed to insure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow to bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These and many other soil properties that affect land use are described in this soil survey. Broad areas of soils are shown on the general soil map. The location of each soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available at the local office of the Soil Conservation Service or the Cooperative Extension Service.

Roland R. Willis
State Conservationist
Soil Conservation Service



Location of Cleveland County in Oklahoma.

Soil Survey of
Cleveland County, Oklahoma

By Bob G. Bourlier, Gerald A. Sample, Bill G. Swafford, and
George Douthit, Soil Conservation Service

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

CLEVELAND COUNTY is near the center of Oklahoma and is almost triangular in shape. It borders Oklahoma County to the north, Canadian County to the northwest, McClain County to the west and south, and Pottawatamie County to the east. The county has a total area of 357,760 acres, or 559 square miles. About 17,830 acres, or 5 percent of the county is water areas larger than 40 surface acres.

Cleveland County had a population of 133,173 in 1980, and Norman, the county seat, had a population of 68,020. Currently about 75 percent of the county is within the incorporated city limits of Norman, Moore, Oklahoma City, Noble, Lexington, and Slaughterville.

About 32 percent of Cleveland County is open rangeland, 24 percent is woodland, 21 percent is tame pasture, 10 percent is cropland, 8 percent is urban land that is partly covered by urban structures, and 5 percent is water areas greater than 40 acres. About 20 percent of the county is prime farmland. The principal crops grown in 1980, in order of their harvested acreage, were winter wheat, alfalfa, grain sorghum, oats, soybeans, corn, forage sorghum, cotton, barley, and peanuts. Truck crops are grown on a limited acreage in parts of the county.

General Nature of the County

This section discusses the climate; settlement and development; physiography, relief, and drainage; natural resources; industry and transportation; and visual resources of Cleveland County.

Climate

Cleveland County is hot in summer but cool in winter when an occasional surge of cold air causes a sharp drop in othewise mild temperatures. Rainfall is uniformly distributed throughout the year, reaching a slight peak in spring. Snowfalls are infrequent. Annual total precipitation is normally adequate for cotton, feed grains, and small grains.

Table 1 gives data on temperature and precipitation for the survey area as recorded at Norman, Oklahoma, in the period 1951 to 1977. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on the growing season.

In winter the average temperature is 40 degrees F, and the average daily minimum temperature is 28 degrees. The lowest temperature on record, which occurred at Norman on January 5, 1959, is -4 degrees. In summer the average temperature is 80 degrees, and the average daily maximum temperature is 92 degrees. The highest recorded temperature, which occurred at Norman on August 6, 1956, is 109 degrees.

Growing degree days are shown in table 1. They are equivalent to "heat units." During the month, growing degree days accumulate by the amount that the average temperature each day exceeds a base temperature (50 degrees F). The normal monthly accumulation is used to schedule plantings of a crop between the last freeze in spring and the first freeze in fall.

The total annual precipitation is 33.14 inches. Of this, 22 inches, or 66 percent, usually falls in April through September. The growing season for most crops falls within this period. In 2 years out of 10, the rainfall in April through September is less than 17 inches. The heaviest

1-day rainfall during the period of record was 4.87 inches at Norman on May 23, 1975. Thunderstorms occur on about 50 days each year, and most occur in summer.

The average seasonal snowfall is 7.4 inches. The greatest snow depth at any one time during the period of record was 8 inches. On an average of 3 days, at least 1 inch of snow is on the ground. The number of such days varies greatly from year to year.

The average relative humidity in midafternoon is about 52 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 75 percent of the time possible in summer and 60 percent in winter. The prevailing wind is from the southwest. Average windspeed is highest, 15 miles per hour, in spring.

Tornadoes and severe thunder storms occur occasionally. These storms are local and of short duration, and the pattern of damage is variable and spotty.

Settlement And Development

Ruth Carroll, area clerk, Soil Conservation Service, Oklahoma City, helped to prepare this section.

The part of Oklahoma that became Cleveland County was first settled by Indians. The Chickasaw Nation bordered on the south and west across the South Canadian River, and the Osage Indians claimed the area north of the river. In 1803, the area was acquired in the Louisiana Purchase by the United States. The Osage Indians controlled the area until 1825. The government then ceded it to the Creek Indians. In 1856, it was given to the Seminole Indians, and in 1866, the federal government acquired limited title through treaties with the Indians.

In 1870, the U.S. Government began surveying the area for subdivision into townships and sections. The project was completed in 1873. Settlers established a few cattle ranches in the area about 1870, but the area was officially opened for settlement in the Oklahoma Land Run of April 22, 1889.

The area remained as part of the Oklahoma Territory. It was originally named the Third County. Following the first election on August 25, 1890, the county was renamed Cleveland County in honor of former President Grover Cleveland *(4)*. The University of Oklahoma in Norman was established in 1890, and construction was completed in 1893.

Most of the early settlers came from Kansas, Arkansas, Texas, Missouri, and Illinois. They lived mostly in one-room dugouts or in aboveground mud houses. Those fortunate enough to have scrub oak on their homesteads built log cabins and heated them with remnants of wood chips, bark, and other timber removed to make way for planting their first crops. Early business buildings were constructed of lumber hauled in by railroad. They were soon replaced with brick made by brick companies established in Norman in 1891 and 1892.

Corn, oats, cotton, wheat, and hay were the principal crops. Corn, oats, and hay were used mostly to feed the horses and other livestock. Cotton and wheat were sold or were traded for other essential items. Most settlers had small gardens. Potatoes, beans, corn, watermelons, strawberries, and orchard crops were grown for food.

Early farming methods consisted mostly of plowing and planting crops without regard to the lay of the land. This method of farming resulted in rapid soil erosion, loss of fertility, and loss of much needed moisture to produce a crop. As a result, many homesteaders were forced to sell their land, or they abandoned it during the 1930's. Much of the land lay idle and continued to erode for many years.

In the mid-1940's, farm commodity prices and climatic conditions began to improve. Urban dwellers began moving back to the country. Most landowners used new and improved farming methods and equipment to reclaim the land. Much of the eroded uplands in the eastern part of the county were sprigged to bermudagrass or seeded to lovegrass and used for tame pastures. Numerous farm ponds were constructed for livestock water and erosion control. Croplands were confined mostly to fertile soils along the streams and to nearly level and very gently sloping soils on uplands. The acreage of cotton and corn fell rapidly. Small grains, grain sorghum, and alfalfa acreage increased as mechanized farming replaced horse-drawn equipment. Farmers along the South Canadian River began drilling irrigation wells for supplemental water for growing alfalfa, corn, soybeans, and wheat.

With the movement of urban dwellers back to the country, farm numbers increased rapidly and farm size decreased. Much of the land has been subdivided into 2.5-acre to 10-acre tracts, particularly in the eastern part of the county. The woodlands, rolling hills, and reasonable land prices attracted people to this area. Most of the landowners continue to work in nearby urban centers. They tend their land and livestock in the evenings and on weekends. Currently Cleveland County has many quarter horse and thoroughbred horse breeding and training farms (fig. 1).

Physiography, Relief, and Drainage

Cleveland County is in the Osage Plains section of the Central Lowland physiographic province *(5)*. The surface relief is an undulating to gently rolling, southeastward sloping plain. Most prairies in western Cleveland County are nearly level to sloping and have broad, very shallow valleys. Small areas of strongly sloping to moderately steep breaks occur along the South Canadian River and along small streams where the prairies give way to the forested uplands. These prairies are in the Central Rolling Red Prairies major land resource area. Forested

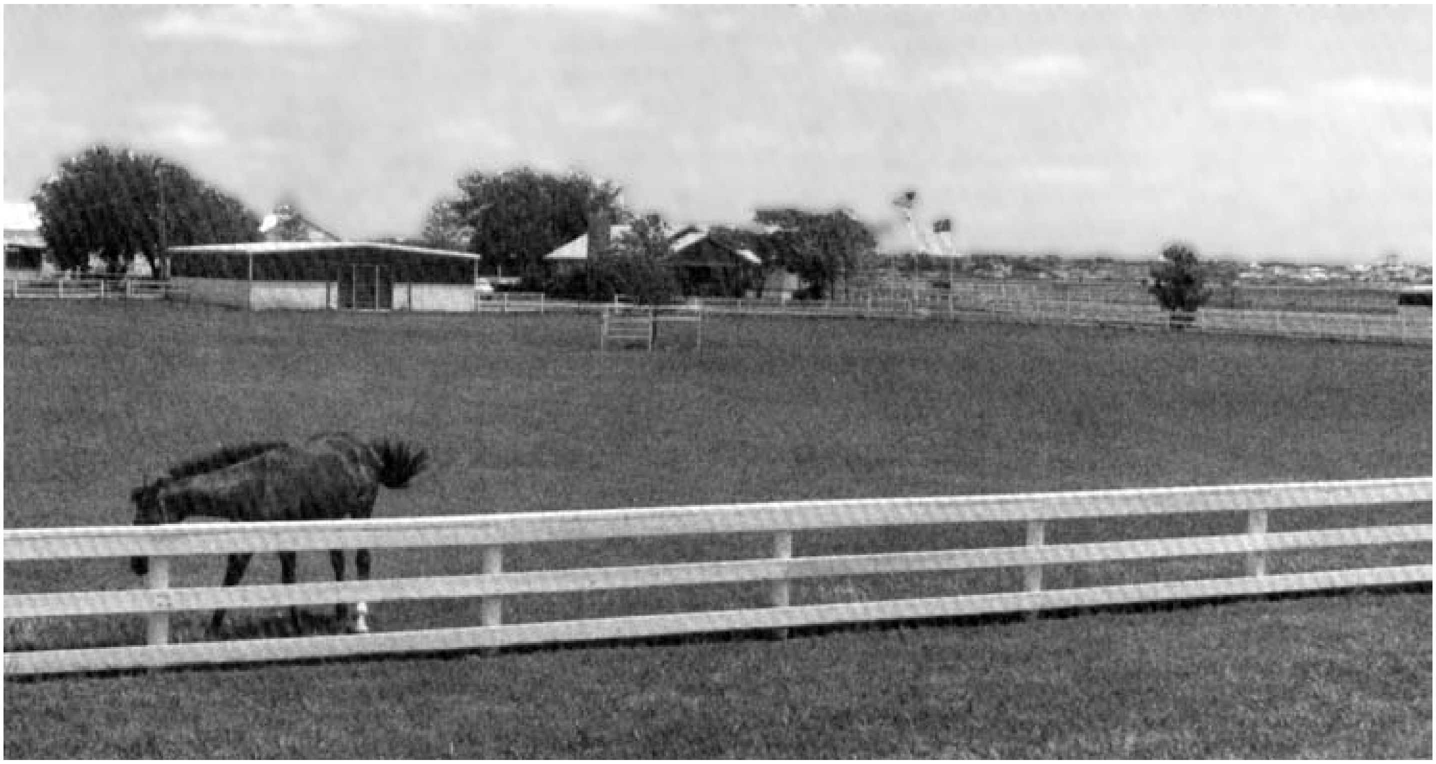


Figure 1.—A quarter horse breeding and training farm in an area of Asher silt loam, clayey substratum, rarely flooded. Urban encroachment (visible in the right background) is a major threat to prime farmland soils in the county.

lands in the eastern part of Cleveland County are in the Cross Timbers major land resource area. They are mostly very gently sloping to sloping uplands that have broad, fairly deep valleys dissected with numerous intermittent and permanent streams. Elevation ranges from about 1,370 feet in the northwest part of the county to about 960 feet in the eastern part.

The South Canadian River flows southeasterly along the western and southern boundary of Cleveland County with a fall of about 9 feet per mile. This river and its short tributaries drain the western two-fifths of the county. The eastern part is drained by the Little River, which heads in the town of Moore and flows southeastward into the South Canadian River. About 12 square miles in the northeast corner of the county drains into the North Canadian River.

Natural Resources

The soils of Cleveland County are an important natural resource. They provide a media for plants to grow and produce crops for food, forage for livestock, or wood for fuel, shelter, or aesthetic purposes. Soils provide a base for building foundations, a source for topsoil used in landscaping, and a source of fill material for road construction or building sites. Some soils are used for their insulating qualities in construction of underground homes. Soil temperature data is becoming more important with the development of heating and cooling systems that extract air from ducts buried within the soil. Sand deposits beneath the Gracemore soils are suitable for concrete and mortar if washed and screened. Gravel and sandy deposits beneath Norge Variant and Teller Variant, 3 to 8 percent slopes, are suitable for surfacing secondary roads.

Water is another important natural resource. Most of the rainfall that runs off is impounded in lakes or farm ponds and used for municipal, industrial, domestic, or livestock use. Lake Thunderbird in the east central part of the county was constructed primarily for municipal and industrial water supply for Norman, Del City, and Midwest City. Lake Stanley Draper in the northeast part of the county is one of three lakes constructed by Oklahoma City for water supply. The underground water supply in Cleveland County is very important. It comes from two main sources *(13)*. The terrace deposits and alluvium along the South Canadian River supplies adequate water for domestic or livestock use and the Garber-Wellington Formation supplies an abundance of water for municipal, industrial, or domestic use. In places, the alluvial deposits along the South Canadian River supply water for sprinkler irrigation systems used primarily to increase production of alfalfa hay, soybeans, wheat, and corn for silage. Underground water wells range mostly from 30 to 150 feet deep in the terrace and alluvial deposits and from about 300 to 900 feet deep in the Garver-Wellington Formation. The water is of very good quality for the most part, and adequate recharge is expected to keep up with the demand for many years.

Oil and gas production are important natural resources in the county. The first exploration well was drilled in 1919 *(7)*. It was drilled to a depth of 2,402 feet before it was abandoned and declared a dry hole. Eleven years later, following discovery of oil in Oklahoma County, the first producing oil well was completed in Cleveland County. Numerous wells have been drilled in the county since the mid 1930's with the greatest production and income coming from oil. Today, more than 20 separate oil and gas fields have been discovered in the county, and the present outlook is still favorable for a thriving industry.

The forested uplands in eastern Cleveland County are a popular natural resource, primarily for their aesthetic value as homesites. Numerous large tracts of land were subdivided into 2.5- to 10-acre tracts during the 1970's. The hilly, rolling topography and friable soils are suitable sites for building underground homes or log cabins and for using wood for fuel or wind generators to produce electricity.

Recreation is a major resource in the county, primarily because the soils, topography, and vegetation are well suited to this use. More than 17,000 surface acres of water are impounded in lakes, reservoirs, and farm ponds. Lake Thunderbird on Little River east of Norman and Lake Stanley Draper on Elm Creek east of Moore are the largest impoundments. User fees are charged for some recreational activities. Little River State Park on the northwest shore of Lake Thunderbird has boating, fishing, camping, picnicking, swimming, playgrounds, and trails. Riding stables are also available. Lexington and Thunderbird public hunting areas are in Cleveland County. Openland and woodland wildlife are available for hunting during season. Quail and deer are concentrated in privately-owned forested uplands in the eastern part of the county and along creeks and river bottoms elsewhere. Wild turkeys are abundant in some areas along wooded streams.

Industry And Transportation

Most of the industrial development in Cleveland County has taken place in the central part of the county near Norman and Moore. It includes manufacturers of oil and gas drilling products *(8)* and heating and cooling equipment, a fence and iron company, and a crystal and salt company. Most residents in the county commute to work daily to the metropolitan areas of Norman and Oklahoma City.

Cleveland County is served by a large network of federal and state highways and local and county roads. Interstate Highway 35 crosses north-south through the center of the county; and Federal Highway 62, commonly referred to as Southwest Expressway, crosses the northwest part of the county. Federal Highway 77 and State Highways 9, 37, and 39 lead to the two major expressways from the rural and suburban parts of the county. The Atchison, Topeka, and Santa Fe railroad crosses north-south through the county. Small airports in Norman and Moore are maintained for small aircraft used for business and recreation.

Visual Resources

David Thompson, landscape architect, Soil Conservation Service, helped to prepare this section.

The appearance, or visual quality, of Cleveland County is an important natural resource. The visual resources are the landforms, vegetation, water elements, and manmade structures of the county. As with any natural resource, visual resources have definite boundaries and need to be properly managed for effective conservation.

Each general soil map unit has a distinctive appearance that can be modified by altering the landscape elements or their patterns. In some areas, the pattern has been extensively changed by agricultural practices or urban expansion.

In each of the soil map units shown on the general soil map of Cleveland County, the visual diversity is described and rated. These descriptions are based on a comparison of landscapes within the county and the patterns that are created by the basic landscape elements.

The elements and patterns of any landscape are readily visible and the diversity of that landscape can be rated as high, medium, or low. A landscape that has high visual diversity has some or all of the following characteristics—

- variations in landforms,
- unique plant communities or varied vegetative patterns,
- rivers or streams that have high clarity or lakes or ponds that have diverse shorelines, and
- manmade structures that harmonize with the landscape and other structures.

In areas of low visual diversity, one landscape element can dominate. This can create a continuous appearance that offers little or no variation in pattern. Areas of low diversity have some of the following characteristics—

- no variations in landforms,
- vegetative cover that has no variation in type, height, or color,
- water bodies that offer limited visual interest and shorelines that have no variety, and

- manmade structures that bear little relation to their surroundings.

Before making any change in landscape elements and patterns, the potential impact on the visual resources should be carefully analyzed. Often, a single practice can increase or decrease the visual resource quality. The grading and revegetating of an eroded area, for example, will increase visual resource quality. On the other hand, if a sloping area that has soil suitable for woodland is cleared and planted to row crops, the soil may erode severely during the spring months if it is not protected by vegetative cover. A severely eroded soil would decrease the visual resource quality. This results in bare unsightly eroded areas, loss of soil, decrease in water quality because of silt loading, and loss of other vegetative areas caused by increased runoff.

The knowledge of each landscape element and the effect of land use changes on an area are necessary to properly manage visual resources. Assistance in visual resource planning is available from the Soil Conservation Service field office in Norman. Proper consideration of the soil characteristics, land use, and the visual elements will enhance or preserve the optimal quality of the area.

How This Survey Was Made

This survey was made to provide information about the soils in the survey area. The information includes a description of the soils and their location and a discussion of the suitability, limitations, and management of the soils for specified uses. Soil scientists observed the steepness, length, and shape of slopes; the general pattern of drainage; the kinds of crops and native plants growing on the soils; and the kinds of bedrock. They dug many holes to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material from which the soil formed. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

The soils in the survey area occur in an orderly pattern that is related to the geology, the landforms, relief, climate, and the natural vegetation of the area. Each kind of soil is associated with a particular kind of landscape or with a segment of the landscape. By observing the soils in the survey area and relating their position to specific segments of the landscape, a soil scientist develops a concept, or model, of how the soils were formed. Thus, during mapping, this model enables the soil scientist to predict with considerable accuracy the kind of soil at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, acidity or alkalinity, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. The system of taxonomic classification used in the United States is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

While a soil survey is in progress, samples of some of the soils in the area are generally collected for laboratory analyses and for engineering tests. Soil scientists interpreted the data from these analyses and tests as well as the field-observed characteristics and the soil properties in terms of expected behavior of the soils under different uses. Interpretations for all of the soils were field tested through observation of the soils in different uses under different levels of management. Some interpretations are modified to fit local conditions, and new interpretations sometimes are developed to meet local needs. Data were assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management were assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can state with a fairly high degree of probability that a given soil will have a high water table within certain depths in most years, but they cannot assure that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Map Unit Composition

A map unit delineation on a soil map represents an area dominated by one major kind of soil or an area dominated by several kinds of soil. A map unit is identified and named according to the taxonomic classification of the dominant soil or soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural objects. In common with other natural objects, they have a characteristic variability in their properties. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of soils of other taxonomic classes. Consequently, every map unit is made up of the soil or soils for which it is named and some soils that belong to other taxonomic classes. In the detailed soil map units, these latter soils are called inclusions or included soils. In the general soil map units, they are called soils of minor extent.

Most inclusions have properties and behavioral patterns similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting (similar) inclusions. They may or may not be mentioned in the map unit descriptions. Other inclusions, however, have properties and behavior divergent enough to affect use or require different management. These are contrasting (dissimilar) inclusions. They generally occupy small areas and cannot be shown separately on the soil maps because of the scale used in mapping. The inclusions of contrasting soils are mentioned in the map unit descriptions. A few inclusions may not have been observed, and consequently are not mentioned in the descriptions, especially where the soil pattern was so complex that it was impractical to make enough observations to identify all of the kinds of soils on the landscape.

The presence of inclusions in a map unit in no way diminishes the usefulness or accuracy of the soil data. The objective of soil mapping is not to delineate pure taxonomic classes of soils but rather to separate the landscape into segments that have similar use and management requirements. The delineation of such landscape segments on the map provides sufficient information for the development of resource plans, but onsite investigation is needed to plan for intensive uses in small areas.

General Soil Map Units

The general soil map at the back of this publication shows broad areas that have a distinctive pattern of soils, relief, and drainage. Each map unit on the general soil map is a unique natural landscape. Typically, a map unit consists of one or more major soils and some minor soils. It is named for the major soils. The soils making up one unit can occur in other units but in a different pattern.

The general soil map can be used to compare the suitability of large areas for general land uses. Areas of suitable soils can be identified on the map. Likewise, areas where the soils are not suitable can be identified.

Because of its small scale, the map is not suitable for planning the management of a farm or field or for selecting a site for a road or a building or other structure. The soils in any one map unit differ from place to place in slope, depth, drainage, and other characteristics that affect management.

The soils in the survey area vary widely in their potential for major land uses. Table 4 shows the extent of the map units shown on the general soil map and the extent of each named soil in each map unit. It lists the potential of each map unit and the potential of each named soil in the map unit in relation to the soils of the other map units. The potential is given for five major land uses, and the soil properties that limit use are listed. Soil potential ratings are based on the practices commonly used in the survey area to overcome soil limitations. These ratings reflect the ease of overcoming the limitations. They also reflect the problems that will persist even if such practices are used.

Each map unit is rated for *cultivated crops, pasture and range, urban uses, recreation areas* and *wildlife habitat.* Cultivated crops are those grown extensively in the survey area. Pasture and range includes tame pasture grasses, native grasses, and hayland. Urban uses include building site development and sanitary facilities used in residential, commercial, and industrial developments. Intensive recreation areas are campsites, picnic areas, ballfields, and other areas that are subject to heavy foot traffic.

Wildlife habitat is areas of land suited to production of food and shelter for openland wildlife, rangeland wildlife, and wetland wildlife.

Deep to Shallow, Moderately Well Drained, Well Drained, and Excessively Drained, Loamy and Sandy Soils; on Forested Uplands

The two map units in this group make up about 47 percent of Cleveland County (fig. 2). The soils in these map units are used mainly for native range and tame pasture, but some areas are used for cropland, hay, or for urban use. Many trees are harvested for firewood. Many 2.5- to 10-acre sites are privately owned.

1. Stephenville-Harrah-Newalla

Moderately deep and deep, very gently sloping to sloping, well drained and moderately well drained, loamy soils that formed in materials weathered from sandstone, colluvium, or shale

The landforms of this map unit have limited diversity. Scrub oak woodland interspersed with prairie openings and tame pasture provide some diversity to the vegetative patterns. Structures are mainly farmsteads and subdivision developments. Water elements are drainageways and occasional farm ponds. Visual diversity in this map unit is medium, and changes in the landscape will be moderately significant.

This map unit makes up about 40 percent of the county. It is about 33 percent Stephenville soils, 33 percent Harrah soils, 12 percent Newalla soils, and 22 percent soils of minor extent.

Stephenville soils are on ridge crests and side slopes in higher positions on the landscape than Harrah soils and are in similar positions on the landscape to Newalla soils. The Stephenville soils are moderately deep, very gently sloping to sloping, and well drained. They are moderately permeable. Typically, the Stephenville soils have a brown fine sandy loam surface layer and pinkish gray loamy fine sand subsurface layer. The subsoil is reddish yellow and light red sandy clay loam underlain by soft, reddish sandstone.

Harrah soils are on foot slopes and side slopes in lower positions on the landscape than Stephenville and Newalla soils. The Harrah soils are deep, gently sloping to sloping, and well drained. They are moderately permeable. Typically, the Harrah soils have a brown fine sandy loam surface layer and light brown loamy fine sand subsurface layer. The subsoil is red sandy clay loam.

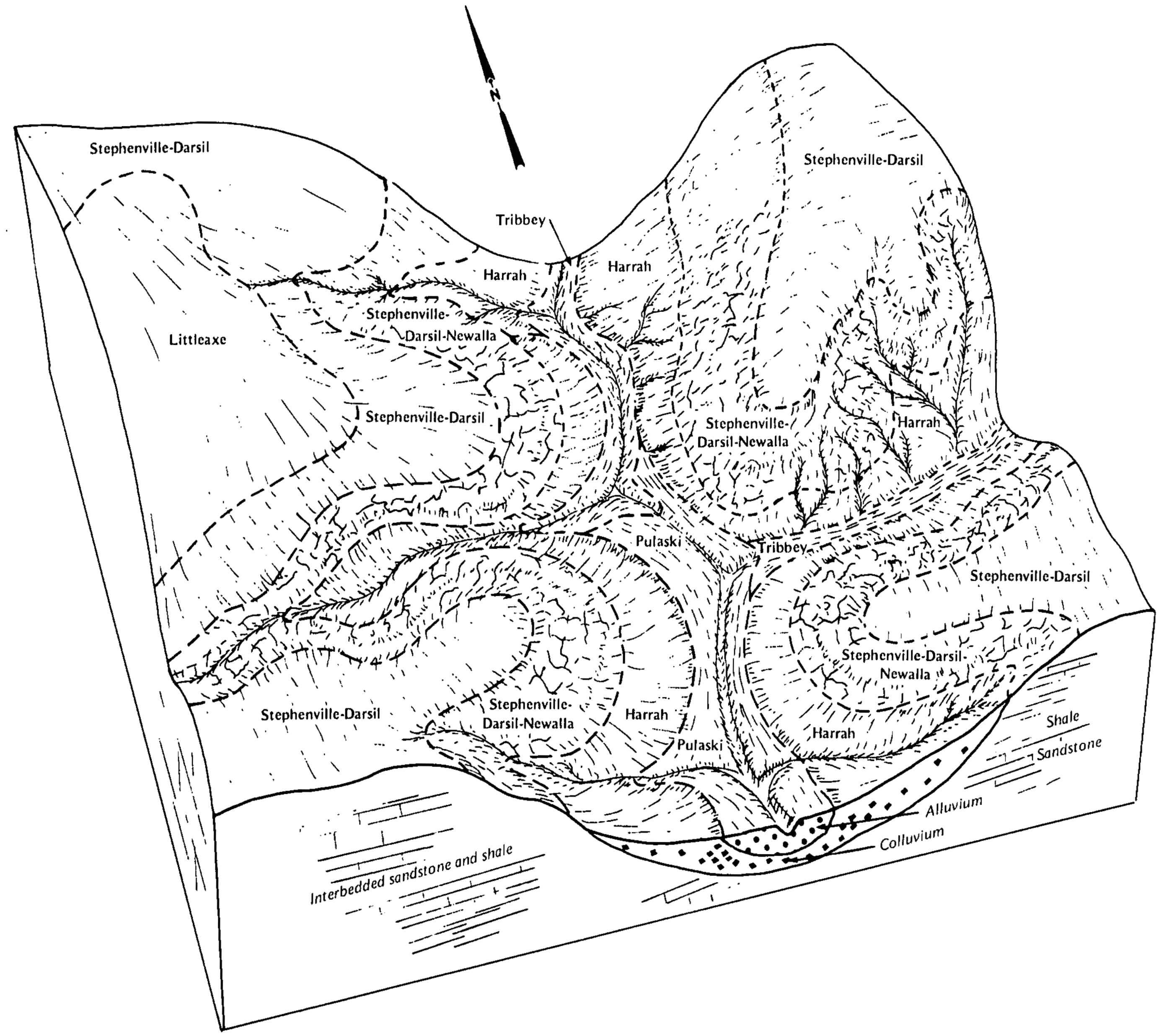


Figure 2.—Typical pattern of soils and underlying material in the Stephenville-Harrah-Newalla map unit, the Stephenville-Littleaxe-Darsil map unit, and the Pulaski-Tribbey map unit.

Newalla soils are on contour bands of side slopes and ridge crests in higher positions on the landscape than Harrah soils and are in similar positions on the landscape to Stephenville soils. The Newalla soils are deep, very gently sloping to sloping, and moderately well drained. They are very slowly permeable. Typically, Newalla soils have a brown fine sandy loam surface layer and light brown fine sandy loam subsurface layer. The subsoil is red sandy clay loam in the upper part, red clay in the middle part, and red shaly silty clay in the lower part. The subsoil is underlain by red, weakly laminated shale.

Of minor extent in this map unit are Darsil, Derby, Grainola, Littleaxe, Lucien, Pulaski, Renfrow, and Tribbey soils. The shallow, excessively drained, rapidly permeable Darsil soils are on narrow contour bands around side slopes and on shoulders of ridge crests. The deep, somewhat excessively drained, rapidly permeable Derby soils are on convex dunes on the crown of ridgetops and on foot slopes. The moderately deep, well drained, slowly permeable Grainola soils are on side slopes of prairie knolls. The deep, well drained, moderately permeable Littleaxe soils are on broad ridgetops at a higher elevation than the other soils in this map unit. The shallow, well drained, moderately permeable to moderately rapidly permeable Lucien soils are on shoulders and crests of prairie ridgetops. The deep, well drained, moderately rapidly permeable Pulaski soils and the deep, somewhat poorly drained, moderately rapidly permeable Tribbey soils are on narrow flood plains. The deep, well drained, very slowly permeable Renfrow soils are on side slopes and foot slopes of prairie openings.

The soils in this map unit are used mostly for native range, bermudagrass and lovegrass pasture, and suburban development. A few areas are planted to wheat or grain sorghum. Many post oak, blackjack oak, and hickory trees are cut for firewood.

The soils in this map unit have low potential for cropland. Excessive slopes, the low available water capacity, runoff, the hazard of erosion, and low fertility and organic matter content are the main limitations. Controlling erosion is a major concern.

The soils in this map unit have medium potential for native range, hay, or tame pasture. Controlling brush and weeds, protecting vegetation from fire, and improving the soil fertility and organic matter content are management concerns.

The Stephenville and Harrah soils in this map unit are best suited to agricultural use. These soils have medium potential for urban use. The depth to rock in the Stephenville soils is a severe limitation for sanitary facilities, but only a slight limitation for use as sites for houses without basements or small commercial buildings. The Harrah soils have slight limitations for use as building sites. The Newalla soils have low potential for urban use. They have a clayey texture, high shrink-swell potential, very slow permeability, and a hazard of corrosion. Many of these limitations can be overcome by special design measures. Preventing runoff and erosion in cleared areas, improving soil fertility and organic matter content, and controlling weeds are management concerns.

The soils in this map unit have high potential for most recreational uses. Steepness of slope is a limitation for playgrounds. Newalla soils have moderate limitations because of very slow permeability and steepness of slope.

The soils in this map unit have high potential for use as openland or rangeland wildlife habitat. They have low potential for use as wetland wildlife habitat.

2. Stephenville-Littleaxe-Darsil

Deep to shallow, very gently sloping and gently sloping, well drained and excessively drained, loamy and sandy soils that formed in materials weathered from sandstone

The landforms of this map unit offer little diversity. Areas of hardwood trees and cleared openings provide diversity to the vegetative patterns. Structures are primarily farmsteads and subdivision developments. Visual diversity in this map unit is medium, and changes will be moderately significant.

This map unit makes up about 7 percent of the county. It is about 49 percent Stephenville soils, 20 percent Littleaxe soils, 9 percent Darsil soils, and 22 percent soils of minor extent.

Stephenville soils are on broad ridge crests in similar positions on the landscape to Littleaxe soils and are in higher positions on the landscape than Darsil soils. The Stephenville soils are moderately deep, very gently sloping to gently sloping, and well drained. They are moderately permeable. Typically, the Stephenville soils have a brown fine sandy loam surface layer and pinkish gray loamy fine sand subsurface layer. The subsoil is reddish yellow and light red sandy clay loam underlain by soft, reddish sandstone.

Littleaxe soils are on broad ridge crests in similar positions on the landscape to Stephenville soils and are in higher positions on the landscape than Darsil soils. These soils are deep, very gently sloping, and well drained. They are moderately permeable. Typically, the Littleaxe soils have a grayish brown loamy fine sand surface layer and pink loamy fine sand subsurface layer. The subsoil is yellowish red sandy clay loam in the upper part and reddish yellow and coarsely mottled reddish yellow fine sandy loam in the lower part. It is underlain by reddish yellow and yellowish red soft sandstone interbedded with red shale.

Darsil soils are on contour bands near shoulders of ridge crests in lower positions on the landscape than the Littleaxe and Stephenville soils. These soils are shallow, very gently sloping to gently sloping, and excessively drained. They are rapidly permeable. Typically, the Darsil soils have a brown loamy fine sand surface layer. Below that, they are pink fine sand underlain by red, weakly cemented, fine grained sandstone.

Of minor extent in this map unit are the Derby, Harrah, Newalla, and Pulaski soils. The deep, somewhat excessively drained, rapidly permeable Derby soils are on convex dunes on the crown of ridgetops. The deep, well drained, moderately permeable Harrah soils are on side slopes and foot slopes below the other soils in this map unit. The deep, moderately well drained, very slowly permeable Newalla soils are in contour bands surrounded by Stephenville soils. The deep, well drained, moderately rapidly permeable Pulaski soils are on narrow flood plains that dissect this map unit.

The soils in this map unit are used mostly for tame pasture and native range. Bermudagrass and lovegrass are the main tame pasture grasses. Many areas have been divided into 2.5- to 10-acre tracts for suburban homesites. Some areas have trees that are cleared for firewood. A few areas are used for wheat or grain sorghum.

The soils in this map unit have medium potential for cropland, hay, pasture, or native range. Steepness of slope, the hazard of erosion, and low fertility and organic matter content are limitations that reduce the capability of these soils for agricultural use. Heavy infestations of scrub oak and severe erosion problems are the main management concerns. Maintaining or improving the fertility and organic matter content, controlling fire, and protecting grasses from overuse are additional concerns.

The soils in this map unit have medium potential for most urban uses. They are best suited to building site development. The depth to rock is a severe limitation of the Stephenville and Darsil soils and a moderate limitation of the Littleaxe soils for use as septic tank absorption fields. Littleaxe soils are better suited to urban uses because of the greater depth to rock. Controlling weedy grasses and using good design and installation procedures for sanitary facilities are management concerns.

Littleaxe and Stephenville soils have high potential for most recreational uses. Steepness of slope is a moderate limitation for playgrounds and a slight limitation for other urban use. Darsil soils have severe limitations for recreational use because of depth to rock.

The soils in this map unit have medium potential for use as habitat for wildlife.

Deep and Moderately Deep, Well Drained and Moderately Well Drained, Loamy Soils; on Prairie Uplands

The three map units in this group make up 37 percent of Cleveland County. The soils in these map units are used mainly for cropland, tame pasture, and urban land, but some areas are used for truck crops, hay, and range. Some of the soils in these map units are mined for topsoil and fill materials.

3. Renfrow-Grainola-Grant

Deep and moderately deep, very gently sloping to moderately steep, well drained, loamy soils that formed in materials weathered from shale, siltstone, or sandstone

The majority of the landforms in this map unit have low diversity. Crops, tame pasture, hay, and range create little diversity in vegetative patterns. Farm ponds and tree-lined drainageways are the only water elements present. Visual diversity in this map unit is low, and changes in the landscape will be visually significant.

This map unit makes up about 15 percent of the county (fig. 3). It is about 34 percent Renfrow soils, 14 percent Grainola soils, 7 percent Grant soils, and 45 percent soils of minor extent and Urban land.

Renfrow and Grant soils are in similar positions on the landscape on ridge crests and side slopes and are generally slightly higher in elevation than Grainola soils. The Renfrow soils are deep, very gently sloping to gently sloping, and well drained. They are very slowly permeable. Typically, the Renfrow soils have a brown silt loam surface layer. The subsoil is reddish brown silty clay loam in the upper part and reddish brown, yellowish red, and red silty clay in the lower part. It is underlain by light red, red, and very pale brown soft, laminated shale.

Grainola soils are generally slightly lower in elevation on steeper side slopes than Renfrow and Grant soils. These soils are moderately deep, gently sloping to moderately steep, and well drained. They are slowly permeable. Typically, the Grainola soils have a thin surface layer of reddish brown silty clay loam. The subsoil is reddish brown silty clay in the upper part, red shaly silty clay in the middle part, and red very shaly silty clay in the lower part. It is underlain by red, weakly laminated shale.

Grant soils are generally on broad, smooth side slopes and ridge crests. These soils are deep, very gently sloping to gently sloping, and well drained. They are moderately permeable. Typically, the Grant soils have a brown silt loam surface layer. The subsoil is reddish brown silt loam in the upper part, reddish brown and yellowish red silty clay loam in the middle part, and red silty clay loam in the lower part. The underlying material is light reddish brown, weakly laminated siltstone or sandstone.

Of minor extent in this map unit are the well drained Kingfisher, Lucien, Norge, Norge Variant, Port, Pulaski, Teller, Teller Variant, and Weswood soils and the moderately well drained Huska soils. The moderately deep, moderately slowly permeable Kingfisher soils are on ridge crests in slightly lower positions on the landscape than Grant soils. The shallow, moderately rapidly permeable Lucien soils are on shoulders of ridge crests at lower elevations than Grant soils. The deep, moderately slowly permeable Norge and Norge Variant soils are on foot slopes below Grainola and Renfrow soils. The deep, moderately permeable Port and Weswood soils and the deep, moderately rapidly permeable Pulaski soils are on narrow flood plains that dissect this map unit. The deep, moderately permeable Teller and Teller Variant soils are on foot slopes. The deep, very slowly permeable saline-alkali Huska soils are intermingled with Grant and Renfrow soils.

The soils of this map unit are used most extensively for native range, hay, and bermudagrass pasture. Some of the less sloping areas are used for wheat, barley, or

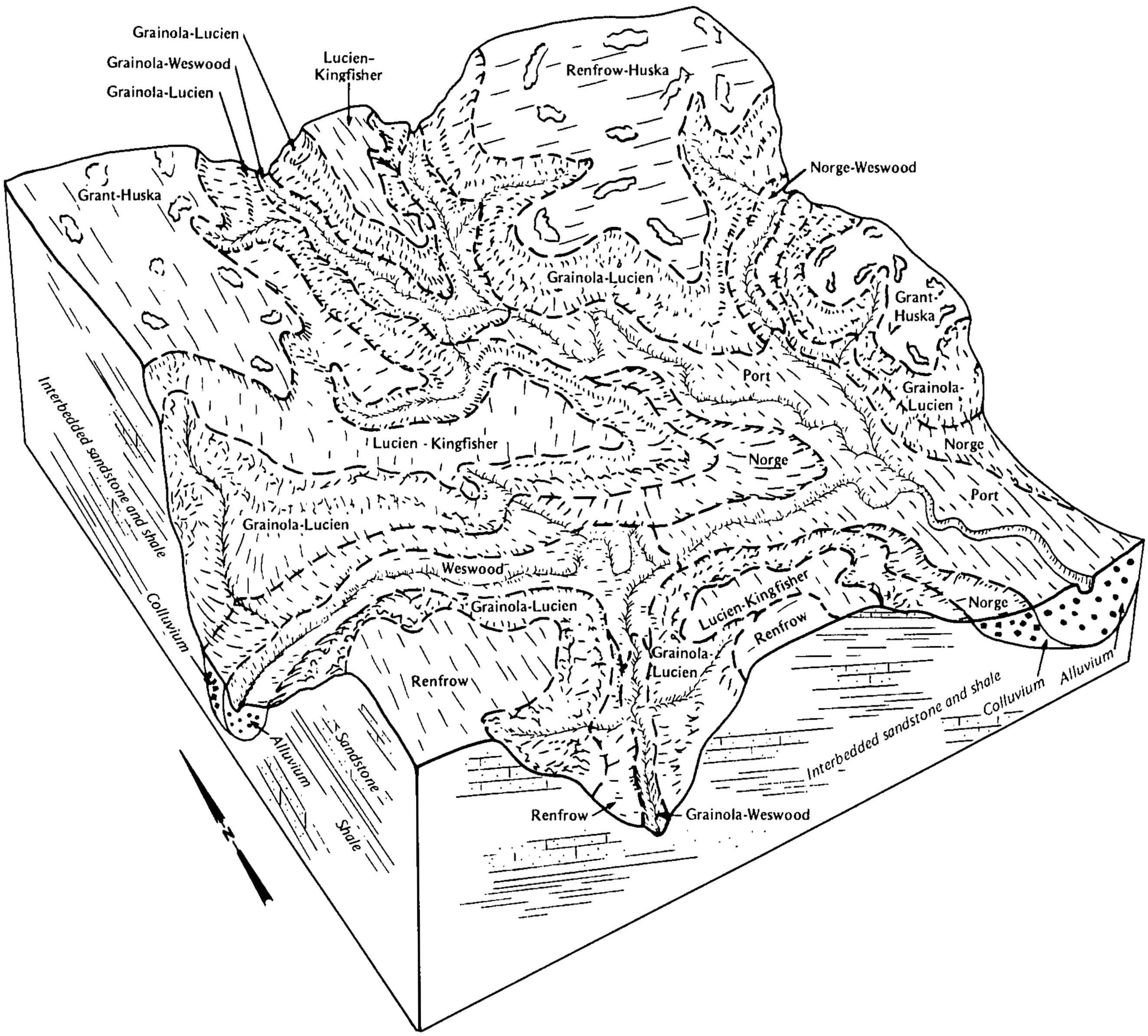


Figure 3.—Typical pattern of soils and underlying material in the Renfrow-Grainola-Grant map unit and the Port-Weswood map unit.

grain sorghum. Some areas in Moore and Norman are in urban use.

Most soils in this map unit have low potential for cropland. Steepness of slope, slow and very slow permeability, and the hazard of erosion are the main limitations. The soils in this map unit have medium potential for pasture and native range. The major concerns of management for agricultural uses are maintaining or improving the quality of grasses, following suitable grazing practices, protecting vegetation from fire, protecting soils from water erosion, and preventing soil compaction when used during wet seasons. Grant soils and areas of Renfrow soils that are not eroded are better suited to cropland or tame pasture. The clayey subsoil in the Renfrow and Grainola soils partially restricts root growth and generally is droughty during periods of below-normal rainfall. Water erosion is a severe limitation of the Grant soils. Runoff is excessive on slopes of more than 3 percent.

The soils in this map unit have low potential for most urban uses. Grant soils are better suited to urban development than Renfrow or Grainola soils. The very slow and slow permeability of the Renfrow and Grainola soils is a severe limitation for use as septic tank absorption fields. The high shrink-swell potential and corrosion potential to steel of the Renfrow and Grainola soils are severe limitations to building site development or for roadfill. The depth to rock and the steeper slopes of the Grainola soils are severe limitations for many urban uses. The Renfrow and Grainola soils have slight limitations for use as sewage lagoons or pond reservoirs. Special design and careful installation are needed to reduce or prevent damage to structures from high shrink-swell changes, high corrosion to steel, and very slow perculation.

The soils of this map unit have medium potential for most recreational uses. The hazard of erosion is a severe limitation for paths and trails. Slope is a moderate to severe limitation for playgrounds. The very slow permeability of the Renfrow soils is a moderate limitation for most recreation uses. Permeability in Grainola and Grant soils is a slight limitation.

Most of the soils in this map unit have high potential for use as habitat for openland wildlife, medium potential for use as habitat for rangeland wildlife, and low potential for use as habitat for wetland wildlife. Lack of water and droughtiness are the main limitations.

4. Norge-Teller-Vanoss

Deep, nearly level to sloping, well drained, loamy soils that formed in old loamy alluvium

The landforms of this map unit have moderate diversity. Diversity is provided by farm ponds and by woody vegetation growing along drainageways and intermingling with cropland and tame pasture. Visual diversity in this map unit is medium, and changes in the landscape will be moderately significant.

This map unit makes up about 14 percent of the county (fig. 4). It is about 28 percent Norge soils, 26 percent Teller soils, 15 percent Vanoss soils, and 31 percent soils of minor extent and Urban land.

Norge soils are mostly on convex side slopes and ridge crests just below the Vanoss soils and above the Teller soils. These soils are deep, very gently sloping to sloping, and well drained. They are moderately slowly permeable. Typically, the Norge soils have a brown silt loam surface layer. The subsoil is reddish brown silty clay loam in the upper part, red silty clay loam in the middle part, and red silty clay in the lower part.

Teller soils are mostly on convex lower side slopes and foot slopes below the Vanoss and Norge soils. These soils are deep, very gently sloping to sloping, and well drained. They are moderately permeable. Typically, the Teller soils have a brown fine sandy loam surface layer. The subsoil is brown fine sandy loam in the upper part, reddish brown sandy clay loam in the middle part, and yellowish red fine sandy loam in the lower part. It is underlain by buried layers of brown and yellowish brown silty clay loam.

Vanoss soils are mostly on broad, smooth plains above the Norge and Teller soils. These soils are deep, nearly level to very gently sloping, and well drained. They are moderately permeable. Typically, the Vanoss soils have a brown silt loam surface layer. The subsoil is brown silt loam in the upper part, brown silty clay loam in the middle part, and light brown silty clay loam in the lower part. The upper part of the underlying material is reddish brown loam and the lower part is light reddish brown sandy clay loam.

Of minor extent in this map unit are the Bethany, Derby, Dougherty, Grant, Konawa, Norge Variant, Renfrow, Slaughterville, Slaughterville Variant, and Teller Variant soils. Small areas of Urban land and Ustorthents are also included. The well drained, slowly permeably Bethany soils are on smooth, broad relief near the Vanoss soils, but are on flatter slopes farther from the streams. The rapidly permeable, somewhat excessively drained Derby soils are on convex dunes on side slopes. The well drained, moderately permeable Dougherty and Konawa soils are on undulating ridge crests near the Teller soils. The well drained, moderately permeable Grant soils are forming from materials weathered from siltstone or sandstone on slightly higher knolls and ridge crests near the Norge soils. The well drained, moderately slowly permeable Norge Variant soils are in similar positions on the landscape as Norge soils. The well drained, very slowly permeable Renfrow soils are on side slopes and ridge crests adjacent to the Norge soils. The well drained, moderately rapidly permeable Slaughterville and Slaughterville Variant soils are mostly on side slopes at lower elevations than Teller soils. The well drained, moderately permeable Teller Variant soils are in similar positions on the landscape to Teller soils. The Bethany and Renfrow soils have high shrink-swell potential, high corrosion potential to steel, and perculation limitations that are difficult to overcome when used for urban development. Urban land is mostly in Norman, Noble, and Lexington. Ustorthents are mostly gravel pits or borrow pits within the map unit.

The soils of this map unit are used mainly for wheat, barley, cotton, grain sorghum, alfalfa, corn for silage, and bermudagrass pasture. A few areas are used for vegetables and peanuts. Teller soils are mined extensively for fill and subgrade materials. Vanoss, Slaughterville, and Teller soils are stripped for topsoil use in some areas.

The soils in this map unit have medium potential for cropland, tame pasture, hay, or native range. The major concerns for management for agricultural uses are keeping prime farmland for future crop production, maintaining the soil tilth and fertility, protecting soils from water erosion, controlling weeds, and preventing compaction. The susceptibility to water erosion is a moderate limitation. The Vanoss soils are better suited to agricultural uses because of the topography and slightly better natural fertility.

The soils in this map unit have medium potential for most urban uses. Teller soils are best suited to urban development. Moderate permeability is a moderate limitation of Teller and Vanoss soils for use as septic tank absorption fields, and moderately slow permeability is a severe limitation of Norge soils. Corrosion to steel, shrinking and swelling, and perculation rate of the Norge and Vanoss soils are management concerns. All soils in this map unit have slight limitations for lawns, landscaping, and golf fairways.

These soils have medium potential for most recreational uses. The limitations are slight for playgrounds on slopes of less than 2 percent, moderate on slopes of 2 to 6 percent, and are severe on slopes over 6 percent. Water erosion is a moderate limitation of Norge and Vanoss soils for use as trails and paths.

The soils in this map unit have high potential for use as openland wildlife habitat and medium potential for rangeland wildlife habitat. They have low potential for use as wetland wildlife habitat.

5. Doolin-Bethany-Urban land

Deep, nearly level to very gently sloping, moderately well drained and well drained, loamy soils that formed in old clayey and loamy alluvium; and Urban land

The landforms of this map unit have limited diversity. Vegetation is primarily cropland and tame pasture. Water elements are limited to shallow drainageways. Structures are numerous throughout the map unit because of the Urban land of Moore, Norman, and Oklahoma City. Visual diversity in this map unit is medium, and changes will be moderately significant.

This map unit makes up about 8 percent of the county. It is about 49 percent Doolin soils, 18 percent Bethany soils, 10 percent Urban land, and 23 percent soils of minor extent.

Doolin soils are in slightly lower positions on the landscape than Bethany soils. These soils are deep, nearly level to very gently sloping, and moderately well drained. They are very slowly permeable. Typically, the Doolin soils have a grayish brown silt loam surface layer and light brownish gray silt loam subsurface layer. The subsoil is silty clay. It is dark gray and dark grayish brown in the upper part, coarsely mottled dark grayish brown, gray, and reddish brown in the middle part, and reddish brown and red in the lower part.

Bethany soils are in slightly higher positions on the landscape than Doolin soils. These soils are deep, nearly level to very gently sloping, and well drained. They are slowly permeable. Typically, the Bethany soils have a dark grayish brown silt loam surface layer. The subsoil is brown silty clay loam in the upper part, pale brown and grayish brown silty clay in the middle part, and coarsely mottled yellowish brown, dark grayish brown, and grayish brown clay loam in the lower part.

Urban land is in the same positions on the landscape as the Doolin and Bethany soils. It consists of areas that have been altered or covered with roads, dwellings, small commercial buildings, and parking lots.

Of minor extent in this map unit are the moderately well drained, saline-alkali Pawhuska soils and the well drained Norge, Renfrow, and Vanoss soils. Pawhuska soils are intermingled with the Doolin and Bethany soils. Norge, Renfrow, and Vanoss soils are at slightly higher elevations than Doolin and Bethany soils on small knolls or on side slopes that break to the drainageways. Pawhuska soils have severe limitations for urban or agricultural uses because of the sodium content, hazard of corrosion to steel and concrete, droughtiness, hazard of erosion, high shrink-swell potential, and very slow permeability.

The soils in this map unit are used mainly for cropland, tame pasture, and urban uses. The main crops are wheat, barley, grain sorghum, cotton, and alfalfa. Most of the urban land in Norman, Moore, and Oklahoma City is in this map unit.

The soils in this map unit have medium potential for crops, tame pasture, and native range. The Bethany soils are best suited to cropland. Surface drainage is needed in some areas of the Doolin soils to prevent drowning of plants. Crops that have moderate to high tolerance to salts are best suited. The major concerns of management for agriculture are maintaining soil tilth and fertility, providing protection from water erosion, and preventing compaction and crusting of surface layer.

The soils in this map unit have low potential for most urban uses. Shrinking and swelling, permeability, corrosion to steel, and erodibility are severe limitations. These soils have slight limitations for sewage lagoons, pond reservoirs, or area-type sanitary landfills. Excess sodium in the Doolin soils is a severe limitation for lawns, landscaping, golf fairways, cover for landfills, and grassed waterways.

The soils in this map unit have medium potential for most recreational uses. Excess sodium is a severe limitation in the Doolin soils, and the hazard of erosion of all soils is a severe limitation for paths and trails.

The soils in this map unit have medium potential for use as habitat for wildlife. Bethany soils are better suited because they have more favorable soil characteristics for plant growth.

Deep, Somewhat Excessively Drained to Somewhat Poorly Drained, Sandy to Clayey Soils; on Flood Plains

The five map units in this group make up 17 percent of Cleveland County. These soils are used mainly for

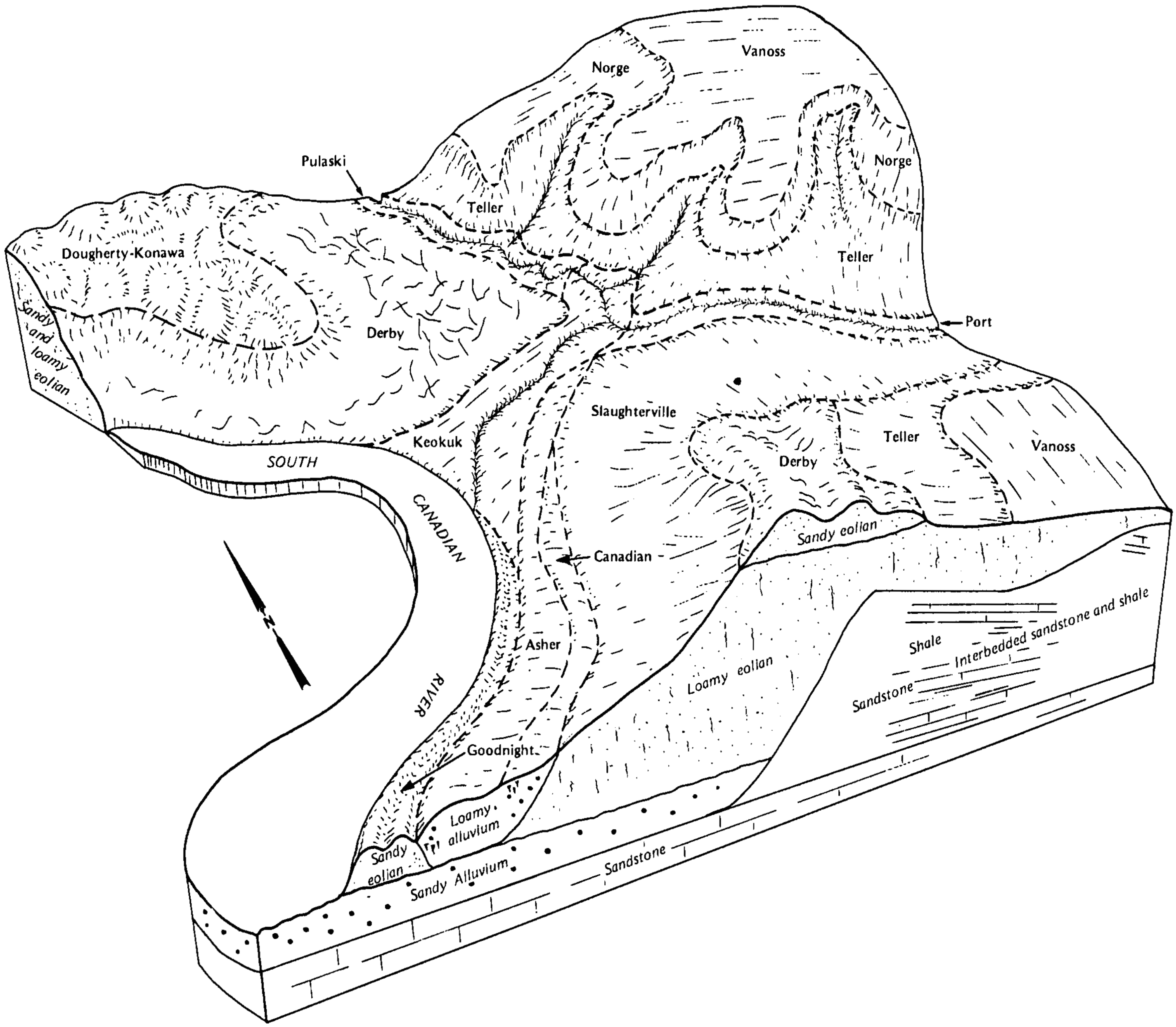


Figure 4.—Typical pattern of soils and underlying material in the Norge-Teller-Vanoss map unit and Asher-Keokuk-Canadian map unit.

cropland and tame pasture, but some areas are used for range, hay, and urban uses.

Sand is mined from some soils along the South Canadian River.

6. Port-Weswood

Nearly level to very gently sloping, well drained, loamy soils that are subject to occasional and frequent flooding; formed in recent loamy alluvium

The landforms of this map unit provide limited diversity. Diverse vegetative patterns result from cropland, tame pasture, woodland, and range. Water elements are small drainageways and creeks. Structures are farmsteads and some residences. Visual diversity for this map unit is medium, and changes in the landscape will be moderately significant.

This map unit makes up about 5 percent of the county. It is about 62 percent Port soils, 31 percent Weswood soils, and 7 percent soils of minor extent and Urban land.

Port soils are generally slightly lower in elevation than Weswood soils. The Port soils are deep, nearly level to very gently sloping, and well drained. They are moderately permeable. Typically, the Port soils have a brown and reddish brown silt loam surface layer. The subsoil is reddish brown silty clay loam. The underlying material is yellowish red, reddish brown, and light red stratified silty clay loam, silty clay, and clay loam. The Port soils are subject to occasional or frequent flooding.

Weswood soils are generally slightly higher in elevation and closer to the stream channel than Port soils. The Weswood soils are deep, nearly level to very gently sloping, and well drained. They are moderately permeable. Typically, the Weswood soils have a reddish brown silt loam surface layer and subsoil. The underlying material is reddish yellow and reddish brown silt loam. This soil has buried horizons that are reddish brown silty clay loam. The Weswood soils are subject to occasional or frequent flooding.

Of minor extent in this map unit are the somewhat poorly drained and very slowly permeable Lomill soils and the well drained and moderately rapidly permeable Pulaski soils. Urban land is also included. Lomill soils are on slightly concave, lower flood plains than Port and Weswood soils in old sloughs and blocked drainageways. Pulaski soils are adjacent to stream channels in slightly lower positions on flood plains than Port and Weswood soils.

The soils of this map unit are used extensively for alfalfa, wheat, grain sorghum, and forage sorghum. Bermudagrass is in some areas. Pecan trees on these soils produce ample nuts in favorable years.

The soils in this map unit have high potential for cropland, tame pasture, hay, and native range. Even though they are subject to flooding, the overall benefits from additional moisture, which increases production, more than offset the crop losses in most years. The hazard of flooding when hay crops are down; maintaining or improving the soil tilth, fertility, and organic matter content; and preventing compaction are management concerns. Keeping these soils for prime farmland use is a major concern.

The soils in this map unit have low potential for urban use. The hazard of flooding is a severe limitation.

The soils in this map unit have medium potential for recreational development. The hazard of flooding is a severe limitation for camp areas, a moderate limitation for playgrounds, and a slight limitation for picnic areas or paths and trails.

The soils in this map unit have high potential for development of habitat for openland and rangeland wildlife and low potential for wetland wildlife habitat. Water is not available for wetland wildlife habitat.

7. Pulaski-Tribbey

Nearly level to very gently sloping, well drained and somewhat poorly drained, loamy soils that are subject to occasional and frequent flooding; formed in recent loamy alluvium

The landforms of this map unit offer limited diversity. Vegetative patterns offer moderate diversity. Water elements are drainageways, farm ponds, and areas where water frequently stands. There are few structures. Visual diversity in this map unit is medium, and changes in the landscape will be moderately significant.

This map unit makes up about 4 percent of the county (see fig. 2). It is about 48 percent Pulaski soils, 47 percent Tribbey soils, and 5 percent soils of minor extent.

Pulaski soils are generally in slightly higher positions on the landscape than Tribbey soils. The nearly level to very gently sloping Pulaski soils are deep, moderately rapidly permeable, and well drained. Typically, they have a reddish brown fine sandy loam surface layer. The upper part of the underlying material is red or yellowish red fine sandy loam, the middle part is red or light reddish brown loamy fine sand, and the lower part is stratified reddish yellow, yellowish red, and reddish brown loamy very fine sand, fine sandy loam, and loam. The Pulaski soils are subject to occasional flooding.

Tribbey soils are generally in slightly lower positions on concave landscapes than Pulaski soils. The nearly level to very gently sloping Tribbey soils are deep, moderately permeable to moderately rapidly permeable, and somewhat poorly drained. A high water table is 1/2 foot to 3 1/2 feet below the surface during fall, winter, and spring. Typically, the Tribbey soils have a reddish brown fine sandy loam surface layer. The upper part of the underlying material is reddish brown fine sandy loam that has thin strata of clay loam and loamy fine sand. In the lower part, it is yellowish red loamy very fine sand that has thin strata of loam and loamy fine sand. The Tribbey soils are subject to frequent flooding.

Of minor extent in this map unit are the well drained and moderately permeable Port and Weswood soils. They are in slightly higher positions on flood plains than Pulaski and Tribbey soils.

The soils of this map unit are used mostly for bermudagrass pasture and native range. Some areas of Pulaski soils are used for wheat, alfalfa, or forage sorghum. Some areas are used for pecan trees that produce nuts in favorable years.

The soils in this map unit have medium potential for cropland. The hazard of flooding, wetness, and low fertility and organic matter content are limitations that reduce yields or prevent use of equipment. The soils in this map unit have high potential for tame pasture and native range. Pastures respond well to additions of fertilizer high in nitrogen. The major management concerns are reducing the hazard of flooding, improving the soil fertility and organic matter content, controlling brush and weeds, and protecting rangeland from overuse and from uncontrolled burning. The well drained Pulaski soils are better suited to most agricultural uses than the Tribbey soils.

The soils in this map unit have low potential for urban use and recreational development. Wetness and the hazard of flooding are severe limitations.

Pulaski soils have high potential for use as habitat for openland and rangeland wildlife and low potential for wetland wildlife habitat. Tribbey soils have medium potential for use as habitat for openland and rangeland wildlife and high potential for wetland wildlife habitat.

8. Gracemore-Gracemont Variant-Gaddy

Nearly level to very gently sloping, somewhat poorly drained and somewhat excessively drained, sandy and loamy soils that are subject to occasional and frequent flooding; formed in recent sandy and loamy alluvium

Landforms of this map unit offer some diversity. Tame pasture, woodlands, and range provide some diversity in the vegetative patterns. The South Canadian River is the predominant water element. Structures are limited. Visual diversity of this map unit is medium, and changes in the landscape will be moderately significant.

This map unit makes up about 3 percent of the county. It is about 61 percent Gracemore soils, 16 percent Gracemont Variant soils, 5 percent Gaddy soils, and 18 percent soils of minor extent.

Gracemore soils are in the lowest positions on flood plains below Gracemont Variant and Gaddy soils. The Gracemore soils are deep, nearly level to very gently sloping, and somewhat poorly drained. They are moderately rapidly permeable or rapidly permeable. A high water table is from 1/2 foot to 3 1/2 feet below the surface in winter and spring. Typically, the Gracemore soils have a brown and light brown loamy fine sand surface layer. The underlying material is pink loamy fine sand and fine sand that has thin strata of darker colors and finer textures. The Gracemore soils are subject to occasional and frequent flooding.

Gracemont Variant soils are in slightly higher positions on the landscape than Gracemore soils and are in slightly lower positions than Gaddy soils. These soils are deep, nearly level to very gently sloping, and somewhat poorly drained. They are moderately permeable. A high water table is between 1/2 foot and 3 1/2 feet below the surface from fall to spring. Typically, the Gracemont Variant soils have a brown and reddish brown silt loam surface layer. The upper part of the underlying material is mottled light reddish brown and reddish brown very fine sandy loam and silt loam and has fine darker strata. The lower part of the underlying material is pink fine sand that has fine darker strata. The Gracemont Variant soils are subject to occasional flooding.

Gaddy soils are on low convex dunes in slightly higher positions on the landscape than Gracemore and Gracemont Variant soils. These soils are deep, nearly level to very gently sloping, and somewhat excessively drained. They are moderately rapidly permeable or rapidly permeable. Typically, the Gaddy soils have a brown loamy fine sand surface layer. The underlying material is light brown and pink loamy fine sand and fine sand that has thin strata of darker colors and finer textures. The Gaddy soils are subject to occasional flooding.

Of minor extent in this map unit are the excessively drained, rapidly permeable Goodnight soils and the moderately well drained, slowly permeable Asher Variant soils. Goodnight soils are on long, narrow dunes in higher positions on the landscape than Gaddy soils. They are subject to flooding only under abnormal conditions. Asher Variant soils are on flood plains at similar elevations to the Gracemont Variant soils. They have a high water table between 20 and 40 inches below the surface most of the time.

The soils of this map unit are used mostly for bermudagrass pasture, native range, or wildlife. A few areas are in wheat. Sand deposits beneath these soils are mined in several areas and used for fill materials or in mortar and concrete construction. A few areas are used for recreation, primarily golf courses and off-road-vehicle tracks.

The soils of this map unit have low potential for cropland. Wetness, salinity, and the hazard of flooding are severe limitations. These soils have high potential for hay, tame pasture, and native range. The low available water capacity is a limitation in the Gaddy soils. The main management concerns are protecting low lying areas from flooding, controlling wind erosion during periods when grasses or crops are being established, improving or maintaining the fertility and organic matter content, controlling brush and weedy grasses, and establishing vegetation in the saline areas.

The soils in this map unit have low potential for urban use. The hazard of flooding, wetness, salinity, and coarse textured soil materials are severe limitations that are difficult to overcome.

The soils in this map unit have low potential for recreational use. Wetness and the hazard of flooding are severe limitations.

The soils in this map unit have medium potential for use as habitat for most wildlife. They are best suited to use as habitat for rangeland or wetland wildlife. Water areas can be developed for habitat for wildlife in most of the Gracemore and Gracemont Variant soils.

9. Asher-Keokuk-Canadian

Nearly level to very gently sloping, moderately well *drained and well drained, loamy soils that are subject to rare flooding; formed in recent loamy alluvium*

The landforms of this map unit provide very little diversity. Most of the soils in this map unit are used for cropland and tame pasture, which provide little diversity to the vegetative patterns. Water elements are narrow, meandering drainageways. Structures consist of farmsteads and some residences. Visual diversity in this map unit is low, and changes in the landscape will be visually significant.

This map unit makes up about 2 percent of the county (see fig. 4). It is about 41 percent Asher soils, 29 percent Keokuk soils, 9 percent Canadian soils, and 21 percent soils of minor extent and Urban land.

Asher soils are on flood plains. They are in slightly higher positions on the landscape than Keokuk soils and in slightly lower positions on the landscape than the Canadian soils. The Asher soils are deep, nearly level to very gently sloping, and moderately well drained. They are slowly permeable. Typically, the Asher soils have a dark grayish brown and brown silt loam surface layer. The subsoil is brown silty clay loam and silt loam. The underlying material is stratified light reddish brown very fine sandy loam, reddish brown mottled silty clay, and light reddish brown loamy fine sand. The Asher soils are subject to rare flooding.

Keokuk soils are on flood plains. They are in slightly lower positions on the landscape than the Asher and Canadian soils. The Keokuk soils are deep, nearly level to very gently sloping, and well drained. They are moderately permeable. Typically, the Keokuk soils have a brown and dark grayish brown very fine sandy loam surface layer. The subsoil is brown very fine sandy loam. The underlying material is light brown and brown very fine sandy loam, brown silty clay loam, light brown very fine sandy loam, and pink fine sandy loam. The Keokuk soils are subject to rare flooding.

Canadian soils are on the highest flood plains in the map unit. They are in slightly higher positions on the landscape than the Asher and Keokuk soils. The Canadian soils are deep, nearly level to very gently sloping, and well drained. They are moderately rapidly permeable. Typically, the Canadian soils have a brown fine sandy loam surface layer and subsoil. The underlying material is brown and reddish yellow fine sandy loam. The Canadian soils are subject to rare flooding.

Of minor extent in this map unit are the somewhat poorly drained and slowly permeable Asher Variant soils, the excessively drained and rapidly permeable Goodnight soils, the somewhat poorly drained and moderately permeable Gracemont Variant soils, the well drained and moderately permeable Port and Weswood soils, and Urban land. The Asher Variant, Gracemont Variant, Port, and Weswood soils are in lower positions on flood plains than the Asher, Keokuk, and Canadian soils, and Goodnight soils are on higher convex dunes.

The soils in this map unit are used extensively for wheat, alfalfa, grain sorghum, and for bermudagrass pasture. Most of the irrigated cropland in Cleveland County is in this map unit. Truck crops are on a few acres of the Canadian soils. Native pecan trees are common on Asher soils and produce nuts during favorable years. Horse breeding and training farms are common. Many farmsteads are along the South Canadian River.

The soils in this map unit have high potential for cropland, tame pasture, hay, and native range. Maintaining tilth, preventing compaction, maintaining fertility and organic matter content, and keeping these soils for prime farmland use are management concerns.

The soils in this map unit have low potential for most urban uses. The hazard of flooding is a severe limitation for dwellings and for small commercial buildings. The soils have slight limitations for lawns, landscaping, and topsoil use.

The soils of this map unit have high potential for most recreational uses. The hazard of flooding is a severe limitation for camp areas. This limitation can be overcome by constructing a dike around the site or by elevating the area with suitable fill materials.

The soils in this map unit have high potential for use as openland and rangeland wildlife habitat. They have low potential for wetland wildlife habitat.

10. Lomill-Brewless

Nearly level, somewhat poorly drained and moderately well drained, clayey and loamy soils that are subject to occasional and rare flooding; formed in recent clayey and loamy alluvium

The landforms of this map unit provide very little diversity. The area is in cultivated crops or tame pasture that provides little diversity to vegetative patterns. Water elements are sloughs and some farm ponds. Structures are limited. Visual diversity for this map unit is low, and changes in the landscape will be visually significant.

This map unit makes up about 2 percent of the county. It is about 45 percent Lomill soils, 36 percent Brewless soils, and 19 percent soils of minor extent and Urban land.

Lomill soils are on slightly concave sloughs and meandering drainageways that drain the higher flood plains. These soils are deep, nearly level, and somewhat poorly drained. They are very slowly permeable. The Lomill soils have a brown silty clay surface layer. The subsoil is dark reddish gray silty clay. The underlying material is brown silty clay and stratified brown, light brown, and reddish brown loam, very fine sandy loam, and silty clay. The Lomill soils are subject to occasional flooding.

Brewless soils are on smooth flood plains in higher positions on the landscape than Lomill soils. These soils are deep, nearly level, and moderately well drained.

They are slowly permeable. Typically, the Brewless soils have a dark grayish brown silty clay loam surface layer. The subsoil is dark brown or brown silty clay in the upper part and brown or light reddish brown silty clay loam in the lower part. The underlying material is brown, reddish brown, and light reddish brown mottled stratified silty clay loam, very fine sandy loam, and silty clay. The Brewless soils are subject to rare flooding.

Of minor extent in this map unit are the moderately well drained and slowly permeable Asher Variant soils and the well drained and moderately permeable Weswood soils. The Asher Variant soils are in lower positions on flood plains than Lomill and Brewless soils, and the Weswood soils are in slightly higher positions on the landscape along small channels.

The soils of this map unit are used mainly for cropland and tame pasture. Wheat, alfalfa, grain sorghum, and corn are the principal crops. Bermudagrass is the dominant tame pasture, but, in some areas, it is overseeded with Kentucky 31 fescue or small grains. In some areas, native pecan trees produce a limited quantity of nuts in favorable years. A few horse breeding and training farms are in this map unit, and a small area in Lexington is used for urban development.

The soils of this map unit have medium potential for cropland and high potential for tame pasture, hay, and native range. The limitations are wetness, the hazard of flooding, permeability, and the clayey soil texture. Surface drainage is the major management concern. Water collects in low lying areas, and slight alterations of the natural flow of water tend to complicate the problem. Other concerns of management are improving or maintaining the soil tilth, structure, fertility, and organic matter content; preventing compaction; and retaining the soils for agricultural use.

The soils in this map unit have low potential for urban use. Severe limitations are the hazard of flooding, wetness, shrinking and swelling, very slow and slow permeability, and corrosivity to steel.

The soils in this map unit have medium potential for recreational use. The susceptibility to flooding, the clayey soil texture, and the soil permeability are limitations that are difficult to overcome.

The soils in this map unit have medium potential for use as habitat for most wildlife.

The Brewless soils are best suited to most uses because they are better drained, have less clay in the surface layer, and are at higher elevations and are less subject to flooding than Lomill soils.

Detailed Soil Map Units

The map units on the detailed soil maps at the back of this survey represent the soils in the survey area. The map unit descriptions in this section, along with the soil maps, can be used to determine the suitability and potential of a soil for specific uses. They also can be used to plan the management needed for those uses. More information on each map unit, or soil, is given under "Use and Management of the Soils."

Each map unit on the detailed soil maps represents an area on the landscape and consists of one or more soils for which the unit is named.

A symbol identifying the soil precedes the map unit name in the soil descriptions. Each description includes general facts about the soil and gives the principal hazards and limitations to be considered in planning for specific uses.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer or of the underlying material, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer or of the underlying material. They also can differ in slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Teller fine sandy loam, 3 to 5 percent slopes, is one of several phases in the Teller series.

Some map units are made up of two or more major soils. These map units are called soil complexes or undifferentiated groups.

A *soil complex* consists of two or more soils in such an intricate pattern or in such small areas that they cannot be shown separately on the soil maps. The pattern and proportion of the soils are somewhat similar in all areas. Stephenville-Darsil-Newalla complex, 3 to 8 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils in a mapped area are not uniform. An area can be made up of only one of the major soils, or it can be made up of all of them. Norge Variant and Teller Variant soils, 3 to 8 percent slopes, is an undifferentiated group in this survey area.

Most map units include small scattered areas of soils other than those for which the map unit is named. Some of these included soils have properties that differ substantially from those of the major soil or soils. Such differences could significantly affect use and management of the soils in the map unit. The included soils are identified in each map unit description. Some small areas of strongly contrasting soils are identified by a special symbol on the soil maps.

This survey includes *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Urban land is an example. Miscellaneous areas are shown on the soil maps. Some that are too small to be shown are identified by a special symbol on the soil maps.

Table 5 gives the acreage and proportionate extent of each map unit. Other tables (see "Summary of Tables") give properties of the soils and the limitations, capabilities, and potentials for many uses. The Glossary defines many of the terms used in describing the soils.

1—Stephenville-Darsil-Newalla complex, 3 to 8 percent slopes. This complex consists of moderately deep, well drained Stephenville soil; shallow, excessively drained Darsil soil; and deep, moderately well drained Newalla soil. The soils in this complex are in the eastern part of the county. The soils of this complex were so intermingled that they could not be separated at the scale selected for mapping. The Stephenville soil is mainly on ridge crests but is also on side slopes between bands of the Darsil soil. The Darsil soil is mainly on shoulders of ridge crests and on narrow contour bands around the side slopes. The Newalla soil is mainly on side slopes below bands of Darsil soil and occasionally on ridge crests. Individual areas of each soil range from 3 to 40 acres. The mapped areas are long and irregular in shape and range from 10 to 700 acres.

The Stephenville soil makes up about 55 percent of the unit. Typically, the surface layer is brown fine sandy loam about 4 inches thick. The subsurface layer is pinkish gray loamy fine sand to a depth of about 10 inches. The subsoil is reddish yellow sandy clay loam to a depth of about 16 inches and is light red sandy clay loam to a depth of about 28 inches. The underlying material is red and yellowish red, soft, fine-grained sandstone to a depth of 36 inches or more.

The Stephenville soil is low in natural fertility and organic matter content. It is medium acid to neutral in the surface layer and strongly acid to slightly acid in the subsurface layer. The subsoil ranges from very strongly acid to slightly acid. Permeability is moderate, runoff is medium to rapid, and the available water capacity is low. This soil is easily eroded by wind or water if not protected by adequate plant cover. The root zone is 20 to 40 inches deep and is easily penetrated by plant roots. This soil has low shrink-swell potential and moderate corrosion potential to steel and concrete.

The Darsil soil makes up about 15 percent of the map unit. Typically, the surface layer is brown loamy fine sand about 5 inches thick. Below that is pink fine sand to a depth of about 17 inches. The underlying material is red, weakly cemented, fine-grained sandstone to a depth of about 23 inches or more.

The Darsil soil is strongly acid to mildly alkaline. It is low in organic matter content and natural fertility. Permeability is rapid, runoff is medium to rapid, and the available water capacity is very low. This soil is easily eroded by wind or water if not protected by adequate plant cover. The root zone is 10 to 20 inches deep and is easily penetrated by plant roots. This soil has low shrink-swell potential, low corrosion potential to steel, and moderate corrosion potential to concrete.

The Newalla soil makes up about 15 percent of the unit. Typically, the surface layer is brown fine sandy loam about 3 inches thick. The subsurface layer is light brown fine sandy loam to a depth of about 6 inches. The subsoil is red sandy clay loam to a depth of about 10 inches, red clay to a depth of about 51 inches, and mottled red shaly silty clay to a depth of about 58 inches. The underlying material is red, weakly laminated, soft shale to a depth of 80 inches or more.

The Newalla soil is low in natural fertility and organic matter content. It is strongly acid to neutral in the surface layer and very strongly acid to neutral in the subsurface layer. The upper part of the subsoil is strongly acid to neutral, and the lower part is strongly acid to moderately alkaline. Permeability is very slow, runoff is rapid, and the available water capacity is medium. The root zone is 40 to 60 inches deep, but the clayey subsoil partially restricts root penetration. This soil is easily eroded by water and has high shrink-swell potential. It has high corrosion potential to steel and moderate corrosion potential to concrete.

Included with this complex in mapping are areas of Derby, Grainola, Harrah, Littleaxe, Lucien, and Pulaski soils. The excessively drained Derby soils are on convex dunes on ridge crests and on valley side slopes. Grainola soils are on steeper side slopes. The moderately permeable Harrah soils are on narrow foot slopes bordering the drainage channels. The moderately permeable Littleaxe soils are on narrow, very gently sloping ridge crests. The shallow Lucien soils are on shoulders of ridges paralleling the side slopes. The Pulaski soils are on narrow flood plains. The included soils make up about 15 percent of the map unit, but individual areas are generally less than 5 acres.

This complex has low potential for cropland. It is generally not suited to cultivated crops because of the severe hazard of erosion and low fertility and organic matter content. The shallow root zone and very low available water capacity of the Darsil soil and the very slow permeability of the Newalla soil are severe limitations that are difficult to overcome. Small plots suitable for home gardens can be located by onsite investigations. Intensive management is needed to control erosion and improve the soil fertility and organic matter content.

This complex has low potential for hay or tame pasture. The low fertility and organic matter content, restricted root zone, and droughty soils limit production and choice of plants. Bermudagrass and weeping lovegrass are best suited. Tame pasture and hay crops respond well to fertilizer that is high in nitrogen. For maximum production of high quality forage, weeds and brush can be controlled by mowing or spraying pastures with herbicides late in spring or early in summer.

This complex has low potential for most urban use. Depth to rock is the main limitation of the Stephenville and Darsil soils for septic tank absorption fields. The very slow permeability, high shrink-swell potential, and high corrosion potential to steel are limitations of the Newalla soil for most building sites and sanitary facilities. Newalla soil has limitations for sewage lagoon areas and pond reservoir areas because of depth to rock. Many of these limitations can be minimized by special design measures.

This complex has low to high potential for recreational use. Stephenville soil is best suited to this use. It has slight limitations for camp areas, picnic areas, and for paths and trails. Darsil soil has severe limitations for camp areas and picnic areas because of depth to rock. It has slight limitations for paths and trails. Newalla soil has moderate limitations for camp areas and picnic areas because of very slow permeability and has severe limitations for paths and trails because of the hazard of erosion. This complex has severe limitations for playgrounds because of slope.

This complex has medium potential for rangeland. Controlling weeds and brush and protecting the range from uncontrolled burning are management concerns. Rotation grazing and timely deferment of grazing help to maintain or improve range grasses.

This complex has medium to low potential for windbreak tree and shrub plantings. Soil depth, the available water capacity, and permeability are limitations that reduce the potential for this use. Redbud, eastern redcedar, skunkbush sumac, Amur honeysuckle, osageorange, and lilac are well suited to these soils. In addition, Austrian pine, American plum, Chinese elm, red mulberry, bur oak, and green ash are best suited to the Stephenville soil; oriental arborvitae, Rocky Mountain juniper, and Arizona cypress are best suited to the Darsil soil; and Austrian pine, Chinese elm, honeylocust, red mulberry, silver maple, and common hackberry are best suited to the Newalla soil. Post oak, blackjack oak, and hickory are native trees adapted to the soils in this complex. Many of the native trees are harvested for firewood.

This complex has high to low potential for use as habitat for openland or rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This complex is in capability subclass VIe. Stephenville and Newalla soils are in Sandy Savannah range site, and Darsil soil is in Shallow Savannah range site.

2—Harrah fine sandy loam, 3 to 8 percent slopes. This deep, well drained, gently sloping to sloping soil is in the eastern part of Cleveland County. It is on concave side slopes and foot slopes of uplands. The mapped areas are long, narrow, irregular in shape and can extend the entire length of the drainage area. They are 20 to more than 300 acres.

Typically, the surface layer is brown fine sandy loam about 6 inches thick. The subsurface layer, to a depth of about 14 inches, is yellowish red loamy fine sand. The subsoil is red sandy clay loam to a depth of 80 inches.

Included with this soil in mapping are areas of Derby, Littleaxe, Pulaski, Stephenville, and Tribbey soils. The somewhat excessively drained Derby soils are mostly on north- or east-facing side slopes above the Harrah soils. The Littleaxe and Stephenville soils are on upper side slopes. The moderately rapidly permeable, well drained Pulaski soils and the somewhat poorly drained Tribbey soils are on the narrow flood plains that entrench the Harrah soils in the upper part of the watershed. The included soils make up about 30 percent of this map unit, but individual areas are generally less than 7 acres.

This Harrah soil is low in natural fertility and organic matter content. It is medium acid to neutral in the surface and subsurface layers and strongly acid to neutral in the subsoil. Permeability is moderate, runoff is slow to medium, and the available water capacity is medium. This soil has good tilth and can be worked throughout a wide range of moisture content. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil is easily eroded by wind or water if not protected by adequate plant cover. It has low shrink-swell potential and moderate corrosion potential to steel and concrete.

This soil has medium potential for row crops and small grains. Low fertility and organic matter content, excessive slope, and the hazard of erosion are the main limitations. Minimum tillage, use of crop residue, and use of cover crops, including grasses and legumes in the cropping system, help to control erosion and improve fertility and organic matter content.

This soil has medium potential for hay, tame pasture, and rangeland. Hay crops and tame pastures respond well to additions of fertilizer that are high in nitrogen. Areas in native range can be improved by harvesting mature trees for firewood, controlling underbrush, using good grazing practices, and protecting the range from fire.

This Harrah soil has high potential for most urban uses. The limitations are slight for sanitary landfills, shallow excavations, dwellings, local roads and streets, lawns, landscaping, and golf fairways. Seepage and slope are limitations if used for sewage lagoons or pond reservoirs. Permeability is a limitation for septic tank absorption fields. Establishment and maintenance of landscape vegetation is difficult because of droughtiness of the surface and subsurface layers. Pocket gophers can cause severe damage to lawns, shrubs, and gardens unless controlled.

This soil has high potential for most recreational uses. Slope is a limitation for playgrounds. Water erosion can be excessive on heavily used areas.

This soil has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil. Black hickory, blackjack oak, chinquapin oak, northern red oak, and post oak are native species adapted to this soil. Many native trees are used locally for firewood.

This soil has high potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Harrah soil is in capability subclass IVe and in Sandy Savannah range site.

3—Grainola-Weswood complex, 0 to 20 percent slopes. This complex consists of moderately deep, well drained Grainola soil and deep, well drained Weswood soil. The soils of this complex were so intermingled that they could not be separated at the scale selected for mapping. They are in the central and western parts of the county. The Grainola soil is on gently sloping to moderately steep side slopes, and the Weswood soil is on nearly level to very gently sloping flood plains. Individual areas of each soil range from 1/4 acre to 10 acres. The mapped areas are long, narrow, and irregular in shape, are 150 to 600 feet wide and 700 to 2,000 feet long, and range from 5 to 150 acres.

The Grainola soil makes up about 55 percent of the map unit. Typically, the surface layer is reddish brown silty clay loam about 3 inches thick. The subsoil is reddish brown silty clay to a depth of about 8 inches and red shaly silty clay and very shaly silty clay to a depth of about 27 inches. The underlying material is red, weakly laminated shale that extends to a depth of 30 inches or more.

The Grainola soil is medium in natural fertility and low in organic matter content. It is mildly alkaline or moderately alkaline throughout. This soil has high shrink-swell potential and is easily eroded by water. Runoff is rapid, permeability is slow, and the available water capacity is medium. The root zone is 20 to 40 inches deep, and plant root development is somewhat restricted. This soil has high corrosion potential to steel and low corrosion potential to concrete.

The Weswood soil makes up about 15 percent of the map unit. Typically, the surface layer is dark reddish gray silt loam about 6 inches thick. The subsoil is reddish brown silt loam to a depth of about 16 inches. The underlying material is stratified reddish brown silt loam and silty clay loam to a depth of about 46 inches and red laminated shale to a depth of 64 inches or more.

The Weswood soil is medium in natural fertility and organic matter content. It is mildly alkaline to moderately alkaline in the surface layer and moderately alkaline and calcareous in the subsoil and underlying material. Permeability is moderate, runoff is slow, and the available water capacity is high. The root zone is more than 40 inches deep and is easily penetrated by plant roots. This soil is subject to frequent flooding for very brief to brief periods in the spring and summer.

Included with this complex in mapping are areas of Huska, Lucien, Norge, Port, Pulaski, and Renfrow soils and soils similar to Grainola soil but less than 20 inches thick. The deep, moderately well drained, very slowly permeable Huska soils are in saline-alkali spots near ridge crests or on foot slopes. The shallow Lucien soils are on shoulders of ridges or on contour bands along side slopes. The deep, moderately slowly permeable Norge soils are on foot slopes. The deep Port and Pulaski soils are on low flood plains. The deep, very slowly permeable Renfrow soils are on side slopes and foot slopes. The included soils make up about 30 percent of the map unit, but individual areas are generally less than 5 acres.

This complex has low potential for cropland. Steepness of slopes, the hazard of erosion on side slopes, and frequent flooding on flood plains are severe limitations that make this complex not suited to cultivation.

This complex has low potential for hay and tame pasture. It is best suited to rangeland. Side slopes can be shaped and smoothed in some less sloping areas and planted to permanent grass. This would help to reduce runoff and lower the hazard of erosion. Fertilizer applied during the spring improves plant vigor and density.

This complex has medium potential for native range. The steepness of slopes and droughty nature of Grainola soil limit the potential of grass production. The quality of the grass can be maintained or improved by controlling weeds, using suitable grazing practices, and protecting the range from fire.

This complex has low potential for all urban uses. The depth to rock, slow permeability, high shrink-swell potential, slope, and the clayey texture are all limitations of Grainola soil. The hazard of flooding is a limitation of Weswood soil. These limitations can be reduced by special design measures.

This complex has medium potential for pond reservoirs and embankments. The clayey texture of Grainola soil is a moderate limitation. The Weswood soil has moderate limitations because of seepage. Coring the dam site and compacting the soil materials under optimum moisture conditions reduce seepage and improve compaction. Permanent vegetation needs to be established on embankments to help prevent erosion.

This complex has low potential for most recreational uses. Frequent flooding is a limitation of Weswood soil for camp areas and playgrounds and a moderate limitation for picnic areas and paths and trails. Slope, slow permeability, and the clayey texture are limitations of Grainola soil for these uses.

This complex has low potential for windbreak tree and shrub plantings. The restricted root zone, slow permeability, and droughtiness of Grainola soil are the main limitations for plant survival. Eastern redcedar, skunkbush sumac, Amur honeysuckle, lilac, red mulberry, osageorange, Austrian pine, and Chinese elm are adapted to these soils. Common hackberry, honeylocust, silver maple, and redbud are adapted to Grainola soil; and American plum, Eastern cottonwood, green ash, and American sycamore are adapted to the Weswood soil.

This complex has medium potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This complex is in capability subclass VIe. Grainola soil is in Shallow Prairie range site, and Weswood soil is in Loamy Bottomland range site.

4—Gracemore-Gaddy complex, occasionally flooded, undulating. This complex consists of somewhat poorly drained Gracemore soil and the somewhat excessively drained Gaddy soil. These soils are on broad, undulating, low flood plains along the South Canadian River. Gracemore soil is in depressions and Gaddy soil is on higher convex ridges (fig. 5). The soils of this complex were so intermingled that they could not be separated at the scale selected for mapping. The soils of this complex are subject to occasional flooding for very brief to brief periods from spring to summer. Gracemore soil has an apparent high water table 1/2 foot to 3 1/2 feet below the surface from fall to spring. Slopes ranges from 0 to 2 percent.

Individual areas of each soil are 1/4 acre to 4 acres. The mapped areas range from 400 to 3,500 feet wide and from 800 to 17,000 feet long and are 10 to more than 300 acres.

The Gracemore soil makes up about 60 percent of the map unit. Typically, the surface layer is reddish brown silty clay loam about 6 inches thick. The underlying material is light reddish brown or pink loamy fine sand or fine sand that has thin strata of darker colored and finer textured materials to a depth of 72 inches or more.

The Gracemore soil is low in natural fertility and organic matter content. It is moderately alkaline and calcareous throughout. Permeability is moderately rapid or rapid, runoff is slow, and the available water capacity is low. The root zone is more than 40 inches deep and is easily penetrated by plant roots. Root penetration is limited by the depth to the high water table. Gracemore soil is easily eroded by wind and water if not protected by adequate plant cover. Scouring and deposition occur during flash floods. This soil has low shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

The Gaddy soil makes up about 25 percent of the map unit. Typically, the surface layer is brown loamy fine sand

Figure 5.—A landscape of Gracemore-Gaddy complex, occasionally flooded, undulating. Gracemore soil is in slight depressions beneath the trees, and Gaddy soil is on convex grass covered dunes.

about 9 inches thick. The underlying material is light brown and pink loamy fine sand and fine sand that has thin strata of darker colored and finer textured materials to a depth of 72 inches or more.

The Gaddy soil is low in natural fertility and organic matter content. It is moderately alkaline and calcareous throughout. Permeability is moderately rapid or rapid, runoff is slow, and the available water capacity is low. The root zone is more than 48 inches deep and is easily penetrated by plant roots. Gaddy soil is easily eroded by wind and water if not protected by adequate plant cover. This soil has low shrink-swell potential and low corrosion potential to steel and concrete.

Included with this complex in mapping are areas of soils similar to Gaddy soil but having a high water table between 40 and 72 inches below the surface, areas of soils similar to Gracemore soil but having a darker and thicker surface layer, and small areas of Gracemore soils that are saline and are subject to frequent flooding. The included soils make up about 15 percent of the map unit, but individual areas are generally less than 10 acres.

This complex has low potential for cultivated crops. The hazard of flooding, depth to the high water table, and the undulating topography are the main limitations. These can be overcome only by major flood control, land shaping, and drainage measures. Maintaining soil structure and fertility and protecting soils from wind erosion, sediment damage, and scouring from overflow are management concerns. Minimum tillage, use of cover crops, stripcropping, or growing small grains continuously help to control erosion and improve soil fertility and structure.

This complex has high potential for hay, tame pasture, and rangeland. It is best suited to use as rangeland. Cool season grasses are best adapted to Gracemore soil, and warm season grasses are best suited to Gaddy soil. Grasses respond well to additions of fertilizer that are high in nitrogen. Providing adequate plant cover during spring and summer helps to protect the soils from blowing and from damage by scouring and deposition during floods. Proper stocking, rotation grazing, timely deferment of grazing, and restricted use during the wet periods help keep the grass and soil in good condition. Controlling trees, brush, and weeds improve native range.

This complex has low potential for urban use and most recreational uses. The high water table and hazard of flooding are limitations that are difficult to overcome unless the soils are drained and protected from overflow. The higher areas of Gaddy soil are better suited to recreational use. They have moderate limitations for playgrounds and slight limitations for picnic areas and paths and trails.

This complex has low potential for windbreak tree and shrub plantings. Soil drainage and wetness are severe limitations that limit the species adapted to these soils. Eastern cottonwood, skunkbush sumac, lilac, Amur honeysuckle, osageorange, American plum, and American sycamore are well suited to these soils. Eastern redcedar, red mulberry, autumn-olive, Austrian pine, and Chinese elm are well suited to Gaddy soil. Honeylocust, redbud, silver maple, green ash, and common hackberry are well suited to Gracemore soil.

This complex has medium potential for use as habitat for rangeland and openland wildlife. It has low potential for use as habitat for wetland wildlife.

This complex is in capability subclass IVw. Gracemore soil is in Subirrigated range site, and Gaddy soil is in Sandy Bottomland range site.

5—Harrah fine sandy loam, 3 to 8 percent slopes, gullied. This deep, well drained, gently sloping to sloping soil is severely eroded. It is on side slopes and foot slopes of uplands in the eastern part of the county. Gullies make up about 10 percent of this map unit. They are 20 to 150 feet apart, 2 to 20 feet deep, and 5 to 60 feet wide. Sandstone or shale is exposed in the gully floor in many areas. The soil between the gullies has a thinner surface layer than normal because of loss from sheet erosion. The mapped areas are 3 to 60 acres.

Typically, the surface layer is brown fine sandy loam about 9 inches thick. The subsurface layer, to a depth of about 19 inches, is light brown loamy fine sand. The subsoil is red sandy clay loam to a depth of about 80 inches or more.

Included with this soil in mapping are areas of Littleaxe, Newalla, and Stephenville soils. The included soils are near the head of gullies. They make up about 30 percent of the map unit, but individual areas are 1/4 acre to 10 acres.

This Harrah soil is low in natural fertility and organic matter content. It is medium acid to neutral in the surface and subsurface layers and strongly acid to neutral in the subsoil. Permeability is moderate, runoff is medium to rapid, and the available water capacity is medium. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil slakes and erodes easily on side slopes of gullies if saturated and exposed to freezing and thawing. It has low shrink-swell potential and moderate corrosion potential to steel and concrete.

This soil has low potential for cropland, tame pasture, and native rangeland. It is so severely eroded and depleted of plant nutrients that it is not suitable for cultivation. It needs to be returned to permanent vegetation and used for rangeland, hay, or tame pasture. The low natural fertility, low organic matter content, and severe hazard of erosion are limitations that can be overcome only by using good management practices. The fertility and organic matter content can be improved by overseeding with legumes, by adding fertilizer, and by using good grazing practices. The gullies need to be shaped, smoothed, mulched, and planted to permanent grasses, such as bermudagrass or weeping lovegrass, that are best adapted for erosion control. Runoff needs to be diverted to reduce the hazard of erosion. Where gullies are too deep to be shaped, erosion can be stabilized by establishing a stand of black locust, constructing erosion control dams, and fencing out livestock (fig. 6).

This Harrah soil has low potential for most urban uses. The gullies impose severe limitations because of the cost of land shaping and constructing roads and underground utilities. The soil between the gullies, however, has high potential for all urban uses except sewage lagoons and septic tank absorption fields. Excessive seepage is the main limitation for sewage lagoons, and moderate permeability is the main limitation for septic tank absorption fields. Establishing and maintaining landscape vegetation is difficult because of the low fertility and droughty nature of the surface layer of the Harrah soil.

Figure 6.—Plantings of adapted trees and grasses help to control erosion on Harrah fine sandy loam, 3 to 8 percent slopes, gullied.

Pocket gophers can cause severe damage to lawns, shrubs, and gardens.

This soil has low potential for most recreational uses. The gullies are a limitation that is difficult to overcome. Major land shaping and alteration would be required before recreational facilities could be constructed.

This soil has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for rangeland and openland wildlife. It has low potential for use as habitat for wetland wildlife.

This Harrah soil is in capability subclass VIe and in Eroded Sandy Savannah range site.

6—Grainola-Lucien complex, 3 to 12 percent slopes. This complex consists of moderately deep, well drained Grainola soil and shallow, well drained Lucien soil. The soils of this complex were so intermingled that they could not be separated at the scale selected for mapping. They are in the central part of the county. Grainola soil is on steeper side slopes below ridge crests, and Lucien soil is on convex ridge crests and narrow contour bands on side slopes. Individual areas of each soil are 1/4 acre to 10 acres. The mapped areas are long and irregular in shape and range from 5 to more than 50 acres.

The Grainola soil makes up about 65 percent of the map unit. Typically, the surface layer is reddish brown gravelly silty clay loam about 4 inches thick. The subsoil is red silty clay to a depth of about 30 inches and red shaly silty clay to a depth of about 38 inches. The underlying material is weakly laminated, red shale bedrock.

The Grainola soil is medium in natural fertility and low in organic matter content. Permeability is slow, runoff is medium or rapid, and the available water capacity is medium. This soil is mildly alkaline or moderately alkaline in the surface layer and is moderately alkaline below that. The root zone is 20 to 40 inches deep, and plant root penetration is slightly restricted. This soil is easily eroded by water. It has high shrink-swell potential, high corrosion potential to steel, and low corrosion potential to concrete.

The Lucien soil makes up about 15 percent of the map unit. Typically, the surface layer is reddish brown very fine sandy loam about 4 inches thick. The subsoil is reddish brown very fine sandy loam to a depth of about 12 inches. The underlying material is red, weakly cemented sandstone.

The Lucien soil is medium in natural fertility and organic matter content. Permeability is moderately rapid, runoff is medium to rapid, and the available water capacity is low. This soil is neutral to moderately alkaline throughout. The root zone is 10 to 20 inches deep and is easily penetrated by plant roots. This soil is easily eroded by water. It has low shrink-swell potential and low corrosion potential to steel and concrete.

Included with this complex in mapping are areas of Kingfisher, Norge, Renfrow, and Weswood soils, small areas of rock outcrop, and soils similar to Grainola soil but less than 20 inches thick over bedrock. The moderately deep Kingfisher soils are on shoulders of ridge crests intermingled with Lucien soil. The deep Norge and Renfrow soils are mostly on foot slopes. The deep Weswood soils are on narrow flood plains. Also included are areas of soils in the northern part of the county that are on slopes of 12 to 45 percent. The included soils make up about 20 percent of the map unit.

This complex has low potential for cultivated crops, hay, and tame pasture. Steepness of slopes, the shallow root zone, the low available water capacity, low organic matter content in Grainola soil, and excessive runoff are the main limitations. Additions of fertilizer, overseeding pastures with legumes, and controlling weeds improve quality of forage, maintain fertility and organic matter, and reduce runoff.

This complex has medium potential for native range. The restricted root zone and the droughty nature of the soils are the main limitations. Quality of the grasses can be improved by controlling brush and weeds, using suitable grazing practices, and protecting the vegetation from fires.

This complex has low potential for most urban uses. Depth to rock in the Lucien soil and the steepness of slopes, slow permeability, and high shrink-swell potential of the Grainola soil are limitations. Seepage is a limitation for use of Lucien soil for sewage lagoons or sanitary landfills. Establishing and maintaining landscape vegetation is difficult because of the restricted root zone and droughty nature of the soils in this complex. High grade concrete, additional reinforcement steel, pier-and-beam type of construction on foundations, and bedding slabs and driveways over sand reduce damage from shrinking and swelling.

This complex has low to high potential for recreational use. Slope, depth to rock, and small stones are the main limitations for playgrounds. Slope and the gravelly surface texture of Grainola soil and depth to rock of Lucien soil are limitations for camp areas and picnic areas. These soils have slight limitations for paths and trails.

This complex has low potential for windbreak tree and shrub plantings. Eastern redcedar, Amur honeysuckle, lilac, skunkbush sumac, osageorange, and redbud are suited to these soils. Common hackberry, red mulberry, honeylocust, silver maple, Austrian pine, and Chinese elm are suited to Grainola soil. Oriental arborvitae, Rocky Mountain juniper, and Arizona cypress are suited to Lucien soil.

This complex has high potential for use as habitat for rangeland wildlife and medium to low potential for use as habitat for openland wildlife. It has low potential for use as habitat for wetland wildlife.

This complex is in capability subclass VIe and in Shallow Prairie range site.

7—Stephenville-Darsil complex, 1 to 5 percent slopes. This complex consists of moderately deep, well drained Stephenville soil and shallow, excessively drained Darsil soil. The soils of this complex were so intermingled that they could not be separated at the scale selected for mapping. They are in the eastern part of the county. Stephenville soil is mainly on the crown of ridge crests, and Darsil soil is mainly on the shoulders of ridge crests. Individual areas of each soil are 1/8 acre to 20 acres. The mapped areas are elongated and irregular in shape and are 15 to more than 200 acres.

The Stephenville soil makes up about 75 percent of the map unit. Typically, the surface layer is brown fine sandy loam about 5 inches thick. The subsurface layer is light brown fine sandy loam to a depth of about 9 inches. The subsoil is red sandy clay loam to a depth of about 20 inches and red fine sandy loam to a depth of about 29 inches. The underlying material is soft, red sandstone to a depth of 34 inches or more.

The Stephenville soil is low in natural fertility and organic matter content. It is medium acid or slightly acid in the surface and subsurface layers. In areas that have been limed, it is neutral. The subsoil is strongly acid to slightly acid. Permeability is moderate, runoff is medium, and the available water capacity is low. This soil has good tilth and can be worked throughout a wide range of moisture content. The root zone is 20 to 40 inches deep and is easily penetrated by plant roots. This soil is easily eroded by wind or water if not protected by adequate plant cover. It has low shrink-swell potential and moderate corrosion potential to steel and concrete.

The Darsil soil makes up about 15 percent of the map unit. Typically, the surface layer is brown loamy fine sand about 4 inches thick. Below that is pink loamy fine sand to a depth of about 14 inches. The underlying material is light reddish brown, soft sandstone to a depth of 20 inches or more.

The Darsil soil is low in natural fertility and organic matter content. It is slightly acid or neutral in the surface layer. Where limed, it ranges from slightly acid to mildly alkaline. The subsoil is medium acid to mildly alkaline. Permeability is rapid, runoff is medium, and the available water capacity is very low. This soil has good tilth and can be worked throughout a wide range of moisture content. The root zone is 10 to 20 inches deep and is easily penetrated by plant roots. This soil is easily eroded by wind or water if not protected by adequate plant cover. It has low shrink-swell potential, low corrosion potential to steel, and moderate corrosion potential to concrete.

Included with this complex in mapping are areas of deep, well drained Littleaxe soils on broad, very gently sloping, convex ridges; deep, moderately well drained Newalla soils on gently sloping, contour bands; and soils on dunes of convex ridges that are similar to Darsil soil but more than 20 inches deep to bedrock. The included soils make up about 10 percent of the map unit.

This complex has medium potential for row crops or small grains. Low fertility, low organic matter content, the low available water capacity, and the shallow root zone are the main limitations. Erosion is a severe hazard if cultivated crops are grown. Terraces, contour farming, minimum tillage, and use of crop residue help to control erosion, conserve moisture, and maintain tilth.

This complex has medium potential for native range, hay, and pasture. The low fertility and low available water capacity are limitations that retard plant growth. Hay crops and tame pastures respond well to additions of fertilizer that are high in nitrogen. Areas in native range can be improved by harvesting mature trees, controlling brush and weeds, using rotation grazing and timely deferment of grazing, and protecting the range from fire.

This complex has medium to low potential for most urban uses. The depth to rock is a limitation for shallow excavations, dwellings, small commercial buildings, lawns, and landscaping. Excessive seepage and the depth to rock are limitations for septic tank absorption fields, sewage lagoons, and sanitary landfills. Building sites and septic tank absorption fields can be improved by adding suitable fill materials.

This complex has high to low potential for most recreational uses. The Stephenville soil is best suited. Steepness of slopes is a limitation for playgrounds. The shallow depth to bedrock in the Darsil soil is the main limitation for most uses.

This complex has medium to low potential for windbreak tree and shrub plantings. Arizona cypress, redbud, eastern redcedar, skunkbush sumac, Amur honeysuckle, oriental arborvitae, osageorange, Rocky Mountain juniper, and lilac are well suited to these soils. Austrian pine, American plum, Chinese elm, common hackberry, honeylocust, red mulberry, bur oak, and green ash are suited to Stephenville soil. Native trees adapted to this complex are post oak, blackjack oak, and hickory. Many of the native trees are utilized locally for firewood.

This complex has high to low potential for use as habitat for openland or rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This complex is in capability subclass IVe. Stephenville soil is in Sandy Savannah range site, and Darsil soil is in Shallow Savannah range site.

8—Stephenville-Darsil-Newalla complex, 2 to 8 percent slopes, gullied. This complex consists of moderately deep Stephenville soil, shallow Darsil soil, and deep Newalla soil. The soils of this complex were so intermingled that they could not be separated at the scale selected for mapping. They are in the eastern part of the county (fig. 7). The well drained Stephenville soil is mainly on upper side slopes between bands of Darsil soil. The excessively drained Darsil soil is mainly on shoulders of upper side slopes and on narrow contour bands on the lower side slopes. The moderately well drained Newalla soil is mainly on side slopes below bands of Darsil soil. Gullies make up about 10 percent of the map unit. They are 2 to 6 feet deep, 20 to 150 feet apart, and 5 to 60 feet wide. Sandstone or shale is exposed in the lower part of the gullies in most areas. The soils between the gullies have a thinner surface layer than normal because of loss from sheet erosion. Individual areas of each soil are 1/8 acre to 20 acres. The mapped areas are long and irregular in shape and range from 5 to more than 50 acres.

The Stephenville soil makes up about 55 percent of the map unit. Typically, the surface layer is brown fine sandy loam about 3 inches thick. The subsurface layer to a depth of about 8 inches is light brown fine sandy loam. The subsoil is red sandy clay loam to a depth of about 26 inches. The underlying material is soft, red sandstone.

The Stephenville soil is low in natural fertility and organic matter content. It is strongly acid to slightly acid in the surface and subsurface layers. Where limed, it ranges from strongly acid to neutral. The subsoil is strongly acid to slightly acid. Permeability is moderate, runoff is medium or rapid, and the available water capacity is low. The root zone is 20 to 40 inches deep and is easily penetrated by plant roots. This soil is easily eroded if not protected by adequate plant cover. The subsoil exposed on gully walls flakes off rapidly if soils are freezing and thawing. This soil has low shrink-swell potential and moderate corrosion potential to steel and concrete.

The Darsil soil makes up about 15 percent of the map unit. Typically, the surface layer is reddish brown loamy fine sand about 7 inches thick. Below that is light reddish brown loamy fine sand to a depth of about 20 inches. The underlying material is reddish brown, soft, massive, fine-grained sandstone to a depth of 26 inches or more.

The Darsil soil is low in natural fertility and organic matter content. It is strongly acid to neutral throughout. Permeability is rapid, runoff is medium to rapid, and the

Figure 7.—An area of Stephenville-Darsil-Newalla complex, 2 to 8 percent slopes, gullied, in need of critical area treatment to reduce soil erosion and downstream pollution.

available water capacity is very low. The root zone is 10 to 20 inches deep and is easily penetrated by plant roots. This soil is easily eroded by wind or water if not protected by adequate plant cover. It has low shrink-swell potential, low corrosion potential to steel, and moderate corrosion potential to concrete.

The Newalla soil makes up about 15 percent of the map unit. Typically, the surface layer is yellowish red fine sandy loam about 3 inches thick. The subsoil is red sandy clay loam to a depth of about 9 inches and red silty clay to a depth of about 46 inches. The underlying material is red, laminated shale to a depth of about 54 inches or more.

The Newalla soil is low in natural fertility and organic matter content. It is medium acid or slightly acid in the surface layer. Where limed, it ranges from medium acid to neutral. The subsoil is strongly acid to moderately alkaline. Permeability is very slow, runoff is rapid, and the available water capacity is medium. The root zone is 40 to 60 inches deep, but the clayey subsoil partially restricts root penetration. This soil is easily eroded by water if not protected by adequate plant cover. The subsoil exposed on sidewalls of gullies flakes readily if the soil freezes and thaws. This soil has high shrink-swell potential, high corrosion potential to steel, and moderate corrosion potential to concrete.

Included with this complex in mapping are areas of Grainola, Harrah, and Littleaxe soils and a few rock outcrops that are on narrow, contour bands on side slopes. The moderately deep, well drained Grainola soils are on small knolls on side slopes. The deep, well drained Harrah soils are on lower side slopes and foot slopes than the soils in this complex. The deep, well drained Littleaxe soils are on narrow ridgetops. The included soils make up about 15 percent of the map unit.

This complex has low potential for cropland. The soils are severely eroded. Uncrossable gullies prohibit the use of most farm equipment to the extent that the soils of this complex are not suitable for cultivation. The soils in this complex need to be returned to permanent vegetation and used for hay, tame pasture, rangeland, or as habitat for wildlife.

This complex has low potential for rangeland, hay, or tame pasture. The low natural fertility, low organic matter content, severe hazard of erosion, and gullies are limitations that are difficult to overcome. The natural fertility and organic matter content can be improved by overseeding with legumes, adding fertilizers high in nitrogen, and using good grazing practices. The gullies need to be shaped and smoothed, where feasible, and planted to permanent grasses, such as bermudagrass or weeping lovegrass, that are adapted for erosion control. Fencing out livestock and applying hay mulch to shaped areas help to control erosion. Soil erosion can be reduced in the deeper gullies where shaping and smoothing are unfeasible by planting adapted trees, such as black locust. Diversion terraces help to control runoff, and erosion control dams catch sediment and reduce runoff. This helps to control erosion.

This complex has low potential for most urban uses. The cost of land leveling and shaping the gullies for building sites and the severe hazard of erosion during construction are severe limitations. The depth to rock in Stephenville and Darsil soils and the very slow permeability of Newalla soil are limitations for sanitary facilities. The high shrink-swell potential of the Newalla soil is a limitation for dwellings, small buildings, and roads. Establishment and maintenance of landscape plantings can be costly because of low fertility and droughty soil conditions, particularly in altered soil. Onsite investigation is needed to locate the best site for a specified use.

This complex has low potential for most recreational uses. The expense of shaping the gullies, building access roads, and controlling erosion during construction are the main limitations. The very slow permeability of the Newalla soil is a limitation for camp areas and picnic areas. The shallow depth to rock of the Darsil soil is the main limitation for most uses. Steepness of slope is a limitation for playgrounds. The Stephenville soils are best suited to recreational uses.

This complex has medium to low potential for windbreak tree and shrub plantings. Gullies, shallow soils, low fertility, or clayey soils are limitations that reduce the growth and choice of plants. Skunkbush sumac, lilac, eastern redcedar, Amur honeysuckle, osageorange, and redbud are suited to these soils. In addition, Austrian pine, bur oak, American plum, red mulberry, green ash, and Chinese elm are best suited to Stephenville soil; oriental arborvitae, Rocky Mountain juniper, and Arizona cypress are best suited to Darsil soil; and Austrian pine, Chinese elm, honeylocust, red mulberry, silver maple, and common hackberry are best suited to Newalla soil.

This complex has high to low potential for use as habitat for openland or rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This complex is in capability subclass VIe. Stephenville and Newalla soils are in Eroded Sandy Savannah range site, and Darsil soil is in Eroded Shallow Savannah range site.

9—Kingfisher-Lucien complex, 1 to 5 percent slopes. This complex consists of moderately deep, well drained Kingfisher soil and shallow, well drained Lucien soil. The soils in this complex were so intermingled that they could not be separated at the scale selected for mapping. Kingfisher soil is mostly on the very gently sloping ridge crests, and the Lucien soil is mostly on shoulders of ridge crests and on narrow, contour bands on gently sloping side slopes of ridges. The soils in this complex are in the central part of the county. Individual areas of Lucien soil are 1/4 acre to 5 acres. Kingfisher soil is mostly in continuous bodies around the Lucien soil. The mapped areas are small and rounded or large and elongated and are 10 to more than 200 acres.

The Kingfisher soil makes up about 60 percent of the map unit. Typically, the surface layer is reddish brown silt loam about 7 inches thick. The subsoil is reddish brown silt loam to a depth of about 12 inches, yellowish red silty clay loam to a depth of about 26 inches, and red silty clay loam to a depth of about 36 inches. The underlying material is red, weakly cemented, very fine-grained, calcareous sandstone.

The Kingfisher soil is high in natural fertility and medium in organic matter content. It is slightly acid to mildly alkaline in the surface layer and upper part of the subsoil and neutral to moderately alkaline in the middle and lower parts. Permeability is moderately slow, runoff is medium, and the available water capacity is medium. The root zone is 20 to 40 inches deep and is easily penetrated by plant roots. This soil erodes easily if not protected by adequate plant cover. It has moderate shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

The Lucien soil makes up about 15 percent of the map unit. Typically, the surface layer is brown very fine sandy loam about 6 inches thick. The subsoil is reddish brown very fine sandy loam to a depth of about 10 inches. The underlying material is red, fine-grained, calcareous, weakly cemented sandstone.

The Lucien soil is medium in natural fertility and low in organic matter content. It is slightly acid to moderately alkaline in the surface layer and neutral to moderately alkaline in the subsoil. Permeability is moderately rapid, runoff is medium to rapid, and the available water capacity is very low. The root zone is 10 to 20 inches deep and is easily penetrated by plant roots. This soil is easily eroded. It has low shrink-swell potential and low corrosion potential to steel and concrete.

Included with this complex in mapping are small areas of Grainola, Grant, Huska, and Renfrow soils and a few areas of rock outcrops. The moderately deep, well drained Grainola soils are on side slopes below the Lucien soil. The deep, well drained Grant soils are intermingled with the Kingfisher soil. The deep, moderately well drained Huska soils are in small, rounded, or elongated, light colored spots on ridge crests. The deep, well drained Renfrow soils are mostly in lower positions on side slopes than Lucien soil. The included soils make up about 25 percent of the map unit, but individual areas average less than 5 acres.

This complex has medium potential for row crops or small grains. Depth to rock, the available water capacity, fertility, the organic matter content, and the hazard of erosion are limitations that reduce or restrict the kind of crops. Minimum tillage, use of crop residue, and cover crops, including grasses and legumes in the cropping system, help to control erosion, conserve moisture, and improve the fertility and organic matter content.

This complex has medium potential for hay, tame pasture, and rangeland. It is best suited to use as rangeland. Hay crops and tame pastures respond well to additions of fertilizer that are high in nitrogen. The quality of native grasses can be maintained or improved by controlling brush and weeds, using suitable grazing practices, and protecting the range from fire.

This complex has medium to low potential for most urban uses. Shrinking and swelling and depth to bedrock are limitations of the Kingfisher soil for use for dwellings and small commercial buildings. The effects of shrinking and swelling can be reduced by bedding concrete foundations and slab floors with sand and by using high grade concrete mix and more reinforcement steel. The depth to bedrock in the Lucien soil is a severe limitation for urban uses. This complex has limitations for use in sewage lagoons, septic tank absorption fields, and sanitary landfills because of shallow depth of bedrock. Moderately slow permeability is the main limitation of the Kingfisher soil for septic tank filter fields. Septic tank filter fields can be improved by increasing the size of the field or lengthening lateral lines.

This complex has medium to high potential for recreational use. Kingfisher soil is best suited because it has slight limitations for camp areas and picnic areas. It has low potential for paths and trails because of the severe hazard of erosion. The slope and depth to rock in the Kingfisher soil is the main limitation for playgrounds, and the shallow depth to bedrock of the Lucien soil is a limitation for camp areas, picnic areas, and playgrounds.

This complex has medium potential for windbreak tree and shrub plantings. Eastern redcedar, Amur honeysuckle, osageorange, lilac, redbud, and skunkbush sumac are adapted to these soils. American plum, common hackberry, honeylocust, black locust, Austrian pine, autumn-olive, Scotch pine, and Chinese elm are adapted to Kingfisher soil, and oriental arborvitae, Rocky Mountain juniper, and Arizona cypress are adapted to Lucien soil.

This complex has high potential for use as habitat for openland wildlife and medium potential for rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This complex is in capability subclass IVe. Kingfisher soil is in Loamy Prairie range site, and Lucien soil is in Shallow Prairie range site.

10—Norge Variant and Teller Variant soils, 3 to 8 percent slopes. This map unit consists of moderately deep to deep, well drained, gently sloping to sloping soils on convex ridge crests and side slopes of uplands that border creeks and streams in the central part of the county. The pattern and extent of Norge Variant and Teller Variant soils are not uniform for each mapped area. Some areas consist mainly of Norge Variant and some mainly of Teller Variant, but most areas consist of both Norge Variant and Teller Variant. The mapped areas are elongated and are 200 to 1,200 feet wide and 500 to 3,500 feet long. They range from 10 to 80 acres.

The Norge Variant soil makes up about 50 percent of the map unit. Typically, the surface layer is reddish brown silt loam about 5 inches thick. The subsoil is reddish brown silt loam to a depth of about 11 inches and reddish brown silty clay loam to a depth of about 29 inches. The underlying material to a depth of 80 inches or more is yellowish red, extremely gravelly sandy loam that has thin strata of sand and gravelly sand. This material ranges from 3 to 25 feet thick and is generally underlain by sandstone or shale.

The Norge Variant soil is high in natural fertility and medium in organic matter content. It is slightly acid to moderately alkaline in the surface layer and subsoil and moderately alkaline and calcareous in the underlying material. Permeability is moderately slow, runoff is medium to rapid, and the available water capacity is medium. The surface layer is friable and easily tilled but compacts easily if tilled when too wet. Plant roots are restricted mainly to the soil above the gravelly material, which is easily penetrated by roots. The soil above the gravelly material is about 20 to 60 inches thick. This soil is easily eroded and needs protective plant cover during periods of intensive rainfall. It has moderate shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

The Teller Variant soil makes up about 25 percent of the map unit. Typically, the surface layer is reddish brown loam about 10 inches thick. The subsoil is reddish brown loam to a depth of about 18 inches and yellowish red, gravelly sandy clay loam to a depth of about 32 inches. The underlying material to a depth of 80 inches or more is red, extremely gravelly loam that has thin strata of fine sand and gravelly fine sand. The underlying material ranges from about 3 to 25 feet thick and is generally underlain by sandstone or shale.

The Teller Variant soil is high in natural fertility and medium in organic matter content. It is slightly acid to moderately alkaline in the surface layer and upper part of the subsoil. The lower part of the subsoil is mildly alkaline or moderately alkaline, and the underlying material is moderately alkaline and calcareous. Permeability is moderate, runoff is medium, and the available water capacity is medium. The surface layer is friable and easily tilled. It is easily eroded if not protected by adequate plant cover. Plant roots are restricted mainly to the soil above the gravelly material, which is easily penetrated by roots. The soil above the gravelly material is about 20 to 60 inches thick. It has low shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

Included with these soils in mapping are areas of Norge soils and soils similar to Harrah and Slaughterville soil but underlain by gravelly material. The included soils make up about 25 percent of the map unit.

The Norge Variant and Teller Variant soils have low potential for row crops or small grains. The hazard of erosion and the available water capacity are the main limitations. Fertility, organic matter content, and tilth can be maintained or improved by returning crop residue to the soil and by regular additions of fertilizer. Runoff and the hazard of erosion can be reduced by terracing, contour farming, or minimum tillage.

These soils have medium potential for hay, tame pasture, or rangeland. They are best suited to use as rangeland. Overseeding tame pastures with legumes and moderate applications of fertilizer improve the soil fertility and organic matter content. Use of adequate plant cover during periods of high rainfall reduces runoff, protects the soil from erosion, and increases the available water capacity. Pasture and rangeland can be improved or maintained by use of rotation grazing, by controlling weeds, and by timely deferment from grazing.

These soils have low to high potential for urban use. Moderate and moderately slow permeability is a limitation for septic tank absorption fields. Increasing the size of the absorption field reduces this limitation. Seepage is a limitation for use for sewage lagoons and sanitary landfills. Shrinking and swelling and steepness of slopes are limitations for some urban uses. High grade concrete mix that has adequate reinforcement steel properly bedded over sand helps to reduce cracking in foundations, slabs, and walls caused by shrinking and swelling. Onsite investigation is needed to locate areas that are best suited to a specific use.

These soils have the best potential of all soils in the county for quarrying mixed gravelly or sandy materials for use for roadfill or surfacing. The gravelly and sandy materials are too variable and contain too much fine material for use in concrete or mortar.

These soils have high potential for camping areas, picnic areas, and for paths and trails. The potential for playgrounds is medium because of steepness of slopes.

These soils have medium potential for windbreak tree and shrub plantings. The available water capacity and restricted root zone are limitations. American plum, Austrian pine, Amur honeysuckle, lilac, skunkbush sumac, eastern redcedar, redbud, common hackberry, honeylocust, black locust, osageorange, and Chinese elm are best suited to these soils.

These soils have high potential for use as habitat for openland wildlife and medium potential for rangeland wildlife. They have low potential for use as habitat for wetland wildlife.

These soils are in capability subclass IVe and in Loamy Prairie range site.

11—Dougherty-Konawa complex, 2 to 8 percent slopes. This complex consists of deep, well drained Dougherty and Konawa soils. The soils of this complex were so intermingled that they could not be separated at the scale for mapping. These undulating, very gently sloping to sloping soils are on uplands that parallel the South Canadian River in the western part of Cleveland County. Dougherty soil is on steep side slopes and concave areas of ridge crests, and Konawa soil is on rounded, convex ridge crests. Individual areas of each soil are 1/8 acre to 15 acres. The mapped areas are long, irregular bands that are 300 to 1,500 feet wide and 1,500 to 5,000 feet long and are 15 to more than 200 acres.

The Dougherty soil makes up about 50 percent of the map unit. Typically, the surface layer is grayish brown loamy fine sand about 7 inches thick. The subsurface layer, to a depth of about 23 inches, is brown and light brown loamy fine sand. The subsoil is reddish brown fine sandy loam to a depth of about 27 inches and yellowish red sandy clay loam and fine sandy loam to a depth of about 65 inches. The underlying material to a depth of 80 inches or more is reddish yellow fine sandy loam sediment several feet thick.

The Dougherty soil is low in natural fertility and organic matter content. It is slightly acid to neutral in the surface and subsurface layers, strongly acid to slightly acid in the subsoil, and strongly acid to neutral in the underlying material. Permeability is moderate, runoff is slow, and the available water capacity is medium. This soil has good tilth and can be worked throughout a wide range of moisture content. The root zone is more than 60 inches deep and is easily penetrated by plant roots. Dougherty soil is easily eroded by wind or water if not protected by adequate plant cover. It has low shrink-swell potential and moderate corrosion potential to steel and concrete.

The Konawa soil makes up about 40 percent of the map unit. Typically, the surface layer is grayish brown loamy fine sand about 6 inches thick. The subsurface layer, to a depth of about 15 inches, is light brown loamy fine sand. The subsoil is reddish brown sandy clay loam to a depth of about 24 inches, yellowish red sandy clay loam to a depth of about 37 inches, and yellowish red fine sandy loam to a depth of about 58 inches. The underlying material to a depth of 80 inches or more is reddish yellow fine sandy loam sediment several feet thick.

The Konawa soil is low in natural fertility and organic matter content. It is slightly acid to neutral in the surface and subsurface layers, strongly acid to slightly acid in the subsoil, and medium acid to neutral in the underlying material. Permeability is moderate, runoff is slow, and the available water capacity is medium. This soil has good tilth and can be worked throughout a wide range of moisture content. The root zone is more than 60 inches deep and is easily penetrated by plant roots. Konawa soil is easily eroded by wind or water if not protected by adequate plant cover. It has low shrink-swell potential and moderate corrosion potential to steel and concrete.

Included with this complex in mapping are minor areas of Derby, Slaughterville, and Teller soils. The somewhat excessively drained Derby soils are mostly on convex ridge crests. The well drained Slaughterville and Teller soils are mostly on side slopes near the outer edge of delineations. The included soils make up about 10 percent of the map unit.

This complex has low potential for row crops or small grain. Low fertility and organic matter content and the hazard of erosion are the main limitations. Minimum tillage, use of crop residue, stripcropping, and cover crops, including grasses and legumes in the cropping system, help to control erosion and improve fertility and organic matter content.

This complex has low potential for hay and tame pasture and medium potential for native range. Hay crops and tame pastures respond well to additions of fertilizer that are high in nitrogen. Best results from fertilizer can be obtained by 2 or 3 low rates of application about 4 to 6 weeks apart. Timely weed control is needed for high quality forage production. Native range can be improved by controlling brush and trees, using good grazing practices, and protecting the range from fire.

This complex has medium potential for most urban uses. It has slight limitations for dwellings and local roads and streets. Moderate permeability is a limitation for septic tank absorption fields, and steepness of slopes is a limitation for small commercial buildings. Excessive seepage is a limitation for sewage lagoons, trench type landfills, and pond reservoirs. Establishment and maintenance of landscape vegetation is difficult because of the sandy, droughty nature of the surface and subsurface layers and the low fertility and organic matter content. Pocket gophers can cause severe damage to lawns, shrubs, and gardens.

This complex has high potential for most recreational uses. Steepness of slopes is a limitation for playgrounds. Water and wind erosion can be excessive on heavily used areas.

This complex has high potential for windbreak tree and shrub plantings. American plum, Austrian pine, ponderosa pine, Scotch pine, skunkbush sumac, eastern redcedar, honeylocust, Amur honeysuckle, osageorange, red mulberry, lilac, Chinese elm, and black locust are well suited to these soils. Post oak, blackjack oak, eastern redcedar, and hickory are native species adapted to these soils. Many native trees are used locally for firewood.

This complex has medium potential for use as habitat for openland wildlife and low potential for wetland wildlife habitat. It has high potential for use as habitat for rangeland wildlife.

This complex is in capability subclass IVe and in Deep Sand Savannah range site.

12—Derby loamy fine sand, 0 to 3 percent slopes. This deep, somewhat excessively drained, nearly level to very gently sloping soil is on slightly undulating upland ridge crests. It is in long, narrow bands from 200 to 800 feet wide and 1,000 to 4,500 feet long. The mapped areas range from about 5 to 200 acres.

Typically, the surface layer is brown loamy fine sand about 10 inches thick. The subsurface layer is brown and light reddish brown loamy fine sand to about 54 inches. The subsoil to a depth of 84 inches or more is light reddish brown loamy fine sand that has thin bands of yellowish red loamy fine sand 1/8 to 1/4 inch thick and 1 inch to 6 inches apart.

Included with this soil in mapping are areas of Dougherty, Konawa, and Slaughterville soils and a few blow-out spots. The well drained Dougherty and Konawa soils are intermingled with the Derby soil. The well drained Slaughterville soils are mostly in slight depressions. The included soils make up about 20 percent of the map unit, but individual areas are generally less than 5 acres.

This Derby soil is low in natural fertility and organic matter content. It is medium acid to mildly alkaline throughout. Permeability is rapid, runoff is very slow, and the available water capacity is low. This soil is easily eroded by wind. It has good tilth and can be worked throughout a wide range of moisture content. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has low shrink-swell potential, low corrosion potential to steel, and moderate corrosion potential to concrete.

This soil has low potential for row crops or small grains. The low available water capacity, susceptibility to wind erosion, and the low natural fertility and organic matter content are the main limitations. The fertility and organic matter content can be improved by seeding legumes, adding fertilizer, and returning crop residue to the soil. Cover crops, minimum tillage, and stripcropping reduce wind erosion. Crop residue left on the soil surface lowers the soil temperature and reduces evaporation. This leaves more moisture available for plant use.

This soil has low potential for hay and tame pasture. The low available water capacity and low fertility are the main limitations. Hay crops and pasture grasses respond well to additions of fertilizer high in nitrogen. Overseeding with legumes improves the soil fertility. Timely mowing or chemical sprays are needed to control weeds.

This soil has medium potential for native range. The range can be improved by harvesting mature trees, controlling brush, using good grazing practices, and protecting the range from fire.

This Derby soil has high potential for most urban uses. It has slight limitations for dwellings, commercial buildings, and roads and streets. Rapid permeability is a limitation for septic tank absorption fields, sewage lagoons, and sanitary landfills. Establishment and maintenance of landscape vegetation is difficult because of the droughty nature of this soil and the low fertility and organic matter content. Pocket gophers can cause severe damage to lawn grasses and shrubs.

This soil has high potential for recreational use. Wind erosion can be excessive in heavily used areas during prolonged dry periods.

This soil has medium potential for windbreak tree and shrub plantings. Droughtiness is the main limitation. American plum, Amur honeysuckle, black locust, eastern redcedar, lilac, oriental arborvitae, osageorange, redbud, red mulberry, Rocky Mountain juniper, and skunkbush sumac are suited to this soil.

This soil has medium potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Derby soil is in capability subclass IVs and in Deep Sand Savannah range site.

13—Derby loamy fine sand, 3 to 15 percent slopes. This deep, somewhat excessively drained, gently sloping to moderately steep soil is on slightly undulating side slopes of uplands along the South Canadian River. It is in long narrow bands from 200 to 1,000 feet wide and 500 to 6,000 feet long. The mapped areas are 5 to more than 100 acres.

Typically, the surface layer is brown loamy fine sand about 11 inches thick. The subsurface layer is light brown and pink loamy sand to a depth of about 52 inches. The subsoil to a depth of 84 inches or more is reddish yellow loamy sand that has thin bands of reddish yellow loamy fine sand 1/16 to 1/8 inch thick and 6 to 12 inches apart.

Included with this soil in mapping are areas of Dougherty, Konawa, and Slaughterville soils. The well drained Dougherty and Konawa soils are intermingled with the Derby soil. The well drained Slaughterville soils are on foot slopes and in slight depressions on side slopes. The included soils make up about 15 percent of the map unit, but individual areas are generally less than 5 acres.

This Derby soil is low in natural fertility and organic matter content. It is medium acid to mildly alkaline throughout. Permeability is rapid, runoff is slow, and the available water capacity is low. This soil is subject to severe wind or water erosion. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has low shrink-swell potential, low corrosion potential to steel, and moderate corrosion potential to concrete.

This soil has low potential for row crops and small grains. The main limitations are steepness of slopes, droughtiness, the severe hazard of erosion, and the low fertility and organic matter content.

This soil is better suited to use as hay, tame pasture, or rangeland. It also has low potential for hay and tame pasture because of steepness of slopes and droughtiness. Applying moderate amounts of fertilizer and including legumes in the tame pasture mixture improve soil fertility and reduce the hazard of erosion. This soil has medium potential for native range. The quality of the grasses can be improved by controlling brush, using suitable grazing practices, and protecting the vegetation from fire.

This soil has low to medium potential for urban use. Rapid permeability is the main limitation for sewage lagoons and sanitary landfills. The unstable nature of this soil imposes a severe limitation for shallow excavations when vertical cuts are made. Steepness of slopes is a severe limitation for commercial buildings and is a moderate limitation for dwellings. Establishment and maintenance of landscape vegetation is difficult because of the droughty nature of the soil. Pocket gophers can cause considerable damage to lawns and shrubs.

This Derby soil has medium potential for recreational uses, such as camp areas and picnic areas, and low potential for playgrounds. Steepness of slopes is the main limitation for these uses. This soil has slight limitations for paths and trails.

This soil has medium potential for windbreak tree and shrub plantings. Droughtiness is the main limitation. American plum, eastern redcedar, osageorange, Amur honeysuckle, lilac, skunkbush sumac, black locust, redbud, red mulberry, Rocky Mountain juniper, and oriental arborvitae are suited to this soil.

This soil has medium potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Derby soil is in capability subclass VIe and in Deep Sand Savannah range site.

14—Derby-Urban land complex, 0 to 15 percent slopes. This complex consists of the deep, somewhat excessively drained Derby soil and Urban land. The Derby soil and Urban land were so intermingled that they could not be separated at the scale selected for mapping. This complex is on nearly level to moderately steep, undulating uplands paralleling the South Canadian River in southwest Norman. The mapped areas are in long, oval, and elongated bands from 300 to 2,000 feet wide and 500 to 4,500 feet long and are 15 to 90 acres.

The Derby soil is in the unaltered areas of the landscape and makes up about 55 percent of the map unit. Typically, the surface layer is grayish brown loamy fine sand about 6 inches thick. The subsurface layer is brown and pink loamy fine sand to a depth of about 48 inches. The subsoil is pink loamy fine sand that has thin wavy bands, 1/16 to 1/4 inch thick and 4 to 10 inches apart, of yellowish red loamy fine sand that extends to a depth of more than 84 inches.

The Derby soil is low in natural fertility and organic matter content. It ranges from medium acid to mildly alkaline throughout. Permeability is rapid, runoff is slow, and the available water capacity is low. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil is susceptible to severe wind erosion if not protected by plant cover or residue. It has low shrink-swell potential, low corrosion potential to steel, and moderate corrosion potential to concrete.

Urban land makes up about 35 percent of the map unit. It consists of areas of soils that are covered with buildings or other urban structures. Typical structures are residential dwellings, single story office buildings, churches, streets, highways, and parking lots of less than 20 acres.

Included with this complex in mapping are areas of Dougherty, Konawa, and Slaughterville soils. These soils have been altered in places. The well drained, moderately permeable Dougherty and Konawa soils are mostly in lower concave areas than Derby soils, and the well drained, moderately rapidly permeable Slaughterville soils are mostly on convex side slopes near the outer edge of delineations. The included soils make up about 10 percent of the map unit.

This complex is not suited to cultivated crops, hay, tame pasture, or rangeland. Areas of Derby soil are too small for operation of most farm equipment or for livestock use.

The complex has medium potential for commercial buildings, residential dwellings, and streets. Cutting and filling the moderately steep slopes is a limitation. Seepage and poor filter materials are a severe limitation for use for sanitary facilities. It has medium potential for lawns and landscape establishment. Droughtiness and slope are moderate limitations for this use. Monthly applications of plant nutrients and frequent watering can help plant survival and plant growth. Incorporating adequate amounts of organic materials, such as peat moss or manure, improves the available water capacity and increases soil fertility.

This complex has medium potential for camp areas and picnic areas and low potential for playgrounds. The moderately steep slopes are the main limitation.

This complex has medium potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, black locust, eastern redcedar, lilac, oriental arborvitae, osageorange, red mulberry, redbud, Rocky Mountain juniper, and skunkbush sumac are well suited to the Derby soil.

This complex is not assigned to a capability subclass or range site.

15—Littleaxe loamy fine sand, 1 to 3 percent slopes. This deep, well drained, very gently sloping soil is on broad ridgetops of uplands in the eastern part of the county. Slopes are smooth and convex. The mapped areas are 20 to more than 400 acres.

Typically, the surface layer is grayish brown loamy fine sand about 7 inches thick. The subsurface layer is pink loamy fine sand to a depth of 16 inches. The subsoil is yellowish red sandy clay loam and fine sandy loam to a depth of 37 inches, reddish yellow fine sandy loam to a depth of 43 inches, and coarsely mottled reddish yellow fine sandy loam to a depth of 52 inches. The underlying material is reddish yellow and yellowish red, weakly cemented sandstone interbedded with red, weakly cemented shale to a depth of 60 inches or more.

Included with this soil in mapping are soils similar to Littleaxe soil but moderately well drained and coarsely mottled in the lower part of the subsoil because of a perched high water table. Also included are Harrah and Stephenville soils that are intermingled with the Littleaxe soils. The included soils make up about 50 percent of the map unit, but individual areas are generally less than 5 acres.

This Littleaxe soil is low in natural fertility and organic matter content. It is medium acid to neutral in the surface and subsurface layers. Where limed, it ranges from medium acid to moderately alkaline. The subsoil is very strongly acid to slightly acid. Permeability is moderate, runoff is slow, and the available water capacity is medium. The root zone is 40 to 60 inches deep and is easily penetrated by plant roots. This soil has good tilth and can be worked throughout a wide range of moisture content. It is easily eroded if not protected by adequate plant cover. It has low shrink-swell potential and moderate corrosion potential to steel or concrete.

This soil has medium potential for row crops and small grains. The low fertility and organic matter content, acidity, the available water capacity, and the hazard of erosion are the main limitations. Minimum tillage, contour farming, crop residue use, and the use of cover crops, including grasses and legumes in the cropping system, reduce the hazard of erosion and help to maintain soil tilth and improve the fertility and organic matter content. Additions of lime corrects soil acidity.

This soil has medium potential for hay, tame pasture, and rangeland. Proper stocking, pasture rotation, weed control, and adding fertilizer high in nitrogen help keep the grasses in good condition and to maintain the soil fertility.

This Littleaxe soil has high potential for most urban uses, such as building sites, local roads and streets, lawns, landscaping, and golf fairways. Depth to rock and seepage are the main limitations for sewage lagoons and sanitary landfills. These limitations can be reduced by using special designs and careful installation procedures. Pocket gophers can cause damage to lawns and shrubs unless controlled.

This soil has high potential for recreational use. Steepness of slopes is a limitation for playgrounds.

This soil has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has low potential for use as habitat for wetland wildlife and medium potential as habitat for openland wildlife. It has high potential for use as habitat for rangeland wildlife.

This Littleaxe soil is in capability subclass IIIe and in Deep Sand Savannah range site.

17—Gracemore silty clay loam, saline, frequently flooded. This deep, somewhat poorly drained, nearly level to slightly undulating soil is high in soluble salts. It is on low flood plains along the South Canadian River. This soil is subject to frequent flooding for very brief to brief periods from spring to summer. It has an apparent high water table from 1/2 foot to 3 1/2 feet below the surface from fall to spring. Slopes range from 0 to 2 percent. The mapped areas are 100 to 1,800 feet wide and 1,000 to 30,000 feet long and are 10 to more than 200 acres.

Typically, the surface layer is reddish brown silty clay loam to about 7 inches thick. The underlying material is light brown loamy fine sand that has strata of dark brown fine sandy loam to a depth of about 23 inches. It is pink fine sand that has thin strata of brown fine sandy loam to a depth of 80 inches or more.

Included with this soil in mapping are a few intermingled areas of Gaddy and Gracemont Variant soils. The somewhat excessively drained Gaddy soils are on higher, convex landscapes parallel to the river. The somewhat poorly drained Gracemont Variant soils are on low concave areas in similar positions on the landscape as Gracemore soil. The included soils make up about 15 percent of the map unit, but individual areas are generally less than 2 acres.

This Gracemore soil is low in natural fertility and organic matter content. It is moderately alkaline and calcareous throughout. Soluble salts are concentrated mostly in the surface layer, and the amount varies over short distances. If dry, the soil surface turns white and crusts over where salt concentrations are highest. Permeability is moderately rapid or rapid, runoff is slow, and the available water capacity is low. The root zone is more than 40 inches deep, but root development and penetration are partially restricted by the high salt content and high water table. In some small areas, the salt content is too high for the soil to support plants. This soil slakes and erodes easily where placed on sloping embankments or fill areas. It has low shrink-swell potential and high corrosion potential to steel and concrete.

This soil has low potential for cultivated crops. Soluble salts, flooding, and the high water table are severe limitations that could be overcome only by major flood control and drainage measures.

This soil has medium potential for hay and tame pasture. Installing a surface drainage system, deep plowing to improve the soil structure, planting salt tolerant grasses, and incorporating large amounts of manure or plant residue along with generous amounts of fertilizer improve the soil condition, decrease the concentration of salts, and improve the soil fertility.

This soil has high potential for native rangeland. The quality of native grasses can be maintained by proper stocking, rotation grazing, and deferment of grazing during the growing season.

This Gracemore soil has low potential for most urban and recreational uses. The salinity, high water table, and flood hazard are severe limitations. These limitations can be overcome only by major upstream flood control and drainage measures.

This soil has low potential for windbreak tree and shrub plantings. Eastern redcedar, Amur honeysuckle, lilac, skunkbush sumac, oriental arborvitae, Rocky Mountain juniper, redbud, Arizona cypress, and osageorange are best suited to these soils. The high salt content restricts the growth and species of plants. Eastern cottonwood and Tamarisk are native trees adapted to this soil.

This soil has low potential for use as habitat for openland and rangeland wildlife and medium potential for use as habitat for wetland wildlife. The adapted plants and growth of food plants are severely limited by the soil salinity.

This soil is in capability subclass Vs and in Subirrigated Saline range site.

18—Gracemore loamy fine sand, frequently flooded. This deep, somewhat poorly drained, nearly level to very gently sloping soil is on low flood plains along the South Canadian River. This soil is subject to frequent flooding for very brief to brief periods from spring to summer. It has an apparent high water table from 1/2 foot to 3 1/2 feet below the surface from fall to spring. Slopes range from 0 to 2 percent. The mapped areas are oblong, 100 to 1,800 feet wide and 1,500 to 16,000 feet long, and are 10 to over 300 acres.

Typically, the surface layer is brown loamy fine sand about 7 inches thick. The next layer is a light brown loamy fine sand to a depth of about 11 inches. The underlying material is pink loamy fine sand and fine sand that has thin strata of finer or coarser material to a depth of 84 inches or more.

Included with this soil in mapping are small areas of soils that have finer textured surface layers than Gracemore soil and are in depressions. Also included are a few intermingled areas of Gaddy soils on narrow, convex dunes and Gracemont Variant soils in similar positions on the landscape as Gracemore soil. The included soils make up about 15 percent of the map unit, but individual areas are generally less than 2 acres.

This Gracemore soil is low in natural fertility and organic matter content. It is moderately alkaline and calcareous throughout. Permeability is moderately rapid to rapid, and the available water capacity is low. Runoff is slow. The root zone is more than 40 inches deep and is easily penetrated by plant roots. The depth of root penetration is limited by the depth to a high water table. This soil is easily eroded by wind if not protected by adequate plant cover. Scouring and deposition can occur during flash floods. This soil has low shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

This soil has low potential for row crops and small grains. The hazard of flooding and the high water table are the main limitations. These limitations could be overcome only by major flood control and drainage measures. Maintaining fertility and protecting the soil from damage by overflow from streams are management concerns.

This soil has high potential for hay, tame pasture, and rangeland. Grasses respond well to additions of fertilizer that are high in nitrogen. Adequate plant cover during spring and summer protects the soil from blowing and from damage by scouring and deposition during floods. Proper stocking, rotation grazing, timely deferment of grazing, and restricted use during the wet periods help keep the grass and soil in good condition.

This soil has low potential for urban and recreational uses. The high water table, excessive seepage, and hazard of frequent flooding are severe limitations that can be overcome only with major flood control and drainage measures.

This soil has low potential for windbreak tree and shrub plantings. Eastern cottonwood, green ash, common hackberry, osageorange, skunkbush sumac, lilac, Amur honeysuckle, American plum, honeylocust, redbud, silver maple, and American sycamore are well suited to this soil.

This soil has medium potential for use as habitat for openland, wetland, and rangeland wildlife. The surface texture and wetness restrict the production of seed for wildlife food.

This Gracemore soil is in capability subclass Vw and in Subirrigated range site.

19—Goodnight loamy fine sand, hummocky. This deep, excessively drained soil is mainly in long, narrow, hummocky areas, 100 to 700 feet wide and 400 to 9,000 feet long, on flood plains along the South Canadian River. These very gently sloping to moderately steep soils are on dunes and are subject to rare flooding. Slopes range from 1 to 20 percent. The mapped areas are 5 to 150 acres.

Typically, the surface layer is brown loamy fine sand about 5 inches thick. The underlying material is reddish yellow loamy fine sand to a depth of 84 inches or more. Thin strata of finer and coarser materials are below a depth of about 22 inches.

Included with this soil in mapping are small depressional areas of soils that have a darker, finer textured surface layer than Goodnight soil and small areas of soils similar to Goodnight soil but with a high water table from 40 to 72 inches below the surface. Small blow-out areas are common and occur at right angles to the prevailing winds. The included soils make up about 10 percent of the map unit.

This Goodnight soil is low in natural fertility and organic matter content. It is neutral to moderately alkaline in the surface layer and mildly alkaline or moderately alkaline in the underlying material. Permeability is rapid, runoff is slow, and the available water capacity is low. This soil has good tilth and can be worked throughout a wide range of moisture content. It is easily eroded by wind. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has a high water table from 6 to 25 feet below the surface most of the year. It has low shrink-swell potential and low corrosion potential to steel and concrete.

This soil has low potential for row crops and small grains. Because of the steepness of slopes, severe wind erosion hazard, low fertility, and low available water capacity, this soil is not suited to cultivation.

This soil has low potential for hay and tame pasture, but it is better suited to this use. Adequate plant cover during spring and summer protects the soil from blowing and from damage by scouring and deposition during floods. Proper stocking, rotation grazing, timely deferment of grazing, and restricted use during dry periods help keep the grass and soil in good condition.

This soil has medium potential for native rangeland. The quality of native grasses can be maintained or improved by controlling brush and weeds, using suitable grazing practices, and protecting the range from fire.

This Goodnight soil has low potential for urban use. The hazard of flooding is a severe limitation that can be overcome only by major flood control measures. Seepage, the sandy condition of the soil, and cutbanks that cave are severe limitations that are difficult to overcome. This soil is suited to use for fill or bedding materials.

This soil has low potential for use in developing camp areas because of the severe hazard of flooding. It has medium potential for playgrounds. Steepness of slopes is the main limitation. This soil has high potential for picnic areas and paths and trails.

This soil has medium potential for windbreak tree and shrub plantings. American plum, American sycamore, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern cottonwood, eastern redcedar, euonymus, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has medium potential for use as habitat for rangeland and openland wildlife. It has low potential for use as habitat for wetland wildlife.

This Goodnight soil is in capability subclass VIe and in Deep Sand range site.

20—Tribbey fine sandy loam, frequently flooded. This deep, somewhat poorly drained, nearly level or very gently sloping soil is on flood plains of small streams in the eastern part of Cleveland County (fig. 8). Slopes are less than 2 percent and are smooth to slightly undulating. This soil is subject to frequent flooding for very brief to brief periods throughout the year. An apparent high water table is within 1/2 foot to 3 1/2 feet below the surface mainly during fall, winter, and spring. The mapped areas are 20 to 100 acres.

Typically, the surface layer is reddish brown fine sandy loam about 4 inches thick. The underlying material, to a depth of about 24 inches, is reddish brown fine sandy loam that has strata of coarser and finer textured materials. To a depth of about 72 inches it is yellowish red loamy very fine sand that has strata of coarser and finer textured materials.

Included with this soil in mapping are areas of the well drained Port and Pulaski soils. Also included are small areas of soils similar to Tribbey soil but having a darker colored and thicker surface layer or having a high water table between 40 and 60 inches below the surface or are browner in all layers beneath the surface layer. The included soils make up about 25 percent of the map unit, but individual areas are generally less than 2 acres.

This Tribbey soil is low in natural fertility and organic matter content. It is medium acid to moderately alkaline throughout. Permeability is moderate or moderately rapid, runoff is very slow, and the available water capacity is medium. The root zone is more than 60 inches deep, but most roots are limited to soil materials above the saturated zone. This soil has low shrink-swell potential, high corrosion potential to steel, and low corrosion potential to concrete.

This soil has low potential for cultivated crops. The high water table and frequency of flooding are the main limitations. Major flood control and drainage measures are needed to protect crops from damage.

This soil has medium potential for tame pasture, hay, and rangeland. Additions of fertilizer or manure or overseeding with legumes improves the soil fertility. Bermudagrass or bermudagrass and fescue pastures are best suited to this wet soil. Timely weed and brush control, rotation grazing, and protection from uncontrolled burning help to maintain plant vigor and production of high quality forage. The high water table provides a reliable source of water in excavated reservoirs for livestock use.

This Tribbey soil has low potential for most urban and recreational uses. The frequency of flooding and high water table are severe limitations that can be overcome

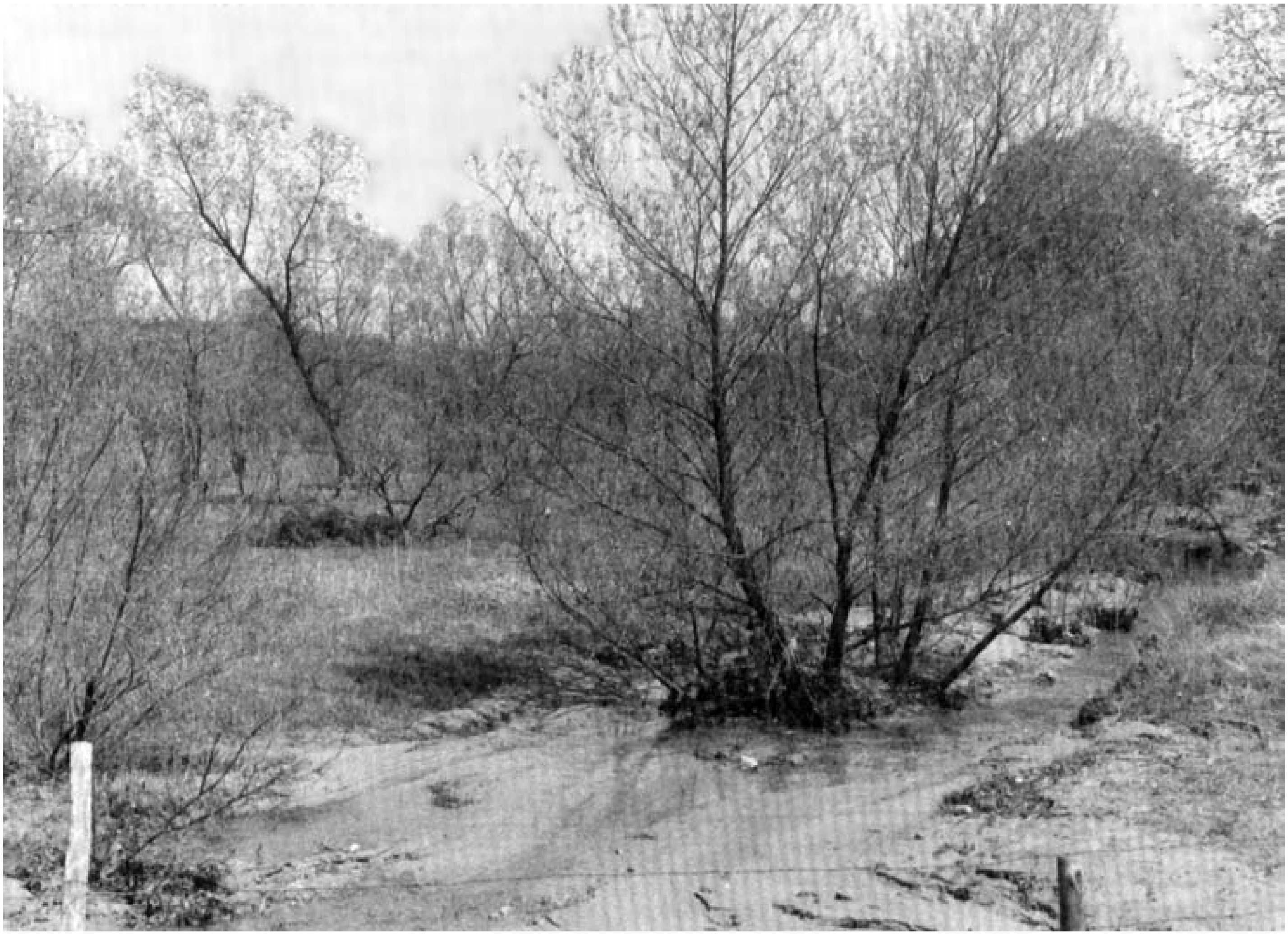


Figure 8.—A landscape of Tribbey fine sandy loam, frequently flooded, adjacent to a sand-choked stream channel. Willow trees generally indicate a soil that has a high water table.

only by major flood control and drainage measures or by land reclamation. Small building sites can be developed by constructing elevated pads for protection from flooding and wetness.

This soil has low potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, lilac, skunkbush sumac, American sycamore, common hackberry, eastern cottonwood, green ash, honeylocust, osageorange, redbud, and silver maple are well suited to this soil.

This soil has high potential for use as habitat for wetland wildlife. It has medium potential for use as habitat for openland and rangeland wildlife.

This Tribbey soil is in capability subclass Vw and in Wetland range site.

21—Ustorthents, loamy. This map unit consists of borrow pits, gravel pits, and sand pits where the soils or underlying material have been removed for building roads, for fill material in urban construction sites, and for topsoil in landscaping around homes and commercial buildings. Most of these excavated areas have nearly vertical sides and nearly level to very gently sloping bottoms. Some areas have sidewalls shaped and revegetated. The excavated areas are 4 to 30 feet deep, 300 to 2,000 feet long, and 200 to 1,000 feet wide. Many areas have restricted surface drainage, and some areas pond water for long periods. Some of these pits have overburden material stockpiled nearby or within the pit area. Most of the soils are loamy and have underlying strata of sand and gravel. Some borrow pits along highways have clayey soil materials on the sidewalls and bottom. In some areas, red shale or sandstone is exposed in the bottom.

Most mapped areas are revegetating naturally and support a sparse cover of annual weeds, grasses, and trees. The potential for grass is low, but most areas are best suited to this use or for use as habitat for wildlife. With good management, low to moderate amounts of native grass can be grown. Shaping and smoothing side slopes, seeding adapted species, deferment of grazing, proper stocking, and rotation grazing are needed.

The potential is low for most urban and recreational uses. Wetness and the hazard of flooding are severe limitations.

Ustorthents are not assigned to a capability subclass or range site.

28—Kingfisher-Urban land-Lucien complex, 1 to 5 percent slopes. This complex consists of moderately deep, well drained Kingfisher soil, shallow, well drained Lucien soil, and Urban land. These soils and Urban land are so intermingled that they could not be separated at the scale selected for mapping. They are not extensive and are in the northeast parts of Norman and Moore. Kingfisher soil is mostly on the very gently sloping ridge crests, and the Lucien soil is mostly on gently sloping side slopes of ridges. The mapped areas are long, narrow, or rounded, are 300 to 800 feet wide and 300 to 2,000 feet long, and range from about 5 to 50 acres.

The Kingfisher soil makes up about 45 percent of the map unit. Typically, the surface layer is reddish brown silt loam about 5 inches thick. The subsoil is reddish brown silt loam to a depth of about 9 inches, red silty clay loam to a depth of about 20 inches, and red silt loam to a depth of about 26 inches. The underlying material is red, weakly cemented, calcareous sandstone to a depth of 30 inches or more.

The Kingfisher soil is high in natural fertility and medium in organic matter content. It is slightly acid to mildly alkaline in the surface layer. The subsoil is slightly acid to moderately alkaline in the upper part and neutral to moderately alkaline in the middle and lower parts. Permeability is moderately slow, runoff is medium, and the available water capacity is medium. The root zone is 20 to 40 inches deep and can be penetrated easily by plant roots. This soil is susceptible to water erosion. It has moderate shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

Urban land makes up about 30 percent of this map unit. It consists of areas of soils that have been covered with buildings or other urban structures. Typical structures in this complex consist mostly of residential dwellings, driveways, sidewalks, and streets. Less extensive areas have apartment housing, schools, playgrounds, and parking lots.

Lucien soil makes up about 15 percent of the map unit. Typically, the surface layer is brown very fine sandy loam about 5 inches thick. The subsoil is reddish brown very fine sandy loam to a depth of about 14 inches. The underlying material is red, fine-grained, calcareous weakly cemented sandstone to a depth of about 22 inches or more.

The Lucien soil is medium in natural fertility and low in organic matter content. It is slightly acid to moderately alkaline in the surface layer and neutral to moderately alkaline in the subsoil. Permeability is moderately rapid, runoff is medium to rapid, and the available water capacity is very low. The root zone is 10 to 20 inches deep and is easily penetrated by plant roots. This soil is susceptible to water erosion. It has low shrink-swell potential and low corrosion potential to steel and concrete.

Included with this complex in mapping are areas of Grainola, Grant, and Renfrow soils. The slowly permeable Grainola soils are on steeper side slopes than Lucien soil. The deeper, well drained Grant soils and the very slowly permeable Renfrow soils are on ridge crests. The included soils make up about 10 percent of the map unit.

This complex has low potential for cropland, hay, tame pasture, or rangeland. Areas of King Fisher and Lucien soils are too small for operation of most form equipment and for livestock use.

This complex has medium potential for most urban uses. Depth to rock is a moderate limitation for single story dwellings, small commercial buildings, and local roads and streets. Shrinking and swelling is a moderate limitation of the Kingfisher soil for building sites, but this can be reduced by using higher strength concrete, bedding with sand below footings and slab floors, and using additional reinforcement steel. The Lucien soil has severe limitations for lawns, shrubs, and gardens because of the thin layer of soil available for plant root growth and the low available water capacity. These limitations can be reduced by adding topsoil to increase the soil depth. Areas along roadsides that are shaped or altered exposing the bedrock need to be covered with sufficient topsoil to support plant growth. This can prevent roadside erosion and reduce pollution downstream.

The Kingfisher soil has high potential for windbreak trees and shrubs, and Lucien soil has low potential. Trees and shrubs suited to these soils are Amur honeysuckle, eastern redcedar, lilac, osageorange, redbud, and skunkbush sumac. The Kingfisher soil is well suited to American plum, Austrian pine, autumn-olive, Scotch pine, black locust, Chinese elm, common hackberry, and honeylocust; and Lucien soil is well suited to oriental arborvitae, Rocky Mountain juniper, and Arizona cypress.

This complex is not assigned to a capability subclass or range site.

29—Lucien-Kingfisher complex, 1 to 8 percent slopes. This complex consists of shallow, well drained Lucien soil and moderately deep, well drained Kingfisher soil. The soils of this complex were so intermingled that they could not be separated at the scale selected for mapping. They are in the central part of the county. Lucien soil is mostly on shoulders of ridge crests and on contour bands on gently sloping or sloping side slopes. Kingfisher soil is mostly on very gently sloping to gently sloping ridge crests. Individual areas of Kingfisher soil are 1/4 acre to 5 acres. The mapped areas are small and elongated or large and irregular in shape and are 10 to more than 100 acres.

The Lucien soil makes up about 75 percent of the map unit. Typically, the surface layer is reddish brown very fine sandy loam about 4 inches thick. The subsoil is yellowish red loam to a depth of about 11 inches. The underlying material is red and light red, weakly cemented, siltstone to a depth of 19 inches or more.

The Lucien soil is medium in natural fertility and low in organic matter content. It is neutral to moderately alkaline in the surface layer and mildly alkaline or moderately alkaline in the subsoil. Permeability is moderately rapid, runoff is medium to rapid, and the available water capacity is very low. The root zone is 10 to 20 inches deep and is easily penetrated by plant roots. This soil is easily eroded. It has low shrink-swell potential and low corrosion potential to steel and concrete.

The Kingfisher soil makes up about 15 percent of the map unit. Typically, the surface layer is reddish brown silt loam about 4 inches thick. The subsoil is reddish brown silt loam to a depth of about 9 inches, red silty clay loam to a depth of about 16 inches, and red silt loam to a depth of about 24 inches. The underlying material is red, weakly cemented, calcareous sandstone to a depth of 30 inches or more.

The Kingfisher soil is high in natural fertility and medium in organic matter content. It is neutral to mildly alkaline in the surface layer, mildly alkaline or moderately alkaline in the upper part of the subsoil, and moderately alkaline in the lower part. Permeability is moderately slow, runoff is medium, and the available water capacity is medium. The root zone is 20 to 40 inches deep and is easily penetrated by plant roots. Kingfisher soil is easily eroded by water if not protected by adequate plant cover. It has moderate shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

Included with this complex in mapping are small areas of Grainola, Huska, and Renfrow soils and areas of rock outcrop and soils similar to Lucien soil but less than 10 inches thick to bedrock. The slowly permeable Grainola soils are on side slopes below the Lucien soil. The very slowly permeable Renfrow soils are mostly above the Kingfisher soil on ridge crests. The moderately well drained Huska soils have a lighter colored surface layer and are in concave spots intermingled with the Kingfisher soil. The included soils make up about 10 percent of the map unit.

This complex has low potential for row crops and small grains. It is best suited to tame pasture or rangeland. The shallow depth, rapid runoff, hazard of erosion, droughtiness, and organic matter content prohibit the use of most farming equipment or reduce the kind and amounts of crops that can be grown.

This complex has low potential for rangeland, hay, and tame pasture. Droughtiness and organic matter content are the main limitations. Adding fertilizer to tame pasture and overseeding with legumes help to improve plant vigor and to reduce runoff. The quality of the native grasses can be improved by controlling brush and weeds, using suitable grazing practices, and protecting the range from fire.

This complex has low potential for most urban uses. The depth to rock is a moderate limitation for dwellings and small commercial buildings and a severe limitation for use in sewage lagoons, sanitary landfills, and septic tank absorption fields. Seepage is a severe limitation for sewage lagoons and sanitary landfills.

This complex has low potential for most recreational uses. The depth to rock is a severe limitation for camp areas, picnic areas, and playgrounds. Slope is a severe limitation for playgrounds. Kingfisher soil is better suited to recreational use than Lucien soil.

This complex has low potential for windbreak tree and shrub plantings. Eastern redcedar, Amur honeysuckle, Arizona cypress, osageorange, oriental arborvitae, Rocky Mountain juniper, lilac, redbud, and skunkbush sumac are suited to these soils. American plum, bur oak, euonymus, green ash, ponderosa pine, red mulberry, autumn-olive, Scotch pine, silver maple, hackberry, honeylocust, black locust, Austrian pine, and Chinese elm are adapted to Kingfisher soil.

This complex has low potential for developing habitat for openland, wetland, and rangeland wildlife.

This complex is in capability subclass VIe. Lucien soil is in Shallow Prairie range site, and Kingfisher soil is in Loamy Prairie range site.

30—Brewless silty clay loam, rarely flooded. This deep, moderately well drained, nearly level soil is on high flood plains along the South Canadian River. Slopes are smooth to slightly convex and are less than 1 percent. This soil is subject to rare flooding and has an apparent high water table between 5 and 10 feet below the surface. The mapped areas of this soil are long and irregular in shape and range from 10 to more than 400 acres.

Typically, the surface layer is dark grayish brown silty clay loam about 9 inches thick. The subsoil is dark brown or brown silty clay to a depth of 24 inches and brown or light reddish brown, mottled silty clay loam to a depth of about 44 inches. The underlying material is brown and reddish brown, mottled, stratified silty clay loam, very fine sandy loam, and silty clay to a depth of about 84 inches.

Included with this soil in mapping are a few areas of Asher, Asher Variant, and Lomill soils. Asher soils are in similar positions on the landscape as Brewless soil. Asher Variant and Lomill soils are in slight depressions. The included soils make up about 10 percent of the map unit, but individual areas generally are less than 2 acres.

This Brewless soil is high in natural fertility and organic matter content. It is slightly acid to moderately alkaline in the surface layer, neutral to moderately alkaline in the upper part of the subsoil, and moderately alkaline in the lower part of the subsoil and in the underlying material. Permeability is slow, and the available water capacity is high. Runoff is slow, and water often stands on the surface for extended periods. In dry seasons the surface layer and upper part of the subsoil shrink, and large, deep cracks are prevalent. The root zone is more than 60 inches deep and is difficult to penetrate. This soil is easily compacted and should be tilled under optimum moisture conditions. It has high shrink-swell potential, high corrosion potential to steel, and low corrosion potential to concrete.

This soil has high potential for row crops, legumes, and small grains. The soil tilth can be improved by returning crop residue to the soil and by refraining from tillage when soil is too wet. The fertility, organic matter content, and soil structure can be maintained by seeding legumes, adding fertilizer, and returning crop residue to the soil. Surface drainage ditches improve runoff and eliminate wet spots.

This soil has high to medium potential for hay and tame pasture. It has high potential for native rangeland. In unfavorable years, this soil can be too droughty in dry seasons or too wet for extended periods in wet seasons to plant and harvest the grasses. Refraining from grazing or harvesting the hay when the soil is too wet reduces compaction. Improving the surface drainage by land smoothing or shaping eliminates wet spots and drowning of plants.

This Brewless soil has low potential for most urban uses. The high shrink-swell potential, high corrosion hazard to steel, slow permeability, and hazard of flooding are severe limitations that are expensive to overcome. The flooding limitation can be overcome only with major upstream flood control structures or by raising the building site on pads constructed of soils that have slight limitations. Seepage is a severe limitation for sewage lagoons.

The soil has high potential for most recreational uses. The hazard of flooding is a severe limitation for camp areas. Major flood control measures are needed to overcome the flooding limitation.

This soil has medium potential for windbreak tree and shrub plantings. American sycamore, Amur honeysuckle, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern cottonwood, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland and wetland wildlife. It has medium potential for use as habitat for rangeland wildlife.

This soil is in capability class I and in Heavy Bottomland range site.

32—Lomill silty clay, occasionally flooded. This deep, somewhat poorly drained, nearly level soil is on high flood plains along the South Canadian River and smaller rivers and streams that drain the western and central prairies. Slopes are less than 1 percent and are smooth or slightly concave. This soil is subject to occasional flooding for very brief to brief periods following heavy rainfall in the spring and summer. It has an apparent high water table between 3 1/2 and 6 feet below the surface most of the year. The mapped areas are elongated or rounded and are 20 to 200 acres.

Typically, the surface layer is brown silty clay about 13 inches thick. The subsoil is dark reddish gray silty clay to a depth of about 25 inches. The underlying material is brown silty clay to a depth of about 34 inches and stratified brown, light brown, and reddish brown loam, very fine sandy loam, and silty clay to a depth of 60 inches or more.

Included with this soil in mapping are areas of Asher, Brewless, and Weswood soils and soils similar to Lomill soil but having a high water table more than 6 feet below the surface. The moderately well drained Asher and Brewless soils are in slightly higher positions on flood plains than Lomill soil. The well drained Weswood soils are on slightly higher overwash fans that terminate onto the Lomill soil. The soils similar to Lomill soil are mostly on flood plains of smaller rivers and streams. The included soils make up about 30 percent of the map unit.

This Lomill soil is high in natural fertility and organic matter content. It is mildly alkaline or moderately alkaline in the surface layer and moderately alkaline in the subsoil and underlying material. It is calcareous in all layers in most areas, but, in some, the soil is leached of lime to a depth of about 15 inches. Permeability and runoff are very slow, and the available water capacity is medium. This soil is easily compacted when moist. Tillage is difficult because of the clay content. The root zone is more than 48 inches deep, but plant roots have difficulty penetrating the clayey layers and are often restricted to the soil materials above the high water table. This soil has high shrink-swell potential, high corrosion potential to steel, and low corrosion potential to concrete.

This soil has medium potential for row crops, small grains, or legumes. Very slow runoff, the hazard of flooding, and very slow permeability are the main limitations. Crops are occasionally damaged or lost because of wetness during the rainy season. Surface drainage ditches and land smoothing help to control runoff and reduce surface wetness. Diversions and dikes can be installed in some areas to prevent flooding. The tilth and intake rate can be improved by using minimum tillage and by returning crop residue or adding other organic materials. Refraining from tillage or from pasturing when the soil is wet improves the tilth and reduces compaction. Deep chiseling, heavy applications of gypsum, and growing deep-rooted legumes in the cropping system improve the permeability and intake rate.

This soil has high potential for tame pasture, hay, and rangeland. Wetness and the hazard of flooding are limitations. These limitations can reduce forage yields in years of high rainfall, but, in years of below normal rainfall, they can be beneficial. Haying and pasturing when the soil is wet causes compaction, reduces the intake of water and air, and destroys the soil structure. Tame pastures overseeded with legumes and applications of moderate to high rates of fertilizer improve the soil fertility, structure, and permeability. Surface drainage ditches and land smoothing before establishing the grasses reduce wetness. Chiseling under optimum moisture conditions increases infiltration.

This Lomill soil has low potential for urban uses. The hazard of flooding, high shrink-swell potential, high corrosion potential to steel, very slow permeability, and wetness are severe limitations that are expensive to overcome. Flooding can be overcome only by major flood control measures. Dikes or elevated pads constructed of desirable soil material can reduce overflow in some areas.

This soil has low to medium potential for recreational use. The hazard of flooding and the clayey texture are severe limitations for camp areas. The clayey surface texture is a severe limitation for playgrounds and a moderate limitation for paths and trails. Very slow permeability and the clayey texture are moderate limitations for picnic areas.

This soil has medium potential for windbreak tree and shrub plantings. American sycamore, Amur honeysuckle, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern cottonwood, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, silver maple, and skunkbush sumac are suited to this soil.

This soil has medium potential for use as habitat for openland wildlife and high potential for wetland wildlife habitat. It has low potential for use as habitat for rangeland wildlife.

This soil is in capability subclass IIIw and in Heavy Bottomland range site.

33—Norge-Weswood complex, 0 to 20 percent slopes. This complex consists of deep, well drained Norge soil and deep, well drained Weswood soil. The soils of this complex were so intermingled that they could not be separated at the scale selected for mapping. These soils are along the upper reaches of drainageways in the central and western parts of Cleveland County. Norge soil is on very gently sloping to moderately steep side slopes. Weswood soil is on nearly level to very gently sloping flood plains and is subject to frequent flooding for very brief to brief periods during the spring and summer. Individual areas of each soil are 1/4 acre to 10 acres. The mapped areas are long, narrow, and irregular in shape, are 150 to 600 feet wide and 900 to 4,500 feet long, and are 20 to 200 acres.

The Norge soil makes up about 55 percent of the map unit. Typically, the surface layer is brown silt loam about 12 inches thick. The subsoil is reddish brown silty clay loam to a depth of about 54 inches and red silty clay loam to a depth of 74 inches.

The Norge soil is high in natural fertility and medium in organic matter content. It is slightly acid or neutral in the surface layer and upper part of the subsoil and slightly acid to moderately alkaline in the lower part. Permeability is moderately slow, runoff is medium or rapid, and the available water capacity is high. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil is moderately susceptible to water erosion. It has moderate shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

The Weswood soil makes up about 15 percent of the map unit. Typically, the surface layer is silt loam about 16 inches thick. It is stratified reddish brown and red in the upper part and brown in the lower part. The subsoil, to a depth of about 33 inches, is reddish brown silt loam. The underlying material extends to a depth of 80 inches or more. It is yellowish red silt loam to a depth of about 45 inches, reddish brown silt loam to a depth of about 54 inches, stratified yellowish red and red silt loam to a depth of about 71 inches, and red silty clay loam below that.

The Weswood soil is medium in natural fertility and low in organic matter content. It is neutral to moderately alkaline in the surface layer and moderately alkaline in the subsoil and underlying material. Permeability is moderate, runoff is slow, and the available water capacity is high. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has low shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

Included with this complex in mapping are areas of Grainola, Lucien, Port, Pulaski, Slaughterville, and Teller soils, and soils similar to the Norge soil but having a thinner surface layer. Teller and Slaughterville soils are on side slopes near the South Canadian River. Grainola and Lucien soils are on side slopes in upper reaches of drainageways. Port and Pulaski soils are on flood plains. The included soils make up about 30 percent of the map unit.

This complex has low potential for cropland. The hazard of erosion, medium or rapid runoff, and steepness of slopes on uplands and the frequent flooding on flood plains are severe limitations that can be overcome only with major reclamation projects.

This complex has low potential for hay and tame pasture and medium potential for rangeland. It is best suited to rangeland. The side slopes can be shaped and smoothed in some of the less sloping areas to reduce the hazard of erosion, then planted to permanent grass. Moderate to high rates of fertilizer applied to tame pasture during the spring improve plant vigor and density and reduce the hazard of erosion. Quality of the grasses can be maintained or improved by controlling brush, using suitable grazing practices, and protecting the vegetation from fire.

This complex has low potential for most urban uses. Steepness of the side slopes and frequency of flooding on flood plains are severe limitations that are difficult to overcome. The moderately slow permeability of the Norge soil is a severe limitation for septic tank absorption fields. Major land reclamation would be required to alter this complex for urban use.

This complex has medium potential for pond reservoirs and embankments. Seepage and unstable fill materials are moderate limitations.

This complex has low to medium potential for recreational use. Steepness of slopes and the hazard of erosion on Norge soil and the hazard of flooding on Weswood soil are severe limitations for most uses. The Weswood soil has moderate limitations for picnic areas and paths and trails because of the hazard of flooding.

This complex has medium to high potential for windbreak tree and shrub plantings. American plum, Austrian pine, Amur honeysuckle, lilac, eastern redcedar, skunkbush sumac, osageorange, and Chinese elm are suited to these soils. Common hackberry, redbud, black locust, and honeylocust are well suited to Norge soil; and American sycamore, eastern cottonwood, green ash, black walnut, pecan, and red mulberry are well suited to Weswood soil.

This complex has medium potential for use as habitat for openland and rangeland wildlife. It is has low potential for use as habitat for wetland wildlife.

This complex is in capability subclass VIe. Norge soil is in Loamy Prairie range site, and Weswood soil is in Loamy Bottomland range site.

34—Brewless-Urban land complex, rarely flooded. This complex consists of the deep, moderately well drained Brewless soil and Urban land. This soil and Urban land are so intermingled that they could not be separated at the scale selected for mapping. The soils of this complex are mostly in the western part of Lexington. The Brewless soil is on nearly level, high flood plains along the South Canadian River. It is subject to rare flooding. The mapped areas are elongated, range from about 250 to 1,000 feet wide and from 2,700 to 3,600 feet long, and are about 30 to 80 acres.

The Brewless soil is on the unaltered parts of the landscape and makes up about 50 percent of the map unit. Typically, the surface layer is dark grayish brown silty clay loam and silty clay about 11 inches thick. The subsoil is brown silty clay to a depth of about 18 inches, reddish brown silty clay to a depth of about 27 inches, and brown clay loam to a depth of about 41 inches. The underlying material is light brown and reddish brown stratified layers of fine sandy loam, loamy very fine sand, and silty clay to a depth of 84 inches or more. It is mottled in the lower part.

The Brewless soil is high in natural fertility and organic matter content. It is slightly acid to moderately alkaline in the surface layer, neutral to moderately alkaline in the subsoil, and moderately alkaline in the underlying material. The lower part of the subsoil and the underlying material contain lime. This soil has an apparent high water table between 5 and 10 feet below the surface in most years. Permeability and runoff are slow, and the available water capacity is high. The root zone is more than 60 inches deep and is difficult to penetrate. This soil is susceptible to water erosion if not protected by plant cover or residue. It has high shrink-swell potential, high corrosion potential to steel, and low corrosion potential to concrete.

Urban land makes up about 40 percent of the map unit. It consists of areas of soils that have been covered with buildings or other urban structures. Typical structures are residential dwellings, churches, commercial buildings, parking lots of less than 2 acres, streets, and highways.

Included with this complex in mapping are areas of Asher and Lomill soils. These soils have been altered in some areas. The moderately well drained, slowly permeable Asher soils are in slightly higher positions on better drained landscapes than Brewless soil. The somewhat poorly drained, very slowly permeable Lomill soils are on slightly concave or depressional landscapes. The included soils make up about 10 percent of the map unit.

This complex has low potential for cropland, hay, tame pasture, or rangeland. Areas of Brewless soil are too small for operation of most farm equipment and for livestock use.

This complex has low potential for most urban uses. The hazard of flooding, high shrink-swell potential, slow permeability, high corrosion potential to steel, and the clayey texture are severe limitations that are difficult to overcome. Dikes constructed for flood prevention or buildings and roadways constructed on elevated fills reduce the hazard of flooding. Cracked foundations, footings, and driveways are caused by shrinking and swelling. This can be reduced by properly bedding concrete with gravel and sand, using high grade concrete mix, increasing the amount and size of reinforcement steel, and improving the surface drainage. The soil permeability and texture can be improved by excavation and replacement of the soil with desirable soil or with generous applications of gypsum that improve the structure of the soil. The corrosion hazard to steel can be reduced by installing coated or noncorrosive materials, such as plastic or copper tubing. Calcareous, sandy soils make excellent bedding or cover materials to reduce corrosion and problems caused by shrinking and swelling. Special design and proper installation are needed. This complex has high potential for lawns, shrubs, and gardens. Minor shaping and smoothing are needed to improve surface drainage.

This complex has low to high potential for most recreational uses. The hazard of flooding is a severe limitation for camp areas but only a slight limitation for other uses. Major flood control measures are needed to overcome the flooding limitation.

This complex has high potential for windbreak tree and shrub plantings. American sycamore, Amur honeysuckle, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern cottonwood, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, silver maple, and skunkbush sumac are well suited to Brewless soil.

This complex is not assigned to a capability subclass or range site.

35—Stephenville-Darsil-Newalla complex, 3 to 8 percent slopes, eroded. This complex consists of eroded areas of moderately deep Stephenville soil, shallow Darsil soil, and deep Newalla soil. These soils are on drainage divides in the eastern part of the county. The soils of this complex were so intermingled that they could not be separated at the scale selected for mapping. The well drained Stephenville soil is mostly on ridge crests, but a few areas of this soil are on side slopes between bands of Darsil soil. The excessively drained Darsil soil is mainly on shoulders of ridge crests and on narrow, contour bands on side slopes intermingled with Stephenville soil. The moderately well drained Newalla soil is mostly on side slopes below bands of Darsil soil, but a few areas of this soil are on ridge crests. The surface layer of these soils has been thinned by erosion, and the present plow layer consists of part of the original surface layer mixed with material from the subsoil. The subsoil is exposed in small rills and shallow gullies in some areas. Individual areas of each soil are 3 to 35 acres. The mapped areas are long and irregular in shape, range from 500 to 1,500 feet wide and 400 to 15,000 feet long, and are 5 to 2,000 acres.

The Stephenville soil makes up about 55 percent of the map unit. Typically, the surface layer is brown fine sandy loam about 8 inches thick. The subsoil is yellowish red, red, and light red sandy clay loam to a depth of about 26 inches. The underlying material is red and yellowish red, soft, fine-grained sandstone.

The Stephenville soil is low in natural fertility and organic matter content. The surface layer is medium acid to neutral. Where limed, it ranges from medium acid to mildly alkaline. The subsoil is strongly acid to slightly acid. Permeability is moderate, runoff is medium or rapid, and the available water capacity is low. The root zone is 20 to 40 inches deep and is easily penetrated by plant roots. This soil is easily eroded by wind or water if not protected by adequate plant cover. It has low shrink-swell potential and moderate corrosion potential to steel and concrete.

The Darsil soil makes up about 15 percent of the map unit. Typically, the surface layer is brown loamy fine sand about 7 inches thick. Below that is pink loamy fine sand to a depth of about 14 inches. The underlying material is red, weakly cemented, fine-grained sandstone to a depth of 20 inches or more.

The Darsil soil is low in natural fertility and organic matter content. It ranges from strongly acid to slightly acid throughout. Where limed, it ranges from strongly acid to neutral. Permeability is rapid, runoff is medium to rapid, and the available water capacity is very low. The root zone is 10 to 20 inches deep and is easily penetrated by plant roots. This soil is easily eroded by wind or water if not protected by adequate plant cover. It has low shrink-swell potential, low corrosion potential to steel, and moderate corrosion potential to concrete.

The Newalla soil makes up about 15 percent of the map unit. Typically, the surface layer is brown fine sandy loam about 4 inches thick. The subsoil is red sandy clay loam to a depth of about 8 inches and red silty clay to a depth of about 42 inches. The underlying material is red, weakly laminated, soft shale to a depth of 80 inches or more.

The Newalla soil is low in natural fertility and organic matter content. It is strongly acid to neutral in the surface layer and upper part of the subsoil and strongly acid to moderately alkaline below that. Permeability is very slow, runoff is rapid, and the available water capacity is medium. The root zone is 40 to 60 inches deep, but the clayey subsoil partially restricts root penetration. This soil is easily eroded by water. It has high shrink-swell potential, high corrosion potential to steel, and moderate corrosion potential to concrete.

Included with this complex in mapping are areas of Derby, Grainola, Harrah, Littleaxe, Lucien, and Pulaski soils. The excessively drained Derby soils are on convex dunes on ridge crests and on valley side slopes. The Grainola soils are on side slopes. The moderately permeable Harrah soils are on narrow foot slopes bordering the drainage channels. The moderately permeable Littleaxe soils are on narrow, very gently sloping ridge crests. The shallow Lucien soils are on shoulders of ridges paralleling the side slopes. The Pulaski soils are on the narrow flood plains. The included soils make up about 15 percent of the map unit, but individual areas are generally less than 5 acres.

This complex has low potential for cropland. The shallow, droughty Darsil soil is not suited to use for cultivated crops. The low fertility and organic matter content and the hazard of erosion of the soils in this complex are the main limitations for use as cropland.

This complex has low potential for hay or tame pasture. The loss of topsoil from erosion, low fertility and organic matter content, restricted root zone, and droughty soils limit production and choice of plants. Bermudagrass and weeping lovegrass, tame pastures, and hay crops respond well to additions of fertilizer that are high in nitrogen. For maximum production of high quality forage, weeds and brush can be controlled by mowing or spraying pastures with herbicides late in spring or early in summer.

This complex has medium potential for rangeland. Native grasses need to be established on clean, firm seedbeds and protected from grazing until plants are well established. Controlling weeds and brush, protecting the range from uncontrolled burning, using rotation grazing, and timely deferment of grazing help to maintain or improve range grasses.

This complex has low potential for most urban uses. Stephenville soil is best suited to urban use. The depth to rock in the Darsil and Stephenville soils is the main limitation for septic tank absorption fields. Increasing the length or size of the septic tank filter field can help to overcome this limitation. The slow permeability, high shrink-swell potential, and high corrosivity for steel of the Newalla soil are limitations for dwellings or commercial development. Bedding concrete foundations and slabs with sand and using high grade concrete and additional reinforcement steel can reduce the limitation of shrinking and swelling. Newalla soil has medium potential for sewage lagoons or pond reservoirs because of the depth to rock. The limitations of these soils for urban uses can be reduced by using specialized design measures and proper installation. Onsite investigations are needed to locate the soil that is best suited to the specified use.

This complex has low to high potential for recreational use. Stephenville soil is best suited to this use. It has slight limitations for camp areas, picnic areas, and paths and trails. Darsil soil has severe limitations for camp and picnic areas and slight limitations for paths and trails because of depth to rock. Newalla soil has moderate limitations for camp and picnic areas because of very slow permeability. It has severe limitations for paths and trails because of the hazard of erosion. The soils in this complex have severe limitations for playgrounds because of steepness of slope.

This complex has medium to low potential for windbreak tree and shrub plantings. The soil depth, low and very low available water capacity, and very slow permeability are the main limitations. Eastern redcedar, osageorange, redbud, Amur honeysuckle, lilac, and skunkbush sumac are suited to these soils. Austrian pine, bur oak, American plum, red mulberry, green ash, and Chinese elm are best suited to Stephenville soil; oriental arborvitae, Rocky Mountain juniper, and Arizona cypress are best suited to Darsil soil; and Austrian pine, Chinese elm, honeylocust, red mulberry, silver maple, and common hackberry are best suited to Newalla soil. Post oak, blackjack oak, and hickory are native trees adapted to the soils of this complex. Many of these native trees are used locally for firewood.

This complex has high to low potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This complex is in capability subclass VIe. Stephenville and Newalla soils are in Sandy Savannah range site, and Darsil soil is in Shallow Savannah range site.

36—Stephenville-Darsil complex, 1 to 5 percent slopes, eroded. This complex consists of eroded areas of moderately deep, well drained Stephenville soil and shallow, excessively drained Darsil soil. The soils of this complex were so intermingled that they could not be separated at the scale selected for mapping. They are in the eastern part of the county. Stephenville soil is mainly on the crown of ridge crests, and Darsil soil is mainly on the shoulders of ridge crests. Individual areas of the Darsil soil are 1/8 acre to 10 acres. In much of the area the present plow layer or surface layer of the soils in this complex has been thinned by erosion and consists of part of the original surface layer mixed with material from the subsoil. The subsoil is exposed in many small rills and shallow gullies in some areas. The mapped areas are elongated and irregular in shape, from 300 to 1,500 feet wide, and 15 to more than 200 acres.

The Stephenville soil makes up about 75 percent of the map unit. Typically, the surface layer is brown fine sandy loam about 7 inches thick. The subsoil is red sandy clay loam to a depth of about 18 inches and red fine sandy loam to a depth of about 24 inches. The underlying material is red, soft, laminated sandstone to a depth of 30 inches or more.

The Stephenville soil is low in natural fertility and organic matter content. The surface layer is medium acid or slightly acid. Where limed, it ranges from medium acid to neutral. The subsoil is strongly acid to slightly acid. Permeability is moderate, runoff is medium, and the available water capacity is low. This soil has good tilth and can be worked throughout a wide range of moisture content. The root zone is 20 to 40 inches deep and is easily penetrated by plant roots. This soil is easily eroded by wind or water if not protected by adequate plant cover. It has low shrink-swell potential and moderate corrosion potential to steel and concrete.

The Darsil soil makes up about 15 percent of the map unit. Typically, the surface layer is brown loamy fine sand about 6 inches thick. Below that is pink loamy fine sand to a depth of about 13 inches. The underlying material is light red, soft, massive sandstone to a depth of 20 inches or more.

The Darsil soil is low in natural fertility and organic matter content. The surface layer is slightly acid or neutral. Where limed, it ranges from slightly acid to mildly alkaline. The subsoil is medium acid to mildly alkaline. Permeability is rapid, runoff is medium, and the available water capacity is very low. This soil has good tilth and can be worked throughout a wide range of moisture content. The root zone is 10 to 20 inches deep and is easily penetrated by plant roots. This soil is easily eroded by wind or water if not protected by adequate plant cover. It has low shrink-swell potential, low corrosion potential to steel, and moderate corrosion potential to concrete.

Included with this complex in mapping are areas of deep, well drained Littleaxe soils that are on broad, very gently sloping, convex ridges. Also included are the deep, moderately well drained Newalla soils on gently sloping, contour bands on ridge crests and soils similar to Darsil soil but are more than 20 inches deep to bedrock and are on dunes of convex ridges. The included soils make up about 10 percent of the map unit.

This complex has low potential for row crops or small grains. Depth to the root zone, low or very low available water capacity, and the low fertility and organic matter content are the main limitations. Erosion is a severe hazard if cultivated crops are grown. Terraces, contour farming, minimum tillage, additions of fertilizer, and the use of crop residue help to control erosion, improve fertility, conserve moisture, and maintain the soil tilth.

This complex has low potential for hay and tame pasture and medium potential for rangeland. The low fertility, low to very low available water capacity, and depth of root zone are limitations that retard plant growth. Hay crops and tame pastures respond well to additions of fertilizer that are high in nitrogen. Overseeding tame pastures with legumes improves soil fertility and quality of forage. Areas of native grasses can be improved by timely weed control, controlling brush, using good grazing practices, and protecting the range from fire.

This complex has medium to low potential for most urban uses. The depth to rock is a moderate to severe limitation for shallow excavations, dwellings, lawns, landscaping, and small commercial buildings. Excessive seepage and the depth to rock are severe limitations for use as septic tank absorption fields, sewage lagoons, and sanitary landfills. Adding suitable, compacted fill material improves the site for septic tank absorption fields and building sites. Pocket gophers can cause considerable damage to lawns and shrubs unless controlled.

This complex has high to low potential for most recreational uses. The Stephenville soil is best suited to recreational use. The Darsil soil has severe limitations for most recreational uses because of the depth to bedrock. Slope is a moderate limitation for developing playgrounds in most areas. The soils of this complex have slight limitations for paths and trails.

This complex has medium to low potential for windbreak tree and shrub plantings. Arizona cypress, eastern redcedar, skunkbush sumac, Amur honeysuckle, oriental arborvitae, osageorange, lilac, Rocky Mountain juniper, and redbud are well suited to these soils. Austrian pine, American plum, Chinese elm, common hackberry, honeylocust, red mulberry, bur oak, and green ash are suited to Stephenville soil. Native trees adapted to this complex are post oak, blackjack oak, and hickory. Many of these trees are used locally for firewood.

This complex has high to low potential for use as habitat for openland or rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This complex is in capability subclass IVe. Stephenville soil is in Sandy Savannah range site, and Darsil soil is in Shallow Savannah range site.

37—Harrah fine sandy loam, 3 to 8 percent slopes, eroded. This deep, well drained, gently sloping to sloping, eroded soil is in the eastern part of the county. It is on concave side slopes and foot slopes of uplands in long, narrow, irregular areas that were previously cultivated and later returned to pasture or range. In much of the area, the present plow layer consists of part of the original surface layer mixed with the subsurface layer and the subsoil. The plow layer is less friable and has poorer tilth than the original surface layer. The mapped areas are 20 to more than 100 acres.

Typically, the surface layer is reddish brown fine sandy loam about 5 inches thick. The subsurface layer, to a depth of about 10 inches, is light reddish brown loamy fine sand. The subsoil is red sandy clay loam to a depth of about 60 inches and light red fine sandy loam to a depth of about 71 inches. The buried layer below is light red sandy clay loam to a depth of 80 inches or more.

Included with this soil in mapping are areas of Derby, Littleaxe, Pulaski, Stephenville, and Tribbey soils. The excessively drained Derby soils are mostly on valley filling north- or east-facing side slopes above the Harrah soil. Littleaxe and Stephenville soils are on upper side slopes. The moderately rapidly permeable, well drained Pulaski soils and the somewhat poorly drained Tribbey soils are on narrow flood plains that entrench the Harrah soil. The included soils make up about 30 percent of this map unit, but individual areas are generally less than 7 acres.

This Harrah soil is low in natural fertility and organic matter content. It is medium acid to neutral in the surface and subsurface layers and strongly acid to neutral in the subsoil. Permeability is moderate, runoff is medium or rapid, and the available water capacity is medium. This soil has fair tilth and can be worked throughout a wide range of moisture content. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil is easily eroded by wind or water if not protected by adequate plant cover. It has low shrink-swell potential and moderate corrosion potential to steel and concrete.

This soil has low potential for row crops or small grains. Low fertility, low organic matter content, excessive slopes, and the hazard of erosion are the main limitations. Minimum tillage, use of crop residue, and cover crops, including grasses and legumes in the cropping system, help to control erosion and improve the tilth, fertility, and organic matter content.

This soil has low potential for hay and tame pasture. Hay crops and tame pastures respond well to additions of fertilizer that are high in nitrogen.

This soil has medium potential for rangeland. Areas that have been reseeded to native grasses can be improved or maintained by proper stocking, rotation grazing, timely deferment of grazing, and restricted use during dry periods to help keep the grass and soil in good condition.

This Harrah soil has high potential for most urban uses. The limitations are slight for sanitary landfills, shallow excavations, dwellings, local roads and streets, lawns, landscaping, and golf fairways. Seepage and slope are limitations for sewage lagoons or pond reservoirs. Permeability is a limitation for septic tank absorption fields. Establishment and maintenance of landscape vegetation is difficult because of droughtiness. Pocket gophers need to be controlled to prevent damage to lawns, shrubs, and gardens.

This soil has high potential for most recreational uses. Steepness of slope is a severe limitation for playgrounds. Water erosion can be excessive in heavily used areas.

This soil has high potential for windbreak tree and shrub plantings. American plum, Arizona cypress, Austrian pine, Amur honeysuckle, lilac, skunkbush sumac, autumn-olive, black locust, bur oak, euonymus, green ash, eastern redcedar, redbud, common hackberry, honeylocust, oriental arborvitae, osageorange, silver maple, ponderosa pine, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, and Chinese elm are suited to this soil.

This soil has high potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Harrah soil is in capability subclass IVe and in Sandy Savannah range site.

38—Asher-Urban land complex, rarely flooded. This complex consists of the deep, moderately well drained Asher soil and Urban land. This soil and Urban land were so intermingled that they could not be separated at the scale selected for mapping. The soils in this complex are in urbanized areas in the western part of Lexington. The Asher soil is subject to rare flooding. It is on nearly level, slightly convex, high flood plains along the South Canadian River. The mapped areas are elongated, about 250 to 1,000 feet in width and 500 to 2,600 feet in length, and about 3 to 50 acres.

The Asher soil is in the unaltered parts of the landscape and makes up about 55 percent of the map unit. Typically, the surface layer is brown silt loam about 13 inches thick. The subsoil is reddish brown silty clay loam to a depth of about 24 inches. The underlying material is reddish brown silt loam to a depth of about 35 inches, yellowish red clay loam to a depth of about 43 inches, reddish yellow very fine sandy loam to a depth of about 77 inches, and reddish yellow loamy fine sand to a depth of about 80 inches or more.

The Asher soil is high in natural fertility and organic matter content. It ranges from slightly acid to moderately alkaline in the surface layer, neutral to moderately alkaline in the subsoil, and moderately alkaline and calcareous in the underlying material. This soil has an apparent high water table from 3 1/2 to 10 feet below the surface most of the year. Permeability and runoff are slow, and the available water capacity is high. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil is highly susceptible to water erosion on slopes that are not protected by plant cover or residue. It has moderate shrink-swell potential, high corrosion potential to steel, and low corrosion potential to concrete. This soil is subject to rare flooding.

Urban land makes up about 40 percent of the map unit. It consists of areas of soils that have been covered or altered by buildings or other urban structures. Typical structures are single family houses, apartment dwellings, nursing homes, churches, small commercial buildings, parking lots of less than 2 acres, streets, and highways.

Included with this complex in mapping are Brewless soils. These moderately well drained, slowly permeable soils are in small, isolated, nearly level areas that tend to collect water following heavy rains. The included soils make up about 5 percent of the map unit.

This complex is not suited to cultivated crops, hay, tame pasture, or rangeland. Areas of Asher soil are too small for operation of most farm equipment and for livestock use.

This complex has low potential for home site or commercial building site development. It has high potential for lawns, shrubs, and gardens. The hazard of flooding is a severe limitation for existing or planned building site development. Dikes constructed for flood prevention or buildings and roadways constructed on elevated fill materials can reduce or prevent flooding. Shrinking and swelling can be reduced using special design measures. The use of high grade reinforced concrete and pier-and-beam construction help to prevent building foundations and footings from cracking. The corrosion hazard to steel can be overcome by installing coated or noncorrosive materials, such as plastic or copper tubing and galvanized pipe. Calcareous sandy soil materials make excellent bedding or cover material to prevent corrosion and shrinking and swelling. Soil erosion on slopes can be reduced by mulching, growing temporary cover crops, or solid sodding with adapted grasses.

This complex has high potential for trees and shrubs. American plum, American sycamore, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, black walnut, bur oak, Chinese elm, common hackberry, eastern cottonwood, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, pecan, ponderosa pine, red mulberry, redbud, Rocky Mountain juniper, Russian-olive, Scotch pine, and silver maple are well suited.

This complex is not assigned to a capability subclass or range site.

39—Asher silt loam, clayey substratum, rarely flooded. This deep, moderately well drained, nearly level soil is on high flood plains along the South Canadian River. It is on smooth or slightly convex relief that has slopes generally less than 2 percent. This soil is subject to rare flooding and has an apparent high water table from 3 1/2 to 10 feet below the surface. The mapped areas are long and narrow, from 200 to 1,500 feet wide and 1,500 to 5,000 feet long, and 5 to 300 acres.

Typically, the surface layer is dark grayish brown and brown silt loam about 11 inches thick. The subsoil is brown silty clay loam and silt loam to a depth of about 30 inches. The underlying material is light reddish brown very fine sandy loam to a depth of about 44 inches, reddish brown, mottled silty clay to a depth of about 69 inches, and to a depth of about 80 inches is light reddish brown loamy fine sand.

Included with this soil in mapping are areas of Brewless, Keokuk, and Lomill soils and areas of Asher soils that have light colored overwash materials. The moderately well drained Brewless soils are in slightly lower positions on flood plains than Asher soil. The well drained Keokuk soils are in slightly higher positions on flood plains than Asher soil. The somewhat poorly drained Lomill soils are in lower positions on concave flood plains. The included soils make up about 20 percent of the map unit, but individual areas are generally less than 3 acres.

This Asher soil is high in natural fertility and organic matter content. It is slightly acid to moderately alkaline in the surface layer, neutral to moderately alkaline in the subsoil, and moderately alkaline in the underlying material. Lime is between 13 and 34 inches below the surface in most areas. This soil is slowly permeable, and the available water capacity is high. Runoff is slow or medium. This soil is friable and is easily tilled. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has moderate shrink-swell potential, high corrosion potential to steel, and low corrosion potential to concrete.

This soil has high potential for row crops, small grains, hay, tame pasture, and rangeland. Diversions and dikes can be installed to help prevent flooding. The tilth and soil structure can be maintained or improved by minimum tillage, seeding legumes, and returning crop residue to the soil. The quality of hay and tame pastures and the soil fertility and organic matter content can be maintained or improved by adding fertilizer or manure, or by overseeding with legumes. Controlling grazing and preventing fires help to maintain native grasses.

This Asher soil has low potential for most urban uses. The hazard of flooding is a severe limitation that can be overcome only by major flood control measures. Corrosion can be reduced by coating steel or by substituting plastic or copper pipe. This soil has medium potential for use as cover material for landfills or as topsoil in landscaping.

This soil has high potential for picnic areas, playgrounds, and paths and trails. The potential for camp areas is low because of the hazard of flooding.

This soil has high potential for windbreak tree and shrub plantings. American plum, American sycamore, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern cottonwood, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil. Pecan and black walnut are native trees adapted to this soil.

This soil has high potential for use as habitat for openland and rangeland wildlife. It has medium potential for use as habitat for wetland wildlife.

This soil is in capability class I and in Loamy Bottomland range site.

40—Asher silty clay loam, clayey substratum, rarely flooded. This deep, moderately well drained, nearly level soil is on high flood plains along the South Canadian River. Slopes are smooth to slightly concave and are 1 percent or less. This soil is subject to rare flooding and has an apparent high water table between 3 1/2 and 10 feet below the surface. The mapped areas are elongated and parallel to the river, range from 100 to 1,800 feet wide and 1,000 to 3,000 feet long, and are 10 to 400 acres.

Typically, the surface layer is dark grayish brown silty clay loam about 8 inches thick. The subsoil is brown silty clay loam to a depth of about 35 inches. The underlying material is light brown very fine sandy loam to a depth of about 50 inches and reddish brown silty clay to a depth of about 80 inches.

Included with this soil in mapping are areas of Brewless, Canadian, and Lomill soils and areas of Asher soils that are silt loam and are subject to rare flooding. The moderately well drained Brewless soils are at slightly lower elevations than Asher soil. The well drained, moderately rapidly permeable Canadian soils are in slightly higher positions on flood plains than Asher soil. The somewhat poorly drained, very slowly permeable Lomill soils are in lower positions on flood plains than Asher soil. The included soils make up about 15 percent of the map unit, but individual areas are generally less than 5 acres.

This Asher soil is high in natural fertility and organic matter content. It is slightly acid to moderately alkaline in the surface layer, neutral to moderately alkaline in the upper part of the subsoil, and moderately alkaline in the lower part of the subsoil and the underlying material. Lime is from 22 to 34 inches below the surface. Permeability and runoff are slow, and the available water capacity is high. This soil is friable and is easily tilled. Plowpans form easily if tilled when too wet. The root zone is more than 60 inches deep and is readily penetrated by plant roots. This soil has moderate shrink-swell potential, high corrosion potential to steel, and low corrosion potential to concrete.

This soil has high potential for row crops, small grains, hay, tame pasture, and rangeland. It is one of the most productive soils in the county and is in areas where irrigation water is often available. The tilth, intake rate, fertility, and organic matter content can be maintained by minimum tillage, crop rotations, and by returning crop residue to the soil. Refraining from tillage when the soil is too wet and varying the depth of tillage help to prevent plowpans. The quality of tame pastures can be improved by overseeding with legumes and adding fertilizers. Grass can be improved by controlling grazing and preventing fires.

This Asher soil has low potential for most urban uses. The hazard of flooding is a severe limitation that can be overcome only by major flood control measures. Seepage and wetness are severe limitations for trench type sanitary landfills. Corrosion to steel can be reduced by coating with protective material or by substituting copper or plastic pipe.

This soil has low potential for camp areas because of the hazard of flooding. It has high potential for playgrounds, picnic areas, and paths and trails.

This soil has high potential for windbreak tree and shrub plantings. American plum, American sycamore, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern cottonwood, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil. Pecan and black walnut are native trees adapted to this soil.

This soil has high potential for use as habitat for openland and rangeland wildlife. It has medium potential for use as habitat for wetland wildlife.

This soil is in capability class I and in Loamy Bottomland range site.

41—Asher Variant silty clay loam, saline, occasionally flooded. This deep, somewhat poorly drained, nearly level soil is on low flood plains along the South Canadian River. It has an apparent high water table within 1 1/2 to 3 1/2 feet of the surface from fall to spring and is subject to occasional flooding for very brief to brief periods during spring and early in summer. Slopes are smooth to slightly concave and are less than 2 percent. The mapped areas are elongated, from 100 to 900 feet wide and 1,000 to 9,000 feet long, and are 15 to 100 acres.

Typically, the surface layer is brown silty clay loam about 11 inches thick. The next layer, to a depth of 21 inches, is reddish brown very fine sandy loam. The next layer is reddish brown and light reddish brown silty clay loam to a depth of 36 inches. The next layer is pink fine sand to a depth of about 51 inches. The next layer is light reddish brown, mottled very fine sandy loam to a depth of 78 inches.

Included with this soil in mapping are Brewless and Asher soils and some areas of soils that have a high water table that ranges up to 8 feet below the surface. The included soils make up about 5 percent of the map unit, but individual areas are generally less than 3 acres.

This Asher Variant soil is high in natural fertility and organic matter content. It is moderately alkaline and calcareous throughout. Permeability and runoff are slow, and the available water capacity is high. This soil is easily compacted when moist. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has moderate shrink-swell potential, high corrosion potential to steel, and low corrosion potential to concrete.

This soil has medium potential for row crops and small grains. It has high potential for rangeland, hay, and tame pasture. The potential for legumes is low. This soil is best suited to tame pasture. The high water table, slow surface runoff, salinity, and occasional flooding are limitations to crop and hay production. In areas where saline spots are prominent, seed germination and crop yields are significantly lower. Surface drainage can be improved by land smoothing. Diversions and dikes can be installed to help prevent flooding. The tilth, intake rate, fertility, and organic matter content can be maintained or improved by minimum tillage and by returning crop residue to the soil. Refraining from tillage or from pasturing when the soil is wet improves the tilth and reduces compaction. The salinity can be improved by installing subsurface drainage, deep chiseling, incorporating large amounts of manure or crop residue, heavy applications of gypsum, and leaching.

This Asher Variant soil has low potential for urban use. Wetness, excess salts, slow permeability, and the hazard of flooding are severe limitations that are difficult to overcome. The hazard of flooding can be reduced by using major flood control measures. The salts are highly corrosive to all metals. The corrosion hazard can be reduced by using plastic or tile pipe where feasible.

This soil has low potential for most recreational uses. Excess salts is a severe limitation for playgrounds and picnic areas. Wetness is a moderate limitation for paths and trails. Excess salts and the hazard of flooding are severe limitations for camp areas.

This soil has low potential for windbreak tree and shrub plantings. Lilac, Amur honeysuckle, skunkbush sumac, oriental arborvitae, Rocky Mountain juniper, eastern redcedar, Arizona cypress, osageorange, and redbud are suited to this soil.

This soil has medium potential for use as habitat for openland and wetland wildlife. It has low potential for use as habitat for rangeland wildlife.

This Asher Variant soil is in capability subclass IVs and in Subirrigated Saline range site.

42—Canadian fine sandy loam, 0 to 1 percent slopes, rarely flooded. This deep, well drained, nearly level soil is on high flood plains along the South Canadian River. Slopes are smooth. This soil is subject to rare flooding. The mapped areas are elongated, 400 to 2,000 feet wide and 1,500 to 5,000 feet long, and range from 10 to 150 acres.

Typically, the surface layer is brown fine sandy loam to a depth of about 19 inches. The subsoil is brown fine sandy loam to a depth of about 32 inches. The underlying material is brown or reddish yellow fine sandy loam to a depth of 84 inches or more.

Included with this soil in mapping are Asher soils and soils similar to Canadian soil but having a thicker surface layer and coarser textured subsoil. The moderately well drained Asher soils are in slightly lower positions on the landscape than Canadian soil. The included soils make up about 20 percent of the map unit and are generally less than 5 acres.

This Canadian soil is high in natural fertility and organic matter content. It is medium acid to neutral in the surface layer and slightly acid to moderately alkaline in the subsoil and underlying material. Permeability is moderately rapid, runoff is slow, and the available water capacity is medium. A high water table is 6 to 10 feet below the surface much of the year. This soil has good tilth and can be worked throughout a wide range of moisture content. Wind erosion is a hazard during extended dry periods. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has low shrink-swell potential and low corrosion potential to steel and concrete.

This soil has high potential for locally adapted crops, hay, tame pasture, and rangeland. It is one of the better soils for agricultural use in the county. Irrigation water is generally available for supplemental use. The tilth, natural fertility, and organic matter content can be maintained by minimum tillage and returning crop residue to the soil in cultivated areas and by seeding legumes and adding fertilizer as needed for tame pasture and hay. All grasses can be maintained by controlling grazing and preventing fires.

This soil has low potential for most urban uses. The hazard of flooding is a limitation for dwellings, commercial buildings, and roads and streets. Flooding can be prevented only by major flood control measures. Seepage is a severe limitation for sewage lagoons and sanitary landfills. This soil has high potential for use as cover material for sanitary landfills, in roadfill, and as a source of topsoil.

This soil has high potential for most recreational uses. The hazard of flooding is a limitation for camp areas.

This soil has high potential for windbreak tree and shrub plantings. Trees and shrubs best suited to this soil are American plum, American sycamore, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern cottonwood, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac.

This soil has high potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This soil is in capability class I and in Loamy Bottomland range site.

49—Doolin-Urban land-Pawhuska complex, 0 to 3 percent slopes. This complex consists of the deep, moderately well drained Doolin and Pawhuska soils and Urban land. The soils and Urban land of this complex were so intermingled that they could not be separated at the scale selected for mapping. This complex is the most extensive of the urban land complexes mapped in Cleveland County. It extends throughout the city of Moore, the northern and eastern sections of Norman, and the southwestern part of Oklahoma City. The soils of this complex are on nearly level to very gently sloping uplands. Doolin soil is in smooth, slightly convex, unaltered parts of the landscape. The saline-alkali Pawhuska soil is in the slightly depressional, unaltered parts of the landscape. The mapped areas are broad, 500 to 10,000 feet wide and 1,000 to 15,000 feet long, and range from about 40 to more than 1,000 acres.

The Doolin soil makes up about 40 percent of the map unit. Typically, the surface layer is grayish brown silt loam about 9 inches thick. The subsurface layer is light brownish gray silt loam to a depth of about 12 inches. The subsoil is dark grayish brown and grayish brown silty clay to a depth of about 40 inches and brown, reddish brown, and yellowish red, mottled silty clay to a depth of 80 inches.

The Doolin soil is high in natural fertility and organic matter content. It ranges from medium acid to mildly alkaline in the surface and subsurface layers, neutral to moderately alkaline in the upper and middle parts of the subsoil, and moderately alkaline and calcareous below that. Lime is within a depth of 24 to 40 inches of the surface. Permeability is very slow, runoff is slow to medium, and the available water capacity is medium. The surface layer is friable, but it is easily compacted when soil is wet. The root zone is more than 60 inches deep, but plant roots are somewhat restricted because of the dense subsoil and presence of soluble salts. This soil is highly susceptible to water erosion in sloping areas that are not protected by plant cover. It has high shrink-swell potential, high corrosion potential to steel, and moderate corrosion potential to concrete.

Urban land makes up about 40 percent of the map unit. It consists of areas of soils that have been covered with buildings or other urban structures. Single family housing, apartment dwellings, commercial buildings, schools, churches, hospitals, airports, golf courses, parking lots of less than 10 acres, streets, driveways, sidewalks, cemeteries, and highways are typical structures.

The Pawhuska soil makes up about 15 percent of the map unit. Typically, the surface layer is grayish brown silt loam about 6 inches thick. The subsoil is silty clay. It is dark grayish brown to a depth of about 17 inches, brown with grayish brown mottles to a depth of 51 inches, and coarsely mottled strong brown, grayish brown, and very dark grayish brown to a depth of 72 inches or more.

The Pawhuska soil is low in natural fertility and organic matter content. It is slightly acid to moderately alkaline in the surface layer, neutral to moderately alkaline in the upper part of the subsoil, and moderately alkaline in the middle and lower parts. The lower part of the subsoil contains lime in most places. Permeability is very slow, runoff is slow, and the available water capacity is low. The subsoil has high salinity and sodium. The root zone is more than 60 inches deep, but root penetration is somewhat restricted because of the dense subsoil. The high salinity and high sodium content of the subsoil restricts most root development to within 3 to 4 feet of the surface. Pawhuska soil is easily compacted when moist. It is highly susceptible to water erosion and slakes easily when wet. Piping is common in cut and fill areas. This soil has high shrink-swell potential and high corrosion potential to steel and concrete.

Included with this complex in mapping are areas of Bethany, Huska, and Renfrow soils. The well drained, slowly permeable Bethany soils are on higher, better drained parts of the landscape than the soils of this complex. The Huska soil is in similar position on the landscape as Pawhuska soil but does not have a deep root zone. The well drained Renfrow soils are on short slopes and in higher positions on the landscape than the soils of this complex. The included soils make up about 5 percent of the map unit.

This complex is not suited to cultivated crops, hay, tame pasture, or rangeland. Areas of Doolin and Pawhuska soils are too small for operation of most farm equipment and for livestock use.

This complex has low potential for most urban uses. The high shrink-swell potential, very slow permeability, high sodium and salt content, high corrosion hazard, high erosion hazard, and low strength are severe limitations that are difficult to overcome. Doolin soil is better suited to urban use because of the lower toxicity to plants. Installing pier-and-beam type reinforced concrete foundations; bedding slab floors, sidewalks, and driveways with sand; and using high grade concrete mix reduce cracking in concrete structures caused by shrinking and swelling. The very slow permeability and toxicity can be improved by excavating undesirable soil materials and replacing or mixing these soils with higher quality soils. Heavy applications of gypsum improve the soil structure. This improves the intake of water and the permeability of the soil. The corrosion hazard to steel can be overcome by installing coated steel, noncorrosive copper tubing, or plastic pipe. Calcareous, sandy soils make excellent bedding or cover materials to prevent corrosion and shrink-swell problems. The hazard of erosion can be reduced by planting temporary cover of a rye or wheat, using plant residue for mulch, or by solid sodding with perennial grasses.

This complex has low potential for windbreak tree and shrub plantings. The high sodium and salt content and the clay content of the subsoil are severe limitations that restrict root growth and limit the kind of plants that will survive. Amur honeysuckle, Arizona cypress, eastern redcedar, lilac, oriental arborvitae, osageorange, redbud, Rocky Mountain juniper, and skunkbush sumac are suited to these soils.

This complex is not assigned to a capability subclass or range site.

50—Doolin silt loam, 0 to 1 percent slopes. This deep, moderately well drained, nearly level soil is on broad, smooth upland flats in the western part of the county. Slopes are mostly less than 1 percent. The mapped areas are long and irregular in shape and are 30 to 500 acres.

Typically, the surface layer is grayish brown silt loam about 9 inches thick. The subsurface layer is pale brown silt loam to a depth of about 11 inches. The subsoil is dark grayish brown silty clay to a depth of about 25 inches; grayish brown silty clay loam to a depth of about 36 inches; brown, mottled silty clay loam to a depth of about 49 inches; coarsely mottled brown, yellowish red, and grayish brown silty clay loam to a depth of about 58 inches; yellowish red, mottled silty clay to a depth of about 76 inches; and red, mottled silty clay to a depth of 80 inches or more.

Included with this soil in mapping are areas of soils similar to Doolin soil but not having mottles in the subsoil, soils similar to Doolin soil but having bedrock at a depth of 40 to 60 inches, and Bethany and Pawhuska soils. The well drained Bethany soils are in slightly higher positions on the landscape than Doolin soil, and the very slowly permeable Pawhuska soils are in slightly concave, rounded areas. The included soils make up about 15 percent of the map unit, but separate areas of each soil are generally less than 3 acres.

This Doolin soil is high in natural fertility and organic matter content. It is medium acid to neutral in the surface and subsurface layers, neutral to moderately alkaline in the upper part of the subsoil, and moderately alkaline in the lower part. Lime is at a depth of 24 to 40 inches. Permeability is very slow, runoff is slow, and the available water capacity is medium. The surface layer is friable and easily tilled, but it is easily compacted by tilling or pasturing when it is too wet. The root zone is more than 60 inches deep, but root penetration is somewhat restricted because of the dense subsoil. The subsoil has high shrink-swell potential. This soil has high corrosion potential to steel and medium corrosion potential to concrete.

This soil has high potential for row crops and small grains (fig. 9). The high sodium content and dense clayey subsoil cause plants that have deep root systems to grow slower and mature earlier. The fertility, organic matter content, and tilth can be maintained or improved by minimum tillage, by returning crop residue, and by adding fertilizer regularly. Tilling the soil under optimum moisture conditions and crop rotations that include grasses and legumes in the cropping system reduce compaction, improve tilth, and increase the intake and percolation. Deep chiseling when the subsoil is dry improves water, air, and root penetration.

This soil has medium potential for hay, tame pasture, and native rangeland. Forage yields are lower because of the high sodium content and dense clayey subsoil. Overseeding pastures with legumes and deep chiseling improve intake and percolation. Rotation grazing and removing livestock during wet periods reduce compaction and improve plant vigor. The quality of native grasses can be maintained or improved by controlling weeds, using suitable grazing practices, and protecting the range from fire.

This Doolin soil has low potential for most urban uses. The high shrink-swell potential, excess sodium, very slow permeability, and clayey texture of the subsoil are severe limitations for most uses. Concrete failures can be reduced by properly bedding with gravel or sand, using higher strength concrete mix, adding additional reinforcement steel, and using pier-and-beam type of construction. Topsoil needs to be stockpiled for later use in landscaping. This provides a thicker, less sodium contaminated media for plant growth. Septic tank absorption fields can be improved by extending length of lateral lines, bedding lateral lines in thick gravel or sand beds, or by excavating the entire area and backfilling with more permeable soils. The corrosion hazard to steel can be overcome by coating with protective materials or by substituting with copper or plastic tubing. Corrosion of concrete can be reduced by removing the soil and backfilling with desirable soils. This soil has high potential for sewage lagoons and farm pond reservoirs.

This soil has low potential for recreational use. Excess sodium and the hazard of erosion are severe limitations.

This soil has low potential for windbreak tree and shrub plantings. The clayey, very slowly permeable subsoil retards movement of air and water and root development. Amur honeysuckle, oriental arborvitae, redbud, Arizona cypress, skunkbush sumac, lilac, osageorange, eastern redcedar, and Rocky Mountain juniper are best adapted to this soil.

This soil has medium potential for use as habitat for openland wildlife. It has low potential for use as habitat for wetland and rangeland wildlife.

This soil is in capability subclass IIs and in Claypan Prairie range site.

51—Doolin-Pawhuska complex, 0 to 3 percent slopes. This complex consists of the deep, moderately well drained Doolin and Pawhuska soils. The soils in this complex were so intermingled that they could not be separated at the scale selected for mapping. These nearly level to very gently sloping soils are mainly on upland flats in the western part of the county. Doolin soil is in slightly convex areas, and the Pawhuska soil is in rounded, slightly concave areas. Individual areas of the Pawhuska soil are 1/8 acre to 5 acres. The Doolin soil surrounds the Pawhuska soil. The mapped areas are elongated and irregular in shape and range from 30 to 200 acres.

The Doolin soil makes up about 70 percent of the map unit. Typically, the surface layer is grayish brown silt loam about 11 inches thick. The subsurface layer is light brownish gray silt loam to a depth of about 13 inches. The subsoil is silty clay and extends to a depth of 80 inches or more. It is dark gray, dark grayish brown, and very dark grayish brown in the upper part; coarsely mottled grayish brown, gray, and reddish brown in the middle part; and reddish brown and red in the lower part.

The Doolin soil is high in natural fertility and organic matter content. It is high in soluble salts. This soil is strongly acid to mildly alkaline in the surface and subsurface layers, slightly acid to moderately alkaline in the upper part of the subsoil, and neutral in the lower part. Lime is within a depth of 24 to 40 inches of the surface. Permeability is very slow, runoff is slow or

Figure 9.—Dryland cotton on Doolin silt loam, 0 to 1 percent slopes.

medium, and the available water capacity is medium. The surface layer is friable and easily tilled, but it is easily compacted if tilled or pastured when too wet. The subsoil has high shrink-swell potential. The root zone is more than 60 inches deep, but root penetration is somewhat restricted because of the high clay content and presence of soluble salts in the subsoil. Doolin soil has high corrosion potential to steel and medium corrosion potential to concrete.

The Pawhuska soil makes up about 15 percent of the map unit. Typically, the surface layer is grayish brown silt loam about 10 inches thick. The subsoil is silty clay and extends to a depth of 80 or more inches. It is dark grayish brown, grayish brown, and brown in the upper part and coarsely mottled brown, yellowish red, and dark gray in the middle part. The lower part is yellowish red and reddish brown and is mottled in shades of brown.

Pawhuska soil is low in natural fertility and organic matter content. It is high in soluble salts. This soil is slightly acid to moderately alkaline in the surface layer, neutral to moderately alkaline in the upper part of the subsoil, and moderately alkaline in the lower part of the subsoil. Lime is within a depth of 15 to 30 inches of the surface. Permeability is very slow, runoff is slow or medium, and the available water capacity is low. This soil is easily compacted when moist. It slakes and erodes easily when wet and crusts over when dry. The root zone is more than 60 inches deep, but plant root development is somewhat restricted because of the high clay content and presence of soluble salts in the subsoil. This soil has high shrink-swell potential and high corrosion potential to steel and concrete.

Included with this complex in mapping are small areas of Bethany and Renfrow soils. Bethany and Renfrow soils are well drained and are intermingled with Doolin soils. The included soils make up about 15 percent of the map unit, but individual areas of the soils are generally less than 3 acres.

This complex has medium potential for row crops, small grains, and native rangeland. It has low potential for hay and tame pasture. The very slow permeability, high clay content, and high content of soluble salts are limitations that retard plant growth. Plants that have deep root systems are slow growing and mature earlier. The fertility, organic matter content, and tilth can be improved by minimum tillage, returning crop residue to the soil, and adding fertilizer. Tilling or deep chiseling under optimum moisture conditions and using crop rotations that include grasses and legumes in the cropping system reduce compaction, improve tilth, and increase the intake rate and percolation. Heavy applications of gypsum and organic materials, such as manure, improve tilth, reduce crusting, and increase the intake rate. Rotation grazing and removing livestock during wet periods reduce compaction and improve plant vigor. The quality of native grasses can be maintained or improved by controlling weeds and using suitable grazing practices.

This complex has low potential for most urban uses. The high shrink-swell potential, excess sodium, excess salts, clayey subsoil, corrosivity, and very slow permeability are severe limitations that are difficult to overcome. High grade concrete mix that has adequate reinforcement steel and is properly bedded over sand reduces cracking in foundations, slabs, and walls caused by shrinking and swelling. Corrosion of concrete can be reduced by using high grade concrete mix. Bedding septic tank lines with gravel and sand, installing more laterals of greater length, or substituting with a sewage lagoon reduce the effect of very slow permeability. Installing corrosion resistant utility lines provides protection against soluble salts in these soils. Topsoil needs to be stockpiled for later use in landscaping. Shrubs, grasses, and trees used in landscaping need to be adapted to these droughty, clayey soils. This complex has high potential for pond reservoirs and sewage lagoons.

This complex has low potential for most recreational uses. Excess sodium, excess salts, and the severe hazard of erosion are limitations that are difficult to overcome.

This complex has low potential for windbreak tree and shrub plantings. Amur honeysuckle, oriental arborvitae, redbud, Arizona cypress, skunkbush sumac, lilac, Rocky Mountain juniper, osageorange, and eastern redcedar are adapted to these soils. Soil drainage, the clayey subsoil, and soluble salts are severe limitations for tree and shrub plantings.

The Doolin soil has medium potential for use as habitat for openland wildlife and low potential for use as habitat for rangeland and wetland wildlife. The Pawhuska soil has low potential for use as habitat for all wildlife.

This complex is in capability subclass IVs. Doolin soil is in Claypan Prairie range site, and Pawhuska soil is in Shallow Claypan range site.

52—Bethany-Pawhuska complex, 0 to 3 percent slopes. This complex consists of the deep, well drained Bethany soil and deep, moderately well drained Pawhuska soil. The soils of this complex were so intermingled that they could not be separated at the scale selected for mapping. These nearly level to very gently sloping soils are mainly on ridge crests on broad upland flats in the western and central part of the county. Bethany soil is in convex, sloping parts of the landscape, and Pawhuska soil is in slightly concave, somewhat rounded or elongated parts. Individual areas of the Pawhuska soil are 1/8 acre to 5 acres. The Bethany soil surrounds the Pawhuska soil. The mapped areas are long and irregular in shape and range from 20 to 100 acres.

The Bethany soil makes up about 60 percent of the map unit. Typically, the surface layer is grayish brown to dark grayish brown silt loam about 12 inches thick. The subsoil is brown silty clay loam to a depth of about 27 inches; brown, mottled silty clay to a depth of about 43 inches; and mottled brownish, reddish, and yellowish silty clay loam and clay loam to a depth of about 80 inches.

The Bethany soil is high in natural fertility and organic matter content. It is slightly acid or neutral in the surface layer. The upper part of the subsoil is neutral or mildly alkaline, and the lower part is mildly alkaline or moderately alkaline. Permeability is slow, runoff is medium, and the available water capacity is high. This soil is easily tilled, but it is easily compacted if tilled or grazed when too wet. The lower part of subsoil has high shrink-swell potential. This soil has high corrosion potential to steel and low corrosion potential to concrete. The root zone is more than 60 inches deep, but plant root penetration is difficult in the subsoil.

The Pawhuska soil makes up about 20 percent of the map unit. Typically, the surface layer is brown silt loam about 9 inches thick. The subsoil is silty clay and extends to a depth of 84 inches or more. It is grayish brown or brown in the upper part, coarsely mottled in the middle part, and red to reddish brown and mottled in the lower part.

The Pawhuska soil is low in natural fertility and organic matter content. It is slightly acid or neutral in the surface layer, neutral to moderately alkaline in the upper part of the subsoil, and moderately alkaline in the lower part. Lime is within a depth of 20 to 35 inches of the surface. Soluble salts are in the middle part of the subsoil in most areas. Permeability is very slow, runoff is slow or medium, and the available water capacity is low. This soil has high shrink-swell potential and high corrosion potential to steel and concrete. It is easily compacted. This soil slakes and erodes easily when wet and crusts over when dry. The root zone is more than 60 inches deep, but plant root development is somewhat restricted because of the high clay content and presence of soluble salts in the subsoil.

Included with this complex in mapping are areas of Doolin and Renfrow soils. The moderately well drained Doolin soils are dominant and are intermingled with Bethany soil. A few areas of the well drained Renfrow soils are intermingled with Bethany soil. The included soils make up about 20 percent of the map unit, but individual areas of the soils are generally less than 3 acres.

This complex has medium potential for row crops and small grains. Plant growth is restricted somewhat in the Pawhuska soil because of the high clay content, very slow permeability, and content of soluble salts in the subsoil. The fertility, tilth, and organic matter content can be maintained or improved by minimum tillage, returning crop residue to the soil, and adding fertilizer. Tilling under optimum moisture conditions and using crop rotations that include grasses and legumes in the cropping system reduce compaction and crusting and improve tilth. Contour farming and use of crop residue reduce runoff and protect the soils from erosion.

The complex has medium potential for hay, tame pasture, and native rangeland. Forage yields are below normal because the clayey, saline, moderately well drained, very slowly permeable subsoil of the Pawhuska soil restricts root growth. In wet periods, a perched high water table drowns plants. In dry periods, the clayey subsoil is droughty. Removing livestock during wet periods and rotation grazing reduce compaction and improve plant vigor.

This complex has low potential for most urban uses. The high shrink-swell potential, clayey subsoil, excess sodium, excess salts. corrosivity, and slow permeability are severe limitations that are expensive to overcome. High grade concrete mix that has adequate reinforcement steel properly bedded over sand helps to reduce cracking in foundations, slabs, and walls caused by shrinking and swelling. Increasing the size of the absorption field reduces the effect of slow permeability. The corrosion hazard can be reduced by special design or by use of corrosion resistant material. Shrubs, grasses, and trees used in landscaping need to be adapted to these soils. Onsite investigation is needed to locate the most desirable building site.

This complex has high potential for farm pond reservoirs, sewage lagoons, and area type landfills. Bethany soil has moderate limitations and Pawhuska soil has severe limitations for use as fill materials for pond embankments. The clayey subsoil is hard to pack and is high in sodium and salt content.

This complex has low to high potential for recreational use. The high sodium and salt content of the Pawhuska soil and the hazard of erosion for both soils are severe limitations for all recreational uses. Bethany soil is best suited to camp and picnic areas.

This complex has low potential for windbreak tree and shrub plantings. The clayey subsoil, low available water capacity of the Pawhuska soil, and soil drainage are severe limitations. Eastern redcedar, lilac, Amur honeysuckle, Arizona cypress, oriental arborvitae, skunkbush sumac, osageorange, redbud, and Rocky Mountain juniper are suited to these soils. Austrian pine, bur oak, common hackberry, euonymus, ponderosa pine, red mulberry, Russian-olive, honeylocust, silver maple, and Chinese elm are suited to Bethany soil.

Bethany soil has high potential for use as habitat for openland wildlife, low potential for wetland wildlife, and medium potential for rangeland wildlife. Pawhuska soil has low potential for use as habitat for all wildlife.

This complex is in capability subclass IIIs. Bethany soil is in Loamy Prairie range site, and Pawhuska soil is in Shallow Claypan range site.

53—Doolin-Pawhuska complex, 0 to 3 percent slopes, eroded. This complex consists of eroded areas of deep, moderately well drained Doolin and Pawhuska soils. The soils of this complex were so intermingled that they could not be separated at the scale selected for mapping. Over much of the area, the present plow layer consists of part of the original surface layer mixed with the subsurface layer and the subsoil. This plow layer is less friable and has poorer tilth than the original surface layer. The soils of this complex are on broad, nearly level to very gently sloping upland flats in the western part of the county. Doolin soil is in slightly convex areas, and Pawhuska soil is in rounded, slightly concave areas. Individual areas of Pawhuska soil are 1/8 acre to 5 acres. The Doolin soil surrounds the Pawhuska soil. The mapped areas are long and irregular in shape and range from 10 to more than 400 acres.

The Doolin soil makes up about 70 percent of the map unit. Typically, the surface layer is brown silt loam 8 inches thick. The subsoil is dark grayish brown and grayish brown silty clay to a depth of about 51 inches, coarsely mottled light brownish gray and brownish yellow silty clay to a depth of about 76 inches, and mottled reddish yellow silty clay loam to a depth of 80 inches or more.

The Doolin soil is medium in natural fertility and organic matter content. It is high in soluble salts. This soil is medium acid to mildly alkaline in the surface layer, neutral to moderately alkaline in the upper part of the subsoil, and moderately alkaline in the lower part. Lime is within a depth of 24 to 40 inches of the surface. Permeability is very slow, runoff is slow or medium, and the available water capacity is medium. The surface layer is friable and easily tilled, but it is easily compacted if tilled or pastured when too wet. The subsoil has high shrink-swell capacity. The root zone is more than 60 inches deep, but plant root penetration is somewhat restricted because of the high clay content and soluble salts in the subsoil. Doolin soil has high potential for corrosion to steel and medium potential for corrosion to concrete.

The Pawhuska soil makes up about 15 percent of the map unit. Typically, the surface layer is a brown silt loam about 8 inches thick. The subsoil is dark brown silty clay to a depth of about 15 inches, brown silty clay to a depth of about 44 inches, and coarsely mottled brown, yellowish brown, and light yellowish brown silty clay loam to a depth of 80 inches or more.

The Pawhuska soil is low in natural fertility and organic matter content. It is high in soluble salts. This soil is slightly acid to moderately alkaline in the surface layer, neutral to moderately alkaline in the upper part of the subsoil, and moderately alkaline in the lower part. Lime is within a depth of 15 to 30 inches of the surface. Permeability is very slow, runoff is slow or medium, and the available water capacity is low. This soil is easily compacted when moist. It slakes and erodes easily when wet and crusts over when dry. The root zone is more than 60 inches deep, but plant root development is somewhat restricted because of the high clay content and presence of soluble salts in the subsoil. Pawhuska soil has high shrink-swell potential and high corrosion potential to steel and concrete.

Included with this complex in mapping are small areas of Bethany and Renfrow soils. Bethany and Renfrow soils are well drained and are intermingled with the Doolin soil. The included soils make up about 15 percent of the map unit, but individual areas of the soils are generally less than 3 acres.

This complex has low potential for row crops, small grains, hay, tame pasture, or native range. If cultivated, water erosion is a severe hazard. The very slow permeability, high clay content, and high content of soluble salts retard plant growth. Plants that have deep root systems are slow growing and mature earlier. The fertility, organic matter content, and tilth can be improved by minimum tillage, returning crop residue to the soil, and adding fertilizer. Tilling or deep chiseling these soils under optimum moisture conditions and using crop rotations that include grasses and legumes in the cropping system help to reduce compaction, improve tilth, and increase the intake rate and percolation. Heavy applications of gypsum and organic material such as manure improve tilth, reduce crusting, and increase the intake rate. Rotation grazing and removing livestock during wet periods reduce compaction and improve plant vigor. Good seedbed preparation and weed control are needed to establish tame pastures or native grass plantings.

This complex has low potential for most urban uses. The high shrink-swell potential, excess sodium, excess salts, clayey subsoil, corrosivity, and very slow permeability are severe limitations that are difficult and expensive to overcome. Good design and proper installation reduce construction failures. High grade concrete mix that has adequate reinforcement steel properly bedded over sand reduces cracking in foundations, slabs, and walls caused by shrinking and swelling. Corrosivity of concrete can be reduced by using high grade concrete mix. Bedding septic lines with gravel and sand, installing more laterals of greater length, or substituting with a sewage lagoon reduce the effects of very slow permeability. Installing corrosion resistant utility lines provides protection against soluble salts. Shrubs, grasses, and trees used in landscaping need to be adapted to these droughty, clayey soils. Topsoil needs to be stockpiled for later use in landscaping. This complex has high potential for pond reservoirs and sewage lagoons.

This complex has low potential for most recreational uses. Excess sodium, excess salts, and the severe hazard of erosion are limitations that are difficult to overcome.

This complex has low potential for windbreak tree and shrub plantings. Amur honeysuckle, oriental arborvitae, redbud, Arizona cypress, skunkbush sumac, lilac, Rocky Mountain juniper, osageorange, and eastern redcedar are adapted to these soils. Soil drainage, the clayey subsoil, and soluble salts are severe limitations for tree and shrub plantings.

The Doolin soil has medium potential for use as habitat for openland wildlife and low potential for rangeland and wetland wildlife. The Pawhuska soil has low potential for use as habitat for all wildlife.

This complex is in capability subclass IVs. Doolin soil is in Claypan Prairie range site, and Pawhuska soil is in Shallow Claypan range site.

54—Slaughterville-Urban land complex, 1 to 5 percent slopes. This complex consists of deep, well drained Slaughterville soil and Urban land. The soil and Urban land of this complex were so intermingled that they could not be separated at the scale selected for mapping. The very gently sloping to gently sloping Slaughterville soil is on uplands paralleling the South Canadian River in the northwest and southwest parts of Norman and the eastern part of Lexington. It is on convex side slopes and ridge crests on the unaltered parts of the landscape. The mapped areas are elongated, from about 400 to 2,000 feet wide and 800 to 5,200 feet long, and range from about 40 to 150 acres.

The Slaughterville soil makes up about 50 percent of the map unit. Typically, the surface layer is brown fine sandy loam about 19 inches thick. The subsoil is brown fine sandy loam to a depth of about 51 inches. The underlying material consists of light brown fine sandy loam to a depth of about 71 inches underlain by reddish yellow loamy fine sand to a depth of 80 inches or more.

The Slaughterville soil is high in natural fertility and medium in organic matter content. It ranges from medium acid to neutral in the surface layer, slightly acid to moderately alkaline in the subsoil, and neutral to moderately alkaline in the underlying material. Permeability is moderately rapid, runoff is slow to medium, and the available water capacity is medium.

The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil is moderately susceptible to wind erosion and mildly susceptible to water erosion. It has low shrink-swell potential and low corrosion potential to steel or concrete.

Urban land makes up about 40 percent of the map unit. It consists of areas of soils that have been covered with buildings or other urban structures. Typical structures are single story dwellings, small commercial buildings, churches, schools, parking lots of less than 5 acres, streets, sidewalks, driveways, state and interstate highways, and cemeteries.

Included with this complex in mapping are small areas of Derby, Dougherty, Konawa, and Teller soils. These soils have been altered in places. The somewhat excessively drained Derby soils are on small mounds or dunes. The moderately permeable Dougherty and Konawa soils are on similar topography as Slaughterville soil but generally have clusters of native post oak and blackjack oak trees. The moderately permeable Teller soils are intermingled with Slaughterville soil. The included soils make up about 10 percent of the map unit.

This complex has low potential for cropland, hay, tame pasture, and rangeland. Most undeveloped areas of Slaughterville soil are too small for operation of farm implements or for livestock use.

This complex has high potential for building site development, such as dwellings, small commercial buildings, roads, streets, and landscape plantings. The potential is low for most sanitary facilities because seepage results in possible underground pollution. The Slaughterville soil is an excellent source of topsoil. The texture, natural fertility, and thickness of this soil makes it one of the most desirable soils for plant media of any soil in Cleveland County. The available water capacity and organic matter content can be improved by incorporating adequate amounts of manure, peat moss, or other kinds of plant residue into the soil. Pocket gophers can cause excessive damage to lawns and shrubs unless controlled.

This complex has high potential for camp areas, picnic areas, and paths and trails. Steepness of slopes is a moderate limitation for playgrounds. This limitation can be overcome easily by making shallow cuts and fills to level the landscape.

This complex has high potential for tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are well suited.

This complex is not assigned to a capability subclass or range site.

55—Slaughterville-Urban land complex, 8 to 25 percent slopes. This complex consists of deep, well drained Slaughterville soil and Urban land in the eastern part of Lexington. The soil and Urban land of this complex are so intermingled that they could not be separated at the scale selected for mapping. The strongly sloping to steep Slaughterville soil is on uplands paralleling the South Canadian River. It is on side slopes on the unaltered parts of the landscape. This complex consists of one mapped area about 200 to 500 feet wide and 3,200 feet long.

The Slaughterville soil makes up about 50 percent of the map unit. Typically, the surface layer is brown fine sandy loam about 11 inches thick. The subsoil is brown fine sandy loam to a depth of about 23 inches. The underlying material is reddish brown fine sandy loam to a depth of about 56 inches underlain by light reddish brown loamy fine sand to a depth of 80 inches or more.

The Slaughterville soil is high in natural fertility and medium in organic matter content. It is slightly acid or neutral in the surface layer, neutral to moderately alkaline in the subsoil, and mildly alkaline or moderately alkaline and calcareous in the underlying material. Permeability is moderately rapid, runoff is rapid, and the available water capacity is medium. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil is easily eroded if not protected by adequate plant cover. It has low shrink-swell potential and low corrosion potential to steel and concrete.

Urban land makes up about 45 percent of the map unit. It consists of areas of soils that have been covered with buildings or other urban structures. Typical structures are mostly single family dwellings, streets, driveways, sidewalks, and a short section of state highway. Deep cuts and fills were required in places to make suitable building sites.

Included with this complex in mapping are areas of the moderately permeable Konawa and Teller soils. These soils are intermingled with the Slaughterville soil on similar landscapes, and in places, they have been altered. The included soils make up about 5 percent of the map unit.

This complex has low potential for cropland, hay, tame pasture, and rangeland. Most undeveloped areas of Slaughterville soil are too small for operation of farm implements or for livestock use.

This complex has low potential for most urban and recreational uses. Cutting and filling to obtain the proper grade for construction is expensive because steepness of slopes limits the operation of heavy equipment. Seepage and steepness of slopes are severe limitations for septic tank filter fields, lagoons, or sanitary landfills. Runoff can be reduced by bench terracing or land leveling. The available water capacity and organic matter content can be improved by incorporating large amounts of manure, peat moss, or other types of residue into the soil. Pocket gophers can cause excessive damage to lawns and shrubs unless controlled.

This complex has medium to high potential for tree and shrub plantings. American plum, Amur honeysuckle, Austrian pine, black locust, Chinese elm, common hackberry, eastern redcedar, green ash, honeylocust, lilac, osageorange, redbud, Rocky Mountain juniper, and skunkbush sumac are well suited.

This complex is not assigned to a capability subclass or range site.

57—Teller-Urban land complex, 1 to 3 percent slopes. This complex consists of deep, well drained Teller soil and Urban land. The soil and Urban land of this complex were so intermingled that they could not be separated at the scale selected for mapping. Teller soil is on very gently sloping, broad, convex ridge crests of uplands paralleling the South Canadian River in the southwest part of Norman. The mapped areas are elongated, about 250 to 3,000 feet wide and 700 to 5,000 feet long, and range from about 5 to 300 acres.

The Teller soil makes up about 45 percent of the map unit. Typically, the surface layer is brown fine sandy loam about 11 inches thick. The subsoil is sandy clay loam to a depth of about 54 inches. It is reddish brown in the upper part and reddish yellow in the lower part. The underlying material is a buried layer of red silty clay that extends to a depth of 80 inches or more.

The Teller soil is high in natural fertility and medium in organic matter content. The surface layer is medium acid or slightly acid. Where limed, it ranges from medium acid to mildly alkaline. The subsoil and buried layer range from slightly acid to moderately alkaline. Permeability is moderate, runoff is slow, and the available water capacity is medium. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil is susceptible to water erosion and mildly susceptible to wind erosion. It has low shrink-swell potential above a depth of 60 inches and moderate potential below that. This soil has low corrosion potential to steel and moderate corrosion potential to concrete.

Urban land makes up about 45 percent of the map unit. It consists of areas of soils that have been covered with buildings or other urban structures. Typical structures are single family dwellings, streets, sidewalks, driveways, multiple unit apartment buildings, swimming pools, schools, churches, motels, small commercial business buildings, parking lots of less than 10 acres, and state and interstate highways.

Included with this complex in mapping are areas of Norge, Slaughterville, and Vanoss soils. These soils have been altered in places. The moderately slowly permeable Norge soils are intermingled with Teller soil. Vanoss soils are in smoother, less sloping positions on the landscape than Teller soil. The moderately rapidly permeable Slaughterville soils are in small isolated areas intermingled with Teller soil. The included soils make up about 10 percent of the map unit, but individual areas are generally less than 5 acres.

This complex has low potential for cropland, hay, tame pasture, and rangeland. Areas of Teller soil are too small for operation of most farm equipment and for livestock use.

This complex has high potential for dwellings, small commercial buildings, local roads and streets, lawns, shrubs, golf fairways, roadfill, topsoil, and area type sanitary landfills. The moderate permeability is the main limitation for septic tank absorption fields. Seepage is a limitation for sewage lagoon areas and trench type sanitary landfills. The Teller soil is a good media for plants and is well suited to use as topsoil. The organic matter content and available water capacity can be improved by incorporating adequate amounts of plant residue, manure, or peat moss. Pocket gophers can cause excessive damage to lawns and shrubs unless controlled.

This complex has high potential for most recreational uses where sizeable areas of Teller soil occur. Steepness of slopes is a limitation for playgrounds.

This complex has high potential for tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, red mulberry, redbud, silver maple, Scotch pine, Rocky Mountain juniper, Russian-olive, and skunkbush sumac are adapted to this soil.

This complex is not assigned to a capability subclass or range site.

58—Teller-Urban land complex, 3 to 8 percent slopes. This complex consists of deep, well drained Teller soil and Urban land. The soil and Urban land of this complex were so intermingled that they could not be separated at the scale selected for mapping. Teller soil is on gently sloping to sloping side slopes and foot slopes of uplands in the southwest and southeast part of Norman paralleling Normandy, Imoff, and Bishop Creeks. The mapped areas are long and narrow, about 200 to 600 feet wide and 700 to 6,000 feet long, and range from about 5 to 120 acres.

The Teller soil makes up about 50 percent of the map unit. Typically, the surface layer is brown fine sandy loam about 11 inches thick. The subsoil is brown fine sandy loam to a depth of about 19 inches, reddish brown to yellowish red sandy clay loam to a depth of about 50 inches, and yellowish red fine sandy loam to a depth of about 63 inches. The underlying material is reddish yellow very fine sandy loam to a depth of 80 inches or more.

The Teller soil is high in natural fertility and medium in organic matter content. The surface layer is medium acid or slightly acid. Where limed, it ranges from medium acid to mildly alkaline. The subsoil ranges from slightly acid to mildly alkaline, and the underlying material is mildly alkaline or moderately alkaline. Permeability is moderate, runoff is medium or rapid, and the available water capacity is medium. The root zone is more than 60 inches deep and is easily penetrated by roots. This soil is susceptible to water erosion and mildly susceptible to wind erosion. It has low shrink-swell potential, low corrosion potential to steel, and moderate corrosion potential to concrete.

Urban land makes up about 40 percent of the map unit. It consists of areas of soils that have been covered with buildings or other urban structures. Typical structures are single family dwellings, apartment dwellings, commercial buildings, streets, sidewalks, parking lots of less than 5 acres, and a golf course.

Included with this complex in mapping are areas of Konawa, Norge, and Slaughterville soils and areas of soils similar to the Teller soil but having buried layers that are silty clay or silty clay loam at a depth of 50 to 60 inches or more. The included soils have been altered in places. The lighter colored Konawa soils are forming along stream channels. The moderately slowly permeable Norge soils are mostly on upper side slopes. The moderately rapidly permeable Slaughterville soils are interspersed with Teller soil. The included soils make up about 10 percent of the map unit, but individual areas are generally less than 5 acres.

This complex has low potential for cropland, hay, tame pasture, and rangeland. Areas of Teller soil are too small for operation of most farm equipment and for livestock use.

This complex has high potential for dwellings, local roads and streets, lawns, golf fairways, roadfill, topsoil, and area type sanitary landfills. The main limitation for small commercial buildings is slopes that require deeper cuts and fills for site preparation. This complex has medium potential for septic tank absorption fields because of the moderate permeability. Seepage in the lower subsoil is a limitation for sewage lagoon areas and trench type sanitary landfills. The Teller soil is well suited to use as topsoil. The organic matter content and available water capacity can be improved by incorporating adequate amounts of plant residue, manure, or peat moss. Burrowing rodents can cause excessive damage to lawns and shrubs unless controlled.

This complex has high potential for most recreational uses where sizeable areas of Teller soil occur. Steepness of slopes is a limitation for playgrounds.

This complex has high potential for tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are well suited.

This complex is not assigned to a capability subclass or range site.

59—Bethany-Urban land complex, 0 to 3 percent slopes. This complex consists of the deep, well drained Bethany soil and Urban land. The soil and Urban land of this complex were so intermingled that they could not be separated at the scale selected for mapping. This complex is mostly in the western and southern parts of Norman and less extensively in southwestern Oklahoma City. The Bethany soil is on broad, nearly level to very gently sloping uplands. The mapped areas are elongated in a northwest-southeast direction, range from about 200 to 2,500 feet wide and from 800 to 4,200 feet long, and are about 5 to 180 acres.

The Bethany soil is in the unaltered parts of the landscape and makes up about 45 percent of the map unit. Typically, the surface layer is brown to grayish brown silt loam about 13 inches thick. The subsoil is brown silty clay loam to a depth of about 22 inches; grayish brown, mottled silty clay loam to a depth of about 41 inches; and light brownish gray, mottled silty clay to a depth of 84 inches or more.

The Bethany soil is high in natural fertility and organic matter content. It is medium acid to neutral in the surface layer. The subsoil is slightly acid or neutral in the upper part, neutral or mildly alkaline in the middle part, and neutral to moderately alkaline in the lower part. Permeability and runoff are slow, and the available water capacity is high. The root zone is more than 60 inches deep, but plant root penetration is difficult in the subsoil. Bethany soil is highly susceptible to water erosion on slopes if not protected by adequate plant cover or residue. It is mildly susceptible to wind erosion. The shrink-swell potential is moderate in the upper and middle parts of the subsoil and high in the lower part. This soil has high corrosion potential to steel and low corrosion potential to concrete.

Urban land makes up about 40 percent of the map unit. It consists of areas of soils that are covered with buildings or other urban structures. Typical structures in this complex are interstate highways, streets, commercial buildings, parking lots of less than 10 acres, single family dwellings, apartment dwellings, swimming pools, dormitories, and university buildings.

Included with this complex in mapping are areas of Doolin, Pawhuska, Renfrow, and Vanoss soils. These soils have been altered in places. The moderately well drained, very slowly permeable Doolin soils are in nearly level areas. The saline-alkali, moderately well drained, very slowly permeable Pawhuska soils are in rounded, slightly concave spots. The well drained, very slowly permeable Renfrow soils and the well drained, moderately permeable Vanoss soils are intermingled with the Bethany soil. The included soils make up about 15 percent of the map unit.

This complex has low potential for cropland, hay, tame pasture, or rangeland. Areas of Bethany soil are too small for operation of most farm implements and for livestock use.

This complex has low potential for most urban uses. The high shrink-swell potential, high corrosion hazard to steel, slow permeability, and clayey subsoil are severe limitations that are difficult and expensive to overcome. The limitations are slight for lawns, landscaping, and golf fairways. The installation of pier-and-beam type reinforced concrete foundations; bedding slab floors, sidewalks, and driveways with sand; and using high grade concrete mix reduce cracking in concrete structures caused by shrinking and swelling. The clayey subsoil and slow permeability can be improved by excavating soil and mixing with coarser-textured soils. Heavy applications of gypsum improve the soil structure, which in turn improves the intake of water and permeability of the soil. The corrosion hazard to steel can be overcome by using coated products or substituting with copper tubing or plastic pipe. Calcareous, sandy soil, like that found in the South Canadian River bed, make excellent bedding or cover material for prevention of corrosion and shrinking and swelling. The hazard of erosion in sloping areas can be reduced by planting temporary cover of rye or wheat, using plant residue for mulch, or by solid sodding with perennial grasses.

This complex has low to high potential for most recreational uses. Slopes of more than 2 percent are moderate limitations for playgrounds. The hazard of erosion is a severe limitation for paths and trails.

This complex has low potential for windbreak tree and shrub plantings. The clayey subsoil limits the trees or plants adapted to these soils. Amur honeysuckle, Austrian pine, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, silver maple, and skunkbush sumac are well suited.

This complex is not assigned to a capability subclass or range site.

60—Bethany silt loam, 0 to 1 percent slopes. This deep, well drained, nearly level soil is on broad upland flats in the western and central parts of the county. Slopes are slightly convex and less than 1 percent. The mapped areas are oblong and irregular in shape and range from 20 to 800 acres.

Typically, the surface layer is dark grayish brown silt loam about 13 inches thick. The subsoil is brown silty clay loam to a depth of about 30 inches, pale brown and grayish brown silty clay to a depth of about 65 inches, and coarsely mottled clay loam to a depth of about 84 inches.

Included with this soil in mapping are areas of Doolin, Pawhuska, and Vanoss soils. The moderately well drained, very slowly permeable Doolin and Pawhuska soils and the well drained Vanoss soils are intermingled with Bethany soil. The included soils make up about 15 percent of the map unit, and individual areas of each soil are generally less than 3 acres.

This Bethany soil is high in natural fertility and organic matter content. It is medium acid to neutral in the surface layer. The subsoil is slightly acid or neutral in the upper part, slightly acid to mildly alkaline in the middle part, and neutral to moderately alkaline in the lower part. Lime is below a depth of 40 inches in some areas. Permeability and runoff are slow, and the available water capacity is high. This soil is easily tilled, but it is easily compacted if tilled or grazed when too wet. The lower part of the subsoil has high shrink-swell potential. This soil has high corrosion potential to steel and low corrosion potential to concrete. The root zone is more than 60 inches deep, but plant root penetration is difficult in the subsoil.

This soil has high potential for all adapted crops. It has medium potential for hay, tame pasture, and rangeland. The fertility, organic matter content, and tilth can be maintained by returning crop residue to the soil, minimum tillage, and adding fertilizer. Refraining from tillage and removing livestock when the soil is wet reduce compaction and maintain good tilth. The quality of tame pasture and hay can be improved by overseeding with legumes and by adding fertilizer. All grasses can be improved by controlling grazing and preventing fire.

This Bethany soil has low potential for most urban uses. The high shrink-swell potential, slow permeability, clayey texture, and corrosivity of the lower part of the subsoil are severe limitations that are expensive to overcome. Use of high grade reinforced concrete and sand for bedding reduce cracking in building foundations, slabs, and footings caused by shrinking and swelling. Steel utility lines can be treated or coated with corrosion resistant material or substituted with copper tubing or plastic pipe to reduce the corrosion hazard. Extending the septic lines and bedding with gravel and sand reduce the effect of slow permeability and damage from soil movement caused by shrinking and swelling.

This soil has high potential for sewage lagoons and pond reservoirs. It has medium potential for embankments, dikes, and levees because of the difficulty of packing the subsoil materials.

This soil has high potential for recreational uses.

This soil has low potential for windbreak tree and shrub plantings. The slow permeability and clayey subsoil retard growth of deep rooted plants. Amur honeysuckle, Austrian pine, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland wildlife and low potential for wetland wildlife. It has medium potential for use as habitat for rangeland wildlife.

This Bethany soil is in capability class I and in Loamy Prairie range site.

61—Bethany silt loam, 1 to 3 percent slopes. This deep, well drained, very gently sloping soil is on broad convex uplands in the central and western parts of the county. The mapped areas are oblong and irregular in shape and range from 20 to 200 acres.

Typically, the surface layer is dark grayish brown silt loam about 12 inches thick. The subsoil, to a depth of about 29 inches, is grayish brown to brown silty clay loam; to a depth of about 62 inches, is brown, mottled silty clay; and to a depth of about 80 inches is yellowish red, mottled silty clay.

Included with this soil in mapping are areas of Norge, Renfrow, and Vanoss soils. These soils are intermingled with Bethany soil. The included soils make up about 15 percent of the map unit, and individual areas of each soil are generally less than 3 acres.

This Bethany soil is high in natural fertility and organic matter content. It is medium acid to neutral in the surface layer. The subsoil is slightly acid or neutral in the upper part, neutral or mildly alkaline in the middle part, and neutral to moderately alkaline in the lower part. Lime is below a depth of 40 inches in some areas. Permeability is slow, runoff is medium, and the available water capacity is high. This soil has good tilth, but plowpans form easily if tilled or grazed when too wet. The soil is subject to water erosion if not protected by adequate residue or plant cover. The root zone is more than 60 inches deep, but plants that have deep root systems are restricted somewhat by the clayey subsoil. This soil has high shrink-swell potential in the lower part of the subsoil, high corrosion potential to steel, and low corrosion potential to concrete.

This soil has high potential for row crops, small grains, hay, and tame pasture. It has medium potential for native rangeland. Terracing, contour farming, and stubble mulch tillage reduce runoff, help to control erosion, and conserve moisture. The fertility, organic matter content, and tilth can be maintained by returning crop residue to the soil, by minimum tillage, and by using crop rotations that include grasses and legumes in the cropping system. Tilling the soil at different depths under optimum moisture conditions and removing livestock during wet periods help to prevent plowpans from forming. The quality of tame pasture and hay can be improved by adding fertilizers and overseeding with legumes. All grasses can be maintained by preventing fire and controlling grazing.

This Bethany soil has low potential for most urban uses. Shrinking and swelling, slow permeability, the clayey texture, and corrosivity are severe limitations. These limitations can be reduced by special design, such as using high grade reinforced concrete; bedding foundations, slabs, and septic lines with gravel and sand; and using treated or corrosion resistant material.

This soil has high potential for sewage lagoons and pond reservoirs. The clayey subsoil is difficult to pack when used for embankments, dikes, or levees.

This soil has low to high potential for recreational use. Erosion is a severe limitation for paths and trails. Steepness of slope is a moderate limitation for playgrounds.

This soil has low potential for windbreak tree and shrub plantings. The clayey subsoil and slow internal drainage are limitations. Amur honeysuckle, Austrian pine, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland wildlife and low potential for wetland wildlife. It has medium potential for use as habitat for rangeland wildlife.

This Bethany soil is in capability subclass IIe and in Loamy Prairie range site.

62—Renfrow silt loam, 1 to 3 percent slopes. This deep, well drained, very gently sloping soil is on ridge crests and side slopes of uplands in the central and western parts of the county. Slopes are smooth and convex. The mapped areas are elongated and are 5 to more than 60 acres.

Typically, the surface layer is brown silt loam about 11 inches thick. The subsoil is reddish brown silty clay loam to a depth of about 16 inches, yellowish red silty clay to a depth of about 33 inches, and red silty clay to a depth of about 71 inches. The underlying material is red, weakly laminated, calcareous shale to a depth of 80 inches or more.

Included with this soil in mapping are small areas of Grainola, Grant, Norge, and Huska soils. The moderately deep Grainola soils, the moderately permeable Grant soils, and the moderately well drained, saline-alkaline Huska soils are intermingled with Renfrow soil. The moderately slowly permeable Norge soils are in lower positions on side slopes than Renfrow soil. The included soils make up about 15 percent of the map unit, and individual areas of each soil are generally less than 3 acres.

This Renfrow soil is high in natural fertility and medium in organic matter content. It is slightly acid or neutral in the surface layer and upper part of the subsoil and mildly alkaline or moderately alkaline in the lower part of the subsoil. Most pedons are calcareous below a depth of

30 inches. Permeability is very slow, runoff is medium, and the available water capacity is high. The soil has good tilth but is easily compacted if tilled or pastured when too wet. This soil is highly susceptible to water erosion if clean tilled. The root zone is more than 60 inches deep, and development and penetration are difficult because of the dense, clayey subsoil. This soil has low corrosion potential to concrete.

This soil has medium potential for row crops and small grains. The very slow permeability and hazard of erosion are limitations that restrict the use of this soil to specific crops. Deep chiseling when the subsoil is dry improves water, air, and root penetration. The fertility, organic matter content, and tilth can be maintained or improved by minimum tillage, returning crop residue to the soil, and adding fertilizer. Terracing, contour farming, and the use of cover crops, including grasses and legumes in the cropping system, reduce runoff and help to control erosion.

This soil has medium potential for hay, tame pasture, and rangeland. Plant growth is limited by the dense, clayey subsoil. Proper stocking rates, rotation grazing, renovation every 3 to 5 years, weed control, and additions of fertilizer high in nitrogen are needed. Overseeding pastures in the fall with small grain and legumes extends the grazing periods and provides higher quality forage. Removing livestock during wet periods reduces soil compaction and helps to maintain the soil structure. Hay can be maintained or improved by timely mowing and by adding fertilizer. Weed and brush control, rotation grazing, timely deferment of grazing, and protecting the vegetation from fire are management concerns.

This Renfrow soil has low potential for most urban uses. High shrink-swell potential, very slow permeability, high corrosivity to steel, the high hazard of erosion, and the dense, clayey subsoil are severe limitations. These limitations can be reduced by special design and careful installation procedures, such as high grade reinforced concrete, pier-and-beam type construction, bedding foundations and septic lines with gravel and sand, or using treated, corrosion resistant material. The hazard of erosion can be reduced by planting small grains or spreading hay mulch for temporary cover during construction. Permanent grasses need to be established immediately upon completion of the project. This soil has medium potential for sewage lagoons and high potential for pond reservoir areas. Steepness of slopes is a moderate limitation for lagoons.

This soil has low to medium potential for recreational use. The very slow permeability is a moderate limitation for camp areas, picnic areas, and playgrounds. Steepness of slopes is a moderate limitation for playgrounds. The hazard of erosion is a severe limitation for paths and trails.

This soil has low potential for windbreak tree and shrub plantings. The very slow permeability and the high clay content of the subsoil retards root development and the movement of air and water. Amur honeysuckle, Austrian pine, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland wildlife and medium potential for rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Renfrow soil is in capability subclass IIIe and in Claypan Prairie range site.

63—Renfrow silt loam, 3 to 5 percent slopes. This deep, well drained, gently sloping soil is on side slopes of uplands in the central and western parts of the county. Slopes are smooth and convex. The mapped areas are elongated and are 10 to more than 80 acres.

Typically, the surface layer is brown silt loam about 8 inches thick. The subsoil is dark reddish gray silty clay loam to a depth of about 13 inches, reddish brown and red silty clay to a depth of about 63 inches, and red silty clay loam to a depth of about 72 inches.

Included with this soil in mapping are small areas of Grainola, Grant, Norge, and Huska soils and soils similar to Renfrow soil but having siltstone or shale at a depth of 40 to 60 inches. Grainola soils are moderately deep, Grant soils are moderately permeable, and the saline-alkaline Huska soils are moderately well drained. The moderately slowly permeable Norge soils are on foot slopes. The included soils make up about 25 percent of the map unit, but individual areas of each soil are generally less than 5 acres.

This Renfrow soil is high in natural fertility and medium in organic matter content. It is slightly acid or neutral in the surface layer and upper part of the subsoil and mildly alkaline to moderately alkaline in the lower part of the subsoil. Permeability is very slow, runoff is medium or rapid, and the available water capacity is high. This soil is highly susceptible to water erosion if not protected by adequate plant cover. It has good tilth but is easily compacted if tilled or trampled when wet. The root zone is more than 60 inches deep, but root development and penetration are difficult because of the dense, clayey subsoil. This soil has high shrink-swell potential, high corrosion potential to steel, and low corrosion potential to concrete.

This soil has medium potential for row crops and small grains. Very slow permeability, medium to rapid runoff, and the hazard of erosion are the main limitations. Deep chiseling when the subsoil is dry improves the water and air movement and root development. Tilling the soil under optimum moisture conditions reduces compaction. The fertility, organic matter content, and tilth can be maintained or improved by minimum tillage, returning crop residue to the soil, and adding fertilizer to the soil.

Terracing, contour farming, and the use of cover crops, including grasses and legumes in the cropping system, reduce runoff and help to control erosion.

This soil has medium potential for hay and tame pasture. The dense, clayey subsoil and medium or rapid runoff are the main limitations. Proper stocking rates, rotation grazing, and additions of fertilizer high in nitrogen are needed. Restricted grazing during wet periods reduces soil compaction and excessive runoff.

This Renfrow soil has medium potential for rangeland and is best suited to this use. Weed and brush control, rotation grazing, timely deferment of grazing, and protection from uncontrolled burning are management concerns.

This soil has low potential for most urban uses. The high shrink-swell potential, high hazard of erosion, very slow permeability, the clayey texture, and high corrosivity to steel are severe limitations that are difficult and expensive to overcome. High grade concrete mix that has adequate reinforcement steel properly bedded over sand reduces cracking in foundations, slabs, and walls caused by shrinking and swelling. Gas and water lines should be treated or coated with corrosion resistant material or substituted with plastic or copper tubing to reduce the hazard of corrosion. Enlarging the septic tank absorption field and bedding lateral lines with gravel and sand reduce the effect of very slow permeability and damage to the lines because of shrinking and swelling. Erosion can be reduced in construction areas by planting small grains for temporary cover or by using hay mulch. Permanent grasses should be established immediately following completion of the project.

This soil has high potential for pond reservoir areas. It has medium potential for sewage lagoons because of the slope. This soil has low potential for embankments, dikes, and levees because of the difficulty of packing the clayey subsoil material.

This soil has medium to low potential for recreational use. Slope and very slow permeability are moderate limitations for playgrounds. The very slow permeability is a moderate limitation for camp areas and picnic areas. The hazard of erosion is a severe limitation for paths and trails.

This soil has low potential for windbreak tree and shrub plantings. The very slow permeability and the dense, clayey subsoil limit root development and the movement of air and water in the subsoil. Amur honeysuckle, Austrian pine, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland wildlife habitat and medium potential for rangeland wildlife habitat. It has low potential for wetland wildlife habitat.

This Renfrow soil is in capability subclass IVe and in Claypan Prairie range site.

64—Renfrow silty clay loam, 1 to 5 percent slopes, eroded. This deep, well drained, very gently sloping to gently sloping eroded soil is on ridge crests and side slopes of uplands in the central and western parts of the county. Slopes are smooth and convex. This soil has been eroded to the extent that the present plow layer over much of the area consists of part of the original surface layer mixed with material from the subsoil. This soil is less fertile, and the surface layer is less friable, thinner, and has poorer tilth than the original surface. The mapped areas are 5 to more than 200 acres.

Typically, the surface layer is dark grayish brown silty clay loam about 5 inches thick. The subsoil is brown silty clay loam to a depth of about 9 inches, reddish brown silty clay to a depth of about 27 inches, and red silty clay to a depth of about 73 inches. The underlying material is red and light gray, weakly laminated, calcareous siltstone and shale to a depth of 80 inches or more.

Included with this soil in mapping are areas of Grainola, Grant, Norge, and Huska soils and soils similar to Renfrow soil but having bedrock from 40 to 60 inches below the surface. The moderately deep Grainola soils, the moderately permeable Grant soils, and the moderately well drained, saline-alkaline Huska soils are intermingled with the Renfrow soil. The moderately slowly permeable Norge soils are in lower positions on side slopes than Renfrow soil. The included soils make up 25 percent of the map unit, and individual areas of each soil are generally less than 5 acres.

This Renfrow soil is medium in natural fertility and low in organic matter content. It is slightly acid or neutral in the surface layer and upper part of the subsoil, neutral or mildly alkaline in the middle part of the subsoil, and moderately alkaline in the lower part. Permeability is very slow, runoff is medium to rapid, and the available water capacity is high. This soil has poor tilth and is easily compacted if tilled or trampled when too wet. The root zone is more than 60 inches deep, but root penetration is difficult because of the dense, clayey subsoil. This soil is highly susceptible to water erosion. It has high shrink-swell potential, high corrosion potential to steel, and low corrosion potential to concrete.

This soil has low potential for row crops and small grains. The loss of fertility, hazard of erosion, excessive runoff, poor tilth, and very slow permeability are the main limitations. The fertility, organic matter content, and tilth can be maintained or improved by minimum tillage, returning crop residue to the soil, growing green manure crops, and adding fertilizer regularly. Terracing, contour farming, and the use of cover crops, including grasses and legumes in the cropping system, reduce runoff and help to control erosion. Deep chiseling when the subsoil is dry improves water, air, and root penetration.

This soil has low potential for hay and tame pasture and medium potential for rangeland. It is best suited to rangeland. Tame pastures do not respond to fertilizer as well as uneroded Renfrow soils because of the less friable, more clayey surface texture. Timely weed and brush control, suitable grazing practices, and protecting the range from fire are needed for tame pastures and native grasses. Removal of livestock during wet periods and renovating pastures early in spring reduce compaction and improve moisture intake. Deferred grazing later in summer and fall helps to maintain and improve the quality of the native grasses.

This Renfrow soil has low potential for most urban uses. High shrink-swell potential, very slow permeability, high corrosivity to steel, the hazard of erosion, and the dense, clayey subsoil are severe limitations. These limitations can be reduced by special design and proper installation procedures, such as high grade reinforced concrete, pier-and-beam type construction, bedding foundations and septic lines with gravel and sand, or using treated corrosion resistant material. The hazard of erosion can be reduced by planting temporary cover of small grains during construction or by mulching with hay. Permanent grasses need to be established immediately upon completion of construction. This soil has medium potential for sewage lagoons and high potential for pond reservoir areas. Steepness of slopes is a moderate limitation for sewage lagoons.

This soil has low to medium potential for recreational use. Very slow permeability is a moderate limitation for picnic areas, camp areas, and playgrounds. Steepness of slopes is a moderate limitation for playgrounds. The hazard of erosion is a severe limitation for paths and trails.

This soil has low potential for windbreak tree and shrub plantings. Slow percolation and the clayey subsoil limit the movement of air and water in the soil and retard root development and penetration. Excessive runoff reduces the moisture available for plant use and carries nutrient and soil particles downstream. Chinese elm, eastern redcedar, common hackberry, honeylocust, osageorange, Russian-olive, silver maple, skunkbush sumac, Amur honeysuckle, lilac, redbud, bur oak, euonymus, oriental arborvitae, ponderosa pine, red mulberry, Rocky Mountain juniper, and Austrian pine are adapted to this soil.

This soil has high potential for use as habitat for openland wildlife and medium potential for rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Renfrow soil is in capability subclass IVe and in Claypan Prairie range site.

65—Renfrow-Huska complex, 1 to 5 percent slopes, eroded. This complex consists of deep, well drained Renfrow soil and deep, moderately well drained Huska soil. The soils of this complex were so intermingled they could not be separated at the scale selected for mapping. The soils of this complex are on eroded uplands in the central and western parts of the county. The Renfrow soil commonly is in smooth, convex, darker color areas of ridge crests and side slopes. The Huska soil is in rounded, slightly concave, lighter color areas. Individual areas of the Huska soil are 1/8 acre to 5 acres. These soils have been eroded to the extent that the present plow layer over much of the area consists of part of the original surface layer mixed with material from the upper part of the subsoil. The plow layer now is more clayey, less fertile, thinner, and has poorer tilth. The mapped areas are irregular in shape and range from 20 to 300 acres.

The Renfrow soil makes up about 65 percent of the map unit. Typically, the surface layer is reddish brown silty clay loam about 5 inches thick. The subsoil is silty clay. It is light reddish brown to a depth of about 19 inches and red to a depth of about 73 inches. The underlying material is red, weakly laminated, calcareous shale and siltstone to a depth of about 80 inches or more.

The Renfrow soil is medium in natural fertility and low in organic matter content. It is slightly acid to mildly alkaline in the surface layer, neutral to moderately alkaline in the upper part of the subsoil, and moderately alkaline in the lower part. Permeability is very slow, runoff is medium or rapid, and the available water capacity is high. The surface layer has poor tilth and is easily compacted if tilled or trampled when too wet. The root zone is more than 60 inches deep, but root penetration is somewhat restricted because of the dense, clayey subsoil. The Renfrow soil is highly susceptible to water erosion if not protected by adequate plant cover. It has high shrink-swell potential, high corrosion potential to uncoated steel, and low corrosion potential to concrete.

The Huska soil makes up about 15 percent of the map unit. Typically, the surface layer is brown silt loam about 6 inches thick. The subsoil is silty clay. It is brown to a depth of about 17 inches and red to a depth of 53 inches. The underlying material is red and pale yellow, weakly laminated, calcareous siltstone and shale.

The Huska soil is low in natural fertility and organic matter content. It is slightly acid or neutral in the surface layer, neutral or mildly alkaline in the upper part of the subsoil, and moderately alkaline in the lower part. This soil is high in soluble salts. Permeability is very slow, runoff is medium to rapid, and the available water capacity is low. This soil is easily compacted if moist. It slakes and erodes very easily if wet and crusts over upon drying (fig. 10). The root zone is 40 to 60 inches deep, but plant root development is very slow because of the high clay content and high content of exchangeable sodium in the subsoil. Huska soil has high shrink-swell potential, high corrosion potential to steel, and moderate corrosion potential to concrete.

Figure 10.—Huska silt loam in an area of Renfrow-Huska complex, 1 to 5 percent slopes, eroded, showing slaking and erosion following removal of topsoil in proposed housing development. Corrosion potential to steel is high.

Included with this complex in mapping are small areas of Grainola, Grant, and Norge soils and soils similar to Renfrow soil but having bedrock at a depth of 40 to 60 inches. The moderately deep Grainola soils and the moderately permeable Grant soils are intermingled with Renfrow and Huska soils mostly on ridge crests. The moderately slowly permeable Norge soils are in lower positions on side slopes than Renfrow and Huska soils. The included soils make up about 20 percent of the map unit, but individual areas of the soils are generally less than 5 acres.

This complex has low potential for row crops, small grains, hay, and tame pasture. The very slow permeability and the hazard of erosion on both soils and the low fertility, high content of exchangeable sodium, and low available water capacity of the Huska soil are severe limitations for agriculture use. Contour farming and terraces reduce runoff and protect the soils from erosion. The fertility, organic matter content, and tilth can be improved by minimum tillage, returning crop residue to the soil, and adding fertilizer. Deep chiseling these soils under optimum moisture conditions and using crop rotations that include grasses and legumes in the cropping system reduce compaction, improve tilth, and increase water intake and percolation. Heavy applications of gypsum and organic materials, such as manure or green manure crops, improve tilth, reduce surface crusting, and increase the water intake on the Huska soil. Proper stocking rates, rotation grazing, and restricted use during wet periods reduce compaction and improve plant vigor.

This complex has medium potential for rangeland and is best suited to this use. Rotation grazing, timely deferment of grazing, restricted use during dry periods, control of brush and weeds, and protection of the range from fire are needed. Deferred grazing late in summer and fall helps to maintain and improve the quality of the native grasses.

This complex has low potential for most urban uses. The high shrink-swell potential, clayey subsoil, corrosion hazard, hazard of erosion, and very slow permeability are severe limitations for homesites, commercial buildings, roads, trench type landfills, and septic tank filter fields. This complex has slight to moderate limitations for sewage lagoons and area type landfills because of steepness of slopes. Foundations constructed on pier-and-beams that have high grade reinforced concrete poured over beds of gravel and sand reduce the possibility of cracking caused by shrinking and swelling. Underground utility lines need to be treated or constructed of material resistant to corrosion to reduce the corrosion hazard. Increasing the size of septic filter fields and bedding the laterals with gravel and sand reduce the effect of very slow permeability. Sewage lagoons are better suited to these soils. The hazard of erosion can be reduced by planting temporary cover of small grains or by using hay mulch during construction. Permanent grasses need to be established immediately upon completion of the project. Onsite investigations are needed to plan urban development on this complex.

This complex has medium to low potential for most recreational uses. Very slow permeability is a moderate limitation, and high content of exchangeable sodium is a severe limitation for all uses except paths and trails. The hazard of erosion is a moderate limitation for playgrounds in some areas.

This complex has low potential for windbreak tree and shrub plantings. These soils are poorly suited because of erosion, excess sodium content, very slow permeability, and droughty soil conditions. Eastern redcedar, osageorange, skunkbush sumac, Amur honeysuckle, lilac, and redbud are adapted to these soils. Chinese elm, Austrian pine, common hackberry, silver maple, and Russian-olive are adapted to Renfrow soil, and oriental arborvitae, Arizona cypress, and Rocky Mountain juniper are adapted to Huska soil.

The Renfrow soil has high potential for use as habitat for openland wildlife, medium potential for rangeland wildlife, and low potential for wetland wildlife. The Huska soil has low potential for use as habitat for all wildlife.

This complex is in capability subclass IVs. Renfrow soil is in Claypan Prairie range site, and Huska soil is in Shallow Claypan range site.

66—Renfrow-Huska complex, 1 to 5 percent slopes. This complex consists of deep, well drained Renfrow soil and deep, moderately well drained saline-alkaline Huska soil. The soils of this complex were so intermingled that they could not be separated at the scale selected for mapping. These soils are on uplands in the central and western parts of the county. The Renfrow soil commonly is in smooth, convex, darker color areas on ridge crests and side slopes. The Huska soil is in rounded, slightly concave, lighter color areas. The Huska soil is in small areas of 1/8 acre to 2 acres. The mapped areas are irregular in shape and range from 10 to 250 acres.

The Renfrow soil makes up about 60 percent of the map unit. Typically, the surface layer is brown silt loam about 8 inches thick. The subsoil is reddish brown silty clay loam to a depth of about 12 inches, reddish brown silty clay to a depth of about 29 inches, yellowish red silty clay to a depth of about 43 inches, and red silty clay to a depth of about 60 inches. The underlying material is light red, red, and very pale brown, soft, laminated shale to a depth of 84 inches or more.

The Renfrow soil is high in natural fertility and medium in organic matter content. It is slightly acid to mildly alkaline in the surface layer and upper part of the subsoil and neutral to moderately alkaline in the lower part. Permeability is very slow, runoff is medium to rapid, and the available water capacity is high. This soil is highly susceptible to water erosion if not protected by adequate plant cover. It has good tilth, but the soil structure is easily destroyed, and the surface layer becomes compacted if the soil is tilled or pastured when too wet. The root zone is more than 60 inches deep, but plant root penetration is somewhat restricted because of the clayey subsoil. This soil has high shrink-swell potential, high corrosion potential to uncoated steel, and low corrosion potential to concrete.

The Huska soil makes up about 15 percent of the map unit. Typically, the surface layer is brown silt loam about 3 inches thick. The subsoil is brown silty clay to a depth of about 24 inches, red silty clay to a depth of about 38 inches, and red silty clay loam to a depth of about 42 inches. The underlying material is red, white, and yellow, soft, laminated siltstone and shale to a depth of about 45 inches or more.

The Huska soil is low in natural fertility and organic matter content. It is slightly acid or neutral in the surface layer, slightly acid to moderately alkaline in the upper part of the subsoil, and moderately alkaline in the middle and lower parts. This soil has high content of exchangeable sodium concentrated mainly at a depth ranging from 24 to 40 inches below the surface. Permeability is very slow, runoff is medium to rapid, and the available water capacity is low. This soil slakes and erodes very easily if wet and crusts over upon drying. It is easily compacted. The root zone is 40 to 60 inches deep, but plant root development is very slow because of the high clay content and high content of exchangeable sodium in the subsoil. This soil has high shrink-swell potential, high corrosion potential for uncoated steel, and moderate corrosion potential to concrete.

Included with this complex in mapping are small areas of Grainola, Grant, and Norge soils and soils similar to Renfrow soil but having bedrock from 40 to 60 inches below the surface. The moderately deep Grainola soils and the moderately permeable Grant soils are intermingled mostly on ridge crests. The moderately slowly permeable Norge soils are in lower positions on side slopes than Renfrow and Huska soils. The included soils make up about 25 percent of the map unit, but individual areas of the soils are generally less than 5 acres.

This complex has low potential for row crops, small grains, hay, and tame pasture. It is best suited to rangeland and has medium potential for this use. The very slow permeability and the hazard of erosion on both soils and the low fertility, high content of exchangeable sodium, and low available water capacity of the Huska soil are severe limitations for agricultural use. Contour farming, minimum tillage, and use of crop residue reduce runoff and protect the soils from erosion. Tilling the soils under optimum moisture conditions and using crop rotations that include grasses and legumes in the cropping system reduce compaction and crusting and maintain tilth. Deep chiseling and heavy applications of gypsum and organic materials, such as manure, disked into the surface layer of the Huska soil improve the structure, tilth, and intake rate. Rotation grazing and removing livestock during wet periods help to prevent compacted layers and improve plant vigor. The fertility and organic matter content can be maintained or improved by overseeding with legumes and by adding fertilizer. Native rangeland can be improved by timely deferment of grazing, restricted use during dry periods, timely weed control, and protection from uncontrolled burning.

This complex has low potential for most urban uses. The high shrink-swell potential, clayey subsoil, corrosion hazard, hazard of erosion, and very slow permeability are severe limitations for homesites, commercial buildings, roads, trench type landfills, and septic filter fields. Depth to bedrock and steepness of slopes are slight to moderate limitations for sewage lagoons and area type landfills. Foundations of homes and buildings constructed on pier-and-beams that have high grade reinforced concrete poured over beds of gravel and sand reduce the possibility of cracking caused by shrinking and swelling. Underground utility lines need to be treated or constructed of material resistant to corrosion. Increasing the size of septic filter fields and bedding the laterals with gravel and sand reduce the effect of very slow permeability. Sewage lagoons are better suited to these soils. The hazard of erosion can be reduced by planting temporary cover of small grains or using hay mulch during construction. Permanent grasses need to be established immediately upon completion of the project. Onsite investigation is needed to plan urban development on this complex.

This complex has medium to low potential for recreational use. Very slow permeability is a moderate limitation and high content of exchangeable sodium is a severe limitation for all uses except paths and trails. The hazard of erosion is a moderate limitation for paths and trails. Steepness of slopes is a moderate limitation for playgrounds in some areas.

This complex has low potential for windbreak tree and shrub plantings. These soils are poorly suited because of excess sodium content, very slow permeability, and droughty soil conditions. Eastern redcedar, skunkbush sumac, Amur honeysuckle, lilac, redbud, and osageorange are adapted to these soils. Chinese elm, Austrian pine, common hackberry, honeylocust, silver maple, and Russian-olive are adapted to Renfrow soil, and oriental arborvitae, Arizona cypress, and Rocky Mountain juniper are adapted to Huska soil.

The Renfrow soil has high potential for use as habitat for openland wildlife, medium potential for rangeland wildlife, and low potential for wetland wildlife. The Huska soil has low potential for use as habitat for all wildlife.

This complex is in capability subclass IVs. Renfrow soil is in Claypan Prairie range site, and Huska soil is in Shallow Claypan range site.

67—Newalla fine sandy loam, 1 to 5 percent slopes. This deep, moderately well drained, very gently sloping to gently sloping soil is on ridge crests and side slopes of uplands in the eastern part of the county. The mapped areas are 10 to 80 acres.

Typically, the surface and subsurface layers are brown and light brown fine sandy loam about 7 inches thick. The subsoil is red sandy clay loam to a depth of about 11 inches and red silty clay to a depth of about 42 inches. The underlying material is red, soft shale that has light brownish gray streaks to a depth of 46 inches or more.

Included with this soil in mapping are areas of Darsil, Grainola, Harrah, Renfrow, and Stephenville soils. The shallow Darsil soils are generally in contour bands on the side slopes. The well drained Harrah and Stephenville soils are on foot slopes and side slopes. The well drained Grainola and Renfrow soils are mostly in small prairie openings. The included soils make up about 20 percent of the map unit, but individual areas of each soil are generally less than 5 acres.

This Newalla soil is low in natural fertility and organic matter content. It is strongly acid to slightly acid in the surface and subsurface layers. The upper part of the subsoil is medium acid to neutral, and the lower part is neutral to moderately alkaline. Permeability is very slow, runoff is medium, and the available water capacity is medium. The root zone is 40 to 60 inches deep, but the clayey texture partially restricts root penetration. This soil is subject to severe water erosion if not protected by adequate residue or plant cover. It has high shrink-swell potential, high corrosion potential to steel, and moderate corrosion potential to concrete.

This soil has low potential for row crops, small grains, hay, rangeland, and tame pasture. Terracing, contour farming, and stubble mulch tillage reduce runoff and help to control erosion and to conserve moisture. The fertility, organic matter content, and tilth can be maintained by returning crop residue to the soil and by using minimum tillage and crop rotations that include grasses and legumes in the cropping system. Tame pastures and hay crops respond well to additions of fertilizer high in nitrogen. Pastures and rangeland can be improved by controlling brush and weeds, rotation grazing, and protecting the vegetation from fire. Mature trees on rangeland can be harvested for firewood or posts. This allows grasses to recover their vigor and to reproduce.

This Newalla soil has low potential for most urban uses. The high shrink-swell potential, very slow permeability, clayey texture, and corrosivity to steel are severe limitations. These limitations can be reduced by using high grade reinforced concrete and pier-and-beam type construction, by bedding foundations and septic lines with gravel and sand, and by using treated or corrosion resistant material. Depth to bedrock is a moderate limitation for sewage lagoon and pond reservoir areas. The clayey subsoil is difficult to pack if used for fill materials, embankments, dikes, or levees.

The soil has medium potential for most recreational uses. The very slow permeability is a moderate limitation for playgrounds, camp areas, or picnic areas. The hazard of erosion is severe on paths and trails.

This soil has low potential for windbreak tree and shrub plantings. The clayey subsoil texture, very slow permeability of air and water, and depth to bedrock restrict the choice of adapted trees and shrubs. Skunkbush sumac, lilac, Amur honeysuckle, Austrian pine, bur oak, euonymus, oriental arborvitae, ponderosa pine, Rocky Mountain juniper, Russian-olive, eastern redcedar, Chinese elm, honeylocust, osageorange, red mulberry, redbud, silver maple, and common hackberry are adapted to this soil.

This soil has high potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Newalla soil is in capability subclass IVe and in Sandy Savannah range site.

68—Newalla sandy clay loam, 1 to 8 percent slopes, gullied. This deep, moderately well drained, very gently sloping to sloping soil is severely eroded. It is on ridge crests and side slopes of uplands in the eastern part of the county. The mapped areas are 5 to 25 acres.

Typically, the surface layer is reddish brown sandy clay loam about 5 inches thick. The subsoil is red silty clay to a depth of about 39 inches and red shaly silty clay to a depth of about 47 inches. The underlying material is red, soft, laminated shale to a depth of 60 inches or more.

Gullies make up about 10 percent of the map unit. They are from 20 to 250 feet apart, 2 to 15 feet deep, and 2 to 50 feet wide. Sandstone or shale is exposed in the gully floor in many areas. Most of the surface layer of the Newalla soil between the gullies is a plow layer that includes part of the subsoil.

Included with this soil in mapping are areas of Darsil, Grainola, Harrah, Lucien, and Stephenville soils. The shallow Darsil soils are generally in contour bands on side slopes. The well drained Harrah and Stephenville soils are on foot slopes and side slopes. The well drained Grainola and Lucien soils are mostly in small prairie openings interspersed with the Newalla soil. The included soils make up about 15 percent of the map unit, but individual areas of each soil are generally less than 5 acres.

This Newalla soil is low in natural fertility and organic matter content. It is slightly acid or neutral in the surface layer, neutral or mildly alkaline in the upper part of the subsoil, and neutral to moderately alkaline in the lower part. Permeability is very slow, runoff is medium or rapid, and the available water capacity is medium. The root zone is 40 to 60 inches deep, but the clayey texture partially restricts root penetration. This soil is subject to severe water erosion if not protected by adequate residue or plant cover. It has high shrink-swell potential, high corrosion potential to steel, and moderate corrosion potential to concrete.

This soil has low potential for cropland. The gullies and the very severe hazard of erosion are the main limitations for cultivation. This soil needs to be returned to permanent grass cover. An expensive major reclamation of the soil would be required to make it suitable for crops.

This soil has low potential for tame pasture and hay. The gullies, hazard of erosion, and low fertility and organic matter content are the main limitations. This soil is suited to bermudagrass, weeping lovegrass, and other adapted old-world bluestem grasses and legumes. Where feasible, the gullies need to be shaped, smoothed, mulched, fertilized, and seeded or sprigged to one or more of these grasses. Runoff needs to be diverted to reduce the hazard of erosion. Planting black locust, constructing erosion control dams, and fencing out livestock help to stabilize deep gullies.

This soil has low potential for rangeland. Severe erosion has removed much of the original surface layer and lowered natural fertility and organic matter content, but with good management, this soil can produce some native grass. Use of this soil for tame pasture, hay, or range helps to control further erosion. Overgrazing during dry periods causes the grass stand to die out. Proper stocking, rotation grazing, and restricted grazing during dry periods help keep the grass and soil in good condition. Gullies need to be shaped, smoothed, and planted to permanent grasses, such as bermudagrass or lovegrass, that are best adapted for erosion control. Runoff needs to be diverted to reduce the hazard of erosion.

This Newalla soil has low potential for most urban uses. The gullies restrict movement of traffic before construction. Major land shaping and smoothing would alter the surface relief and improve the building site. The high shrink-swell potential, very slow permeability, clayey texture, and corrosivity to steel are severe limitations. These limitations can be reduced by using high grade reinforced concrete and pier-and-beam type construction, by bedding foundations and septic lines with gravel and sand, and by using treated or corrosion resistant material. Depth to bedrock and steepness of slopes are limitations for sewage lagoons and pond reservoir areas. The clayey subsoil is difficult to pack if used for fill materials, embankments, dikes, or levees.

This soil has low to medium potential for recreational use. The very slow permeability is a moderate limitation for camp areas or picnic areas. The gullies and hazard of erosion are severe limitations for paths and trails, and steepness of slopes is a severe limitation for playgrounds.

This soil has low potential for windbreak tree and shrub plantings. The clayey subsoil, very slow permeability of air and water, and depth to bedrock restrict the choice of adapted trees and shrubs. Skunkbush sumac, lilac, Amur honeysuckle, Austrian pine, eastern redcedar, Chinese elm, honeylocust, osageorange, red mulberry, redbud, silver maple, and hackberry are adapted to this soil.

This soil has medium potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Newalla soil is in capability subclass VIe and in Eroded Sandy Savannah range site.

69—Renfrow-Urban land-Huska complex, 1 to 5 percent slopes. This complex consists of deep, well drained Renfrow soil; deep, moderately well drained Huska soil; and Urban land. The soils and Urban land of this complex were so intermingled they could not be separated at the scale selected for mapping. This complex is most extensive throughout the city of Moore and in the northeastern and southeastern parts of Norman. Less extensive areas are in southwestern Oklahoma City and eastern Noble. The Renfrow soil is on smooth, convex, darker colored ridge crests and side slopes on uplands. The Huska soil is intermingled in rounded or elongated, slightly concave, lighter colored areas. The mapped areas are long, narrow, rectangular, or elongated; from about 250 to 3,000 feet wide and 800 to 12,000 feet long, and about 15 to 450 acres.

The Renfrow soil makes up about 35 percent of the map unit. Typically, the surface layer is brown silt loam about 8 inches thick. The subsoil is reddish brown silty clay loam to a depth of about 12 inches, reddish brown and yellowish red silty clay to a depth of about 52 inches, and red silty clay to a depth of about 62 inches. The underlying material is light red and red, soft, laminated shale to a depth of 80 inches or more.

The Renfrow soil is medium to high in natural fertility and medium in organic matter content. It ranges from slightly acid to mildly alkaline in the surface layer and upper part of the subsoil, neutral to moderately alkaline in the middle part, and moderately alkaline and calcareous in the lower part. Permeability is very slow, runoff is medium or rapid, and the available water capacity is high. The root zone is more than 60 inches deep, but plant roots are mostly restricted to cracks along the surface of the peds because of the firm, clayey subsoil. The Renfrow soil is highly susceptible to water erosion and slightly susceptible to wind erosion. It has high shrink-swell potential, high corrosion potential to steel, and low corrosion potential to concrete.

Urban land makes up about 35 percent of the map unit. It consists of areas of soils that are covered with buildings or other urban structures. Single family dwellings, apartment buildings, garages, driveways, sidewalks, patios, streets, schools, churches, shopping centers, office buildings, highways, industrial sites, and parking lots of less than 15 acres are typical structures.

The Huska soil makes up about 15 percent of the map unit. Typically, the surface layer is brown silt loam about 4 inches thick. The subsoil is brown silty clay to a depth of about 19 inches, reddish brown and red silty clay to a depth of about 40 inches, and red silty clay loam to a depth of about 46 inches. The underlying material is red, soft, laminated siltstone and shale to a depth of 50 inches or more.

The Huska soil is low in natural fertility and organic matter content. It is slightly acid or neutral in the surface layer, slightly acid to moderately alkaline in the upper part of the subsoil, and moderately alkaline throughout the middle and lower parts. Permeability is very slow, runoff is medium or rapid, and the available water capacity is low. The subsoil is moderately to highly saline. The root zone is 40 to 60 inches deep, but plant root development is very slow because of the high clay content, high salinity content, and high sodium content. Huska soil is highly susceptible to water erosion and slightly susceptible to wind erosion. It slakes easily if wet. Piping is common in cut and fill areas. This soil has high shrink-swell potential, high corrosion potential to steel, and moderate corrosion potential to concrete.

Included with this complex in mapping are areas of Bethany, Doolin, Grainola, Grant, and Pawhuska soils. These soils have been altered in places. The well drained, slowly permeable Bethany soils are on nearly level ridge crests. Doolin soils contain less sodium than Huska soil; have a thicker, dark surface layer; and are on broad, nearly level ridge crests. The moderately deep, well drained, slowly permeable Grainola soils are on steeper side slopes that slope to the small, intermittent streams. The deep, well drained, moderately permeable Grant soils are mostly on ridge crests. The deep, moderately well drained, very slowly permeable, saline-alkali Pawhuska soils are intermingled with Huska soil and have a deeper root zone than Huska soil. The included soils make up about 15 percent of the map unit.

This complex has low potential for cropland, hay, tame pasture, or rangeland. Areas of Renfrow and Huska soils are too small for operation of most farm implements and for livestock use.

This complex has low potential for most urban uses. High shrink-swell potential, very slow permeability, high sodium content of Huska soil, high corrosion hazard to steel, and the hazard of erosion are severe limitations that are difficult to overcome. Renfrow soil is better suited to urban use than Huska soil because it has higher natural fertility and organic matter content, a deeper root zone, better internal soil drainage, and no toxicity to plant life. Installing pier-and-beam type reinforced concrete foundations; bedding slab floors, sidewalks, and driveways with sand; and using high grade concrete mix reduce cracking in concrete structures caused by shrinking and swelling. The effects of very slow permeability and toxicity can be reduced by excavating the undesirable soil and replacing or mixing it with better quality soil. Heavy applications of gypsum improve soil structure. This improves the intake of water and air in the soil. The corrosion hazard to steel can be overcome by installing coated steel, noncorrosive copper tubing, or plastic pipe. Calcareous, sandy soil, like that in the South Canadian River streambed, makes excellent bedding or cover material for prevention of corrosion and problems caused by shrinking and swelling. The hazard of erosion can be reduced by planting temporary cover crops, such as rye or wheat, using plant residue for mulch, or by solid sodding with adapted bermudagrass. Soil slaking and piping can be prevented by stockpiling the topsoil from Renfrow soil and replating the sodium-affected Huska soil with an adequate amount of this topsoil to support plant life. Onsite investigations are needed to plan urban development.

This complex has low to medium potential for most recreational uses. Very slow permeability is a moderate limitation. The high content of exchangeable sodium is a severe limitation for camp areas, picnic areas, and playgrounds. The hazard of erosion is severe on paths and trails. Renfrow soil is better suited to recreational use than Huska soil.

This complex has low potential for tree and shrub plantings. The high sodium content, very slow permeability, low available water capacity, and low fertility of the Huska soil and high clay content of both soils restrict root growth and limit the plants that survive. Amur honeysuckle, eastern redcedar, lilac, osageorange, redbud, and skunkbush sumac are suited to these soils. Austrian pine, Chinese elm, common hackberry, Russian-olive, and silver maple are suited to Renfrow soil, and oriental arborvitae, Arizona cypress, and Rocky Mountain juniper are suited to Huska soil.

This complex is not assigned to a capability subclass or range site.

70—Slaughterville fine sandy loam, 1 to 3 percent slopes. This deep, well drained, very gently sloping soil is on side slopes and ridge crests of upland terraces in the western part of the county. Slopes are smooth and convex. The mapped areas are elongated and range from 10 to more than 160 acres.

Typically, the surface layer is brown fine sandy loam about 19 inches thick. The subsoil is brown fine sandy loam to a depth of about 42 inches. The underlying material is light brown fine sandy loam to a depth of 60 inches and reddish yellow loamy fine sand to a depth of 80 inches or more.

Included with this soil in mapping are soils similar to Slaughterville soil but having silty and clayey layers below a depth of 40 inches. Also included are Vanoss and Teller soils on similar topography. The included soils make up about 35 percent of the map unit, but individual areas are generally less than 10 acres.

This Slaughterville soil is high in natural fertility and medium in organic matter content. It is medium acid to neutral in the surface layer, slightly acid to moderately alkaline in the subsoil, and neutral to moderately alkaline in the underlying material. Permeability is moderately rapid, runoff is slow, and the available water capacity is medium. This soil has good tilth and can be worked throughout a wide range of moisture content. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has low shrink-swell potential and low corrosion potential to steel and concrete.

This soil has high potential for row crops, small grains, and legumes. Good tilth and fertility are easily maintained by returning crop residue to the soil and by adding fertilizer. Erosion is a moderate hazard where row crops are grown. Terracing, contour farming, minimum tillage, and the use of cover crops, including grasses and legumes in the cropping system, help to control erosion.

This soil has medium potential for tame pasture, hay, and rangeland. The available water capacity is the main limitation. Proper stocking rates, pasture rotations, and timely deferment of grazing help keep the tame pastures, range grasses, and soil in good condition. Overseeding tame pasture with legumes and adding fertilizer high in nitrogen increase yields and improve the organic matter content of the soil. Timely weed control is needed for high quality forage production.

This soil has high potential for building site development, such as dwellings, small commercial buildings, roads, streets, and landscape plantings. The potential is low for sanitary facilities because seepage can result in underground pollution. This soil is an excellent source of topsoil. The texture, natural fertility, and thickness of this soil makes it one of the most desirable soils for plant media. The available water capacity and organic matter content can be improved by incorporating adequate amounts of manure, peat moss, or plant residue into the soil. Pocket gophers can cause excessive damage to lawns and shrubs unless controlled. Onsite investigations are needed to locate areas of soils that have clayey or loamy materials below a depth of 40 inches.

This soil has low potential for farm pond reservoirs because of seepage. It has low potential for embankments, dikes, and levees because of seepage and piping.

This soil has high potential for most recreational uses. Steepness of slopes is a moderate limitation for playgrounds.

This soil has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This soil is in capability subclass IIe and in Sandy Prairie range site.

71—Slaughterville fine sandy loam, 3 to 5 percent slopes. This deep, well drained, gently sloping soil is on side slopes of upland terraces in the western part of the county. Slopes are smooth and convex. The mapped areas are elongated and range from 10 to more than 150 acres.

Typically, the surface layer is brown fine sandy loam about 18 inches thick. The subsoil is brown fine sandy loam to a depth of about 30 inches. The underlying material is yellowish red fine sandy loam to a depth of about 58 inches and yellowish red loamy fine sand to a depth of more than 76 inches.

Included with this soil in mapping are soils similar to Slaughterville soil but having silty and clayey layers below a depth of 40 inches. Also included are Teller soils in similar positions on the landscape. These included soils make up about 30 percent of the map unit, but individual areas are generally less than 10 acres.

This Slaughterville soil is high in natural fertility and medium in organic matter content. It is slightly acid or neutral in the surface layer, neutral in the subsoil, and neutral to moderately alkaline in the underlying material. Permeability is moderately rapid, runoff is slow or medium, and the available water capacity is medium. This soil is susceptible to wind or water erosion if not protected by adequate plant cover. It has good tilth and can be tilled throughout a wide range of moisture content. The root zone is more than 60 inches deep and is easily penetrated by plant roots.

This soil has medium potential for row crops, small grains, hay, tame pasture, and rangeland. Controlling erosion and maintaining soil fertility and structure are management concerns. Terracing, contour farming, and minimum tillage are needed to reduce runoff and control erosion in cultivated areas. Stubble mulching or cover crops grown during the winter and spring protect the soil from wind erosion. Additions of fertilizer high in nitrogen help to decay the stubble and plant residue on the soil surface and to maintain or improve the soil fertility and organic matter content. Hay and tame pastures can be improved by overseeding with legumes and adding fertilizer high in nitrogen. Proper stocking rates, pasture rotation, timely deferment of grazing, and timely weed control help keep the pasture and soil in good condition. Rangeland and pasture need to be protected from uncontrolled burning.

This Slaughterville soil has high potential for most urban uses. The limitations are slight for building site development, such as dwellings, small commercial buildings, roads, streets, and landscape plantings. The potential is low for sanitary facilities because seepage can result in underground pollution. This soil is an excellent source for topsoil. The texture, natural fertility, and thickness of this soil makes it one of the most desirable soils for plant media. The available water capacity and organic matter content can be improved by incorporating manure, peat moss, or plant residue into the soil. Pocket gophers can cause excessive damage to lawns and shrubs unless controlled. Onsite investigations are needed to locate areas of soils that have clayey or loamy materials below a depth of 40 inches.

This soil has low potential for farm pond reservoirs because of seepage in the reservoir area and piping through the embankments, dikes, and levees. Piping and seepage can be reduced by adding bentonite to the soil or by covering the impounded area with polyethylene plastic.

This soil has high potential for most recreational uses. Steepness of slope is a moderate limitation for playgrounds.

This soil has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This soil is in capability subclass IIIe and in Sandy Prairie range site.

72—Slaughterville Variant fine sandy loam, 5 to 8 percent slopes. This deep, well drained, sloping soil is on side slopes of upland terraces in the western part of the county. Slopes are smooth and convex. The mapped areas are long and narrow and range from 5 to more than 80 acres.

Typically, the surface layer is brown fine sandy loam about 11 inches thick. The subsoil is brown fine sandy loam to a depth of about 26 inches. The underlying material is light brown fine sandy loam to a depth of about 38 inches and pink fine sandy loam to a depth of about 45 inches. Below that are buried layers that are light brown silty clay loam and loam to a depth of 74 inches or more.

Included with this soil in mapping are intermingled areas of soils similar to the Slaughterville Variant soil, but depth to the buried layers is more than 60 inches. Also included are Teller soils in similar positions on the landscape. The included soils make up about 25 percent of the map unit, but individual areas are generally less than 10 acres.

This Slaughterville Variant soil is high in natural fertility and medium in organic matter content. It is medium acid or slightly acid in the surface layer, slightly acid to moderately alkaline in the subsoil, and neutral to moderately alkaline in the underlying material. The buried layers are neutral to moderately alkaline. Permeability is moderate, runoff is medium or rapid, and the available water capacity is medium. Erosion is a severe hazard, especially where row crops are grown. This soil has good tilth and can be worked throughout a wide range of moisture content. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has low shrink-swell potential above the buried layers and moderate shrink-swell potential in the buried layers. It has low corrosion potential to steel and concrete.

This soil has medium potential for row crops and small grains. Steepness of slopes, runoff, the available water capacity, and the hazard of erosion are the main limitations. Terraces, contour farming, and use of crop residue are needed to reduce erosion, conserve moisture, and to maintain tilth and soil structure. Minimum tillage and growing cover crops during the winter and spring protect the soil from wind and water erosion. Additions of fertilizer and the use of legumes in the cropping system help to maintain and improve the fertility and organic matter content of the soil.

This soil has medium potential for hay, tame pasture, and rangeland. It is best suited to these uses. Runoff and the available water capacity are the main limitations. Proper stocking rates, pasture rotation, and timely deferment of grazing help to control weeds, reduce runoff, and increase water intake. Overseeding tame pastures with legumes and adding fertilizer high in nitrogen improve the quality of forage and maintain the fertility and organic matter content of the soil. Native grasses can be maintained or improved by controlling brush and weeds, using suitable grazing practices, and protecting the range from uncontrolled burning.

This Slaughterville Variant soil has high potential for most urban uses. Seepage is a moderate limitation for sewage lagoons and pond reservoir areas. Steepness of slopes is a moderate limitation for small commercial buildings. Moderate permeability is a limitation for septic tank absorption fields. This soil has severe limitations for embankments, dikes, or levees because of piping. Pocket gophers can cause excessive damage to lawns and shrubs unless controlled.

This soil has high potential for camp areas, picnic areas, and paths and trails. It has low potential for playgrounds because of excessive slope.

This soil has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This soil is in capability subclass IVe and in Sandy Prairie range site.

73—Slaughterville fine sandy loam, 8 to 25 percent slopes. This deep, well drained, strongly sloping to steep soil is on breaks and side slopes of uplands bordering the flood plains of the South Canadian River. Slopes are wavy and convex. The mapped areas are long and narrow and range from 10 to more than 60 acres.

Typically, the surface layer is brown fine sandy loam about 11 inches thick. The subsoil is brown fine sandy loam to a depth of about 25 inches. The underlying material is reddish brown fine sandy loam to a depth of about 60 inches and pink loamy fine sand to a depth of 72 inches or more.

Included with this soil in mapping are soils similar to Slaughterville soil but having buried silty and clayey layers below a depth of 40 inches and soils on concave foot slopes but have a dark brown surface layer that is 20 to 40 inches thick. Small areas of severely eroded Slaughterville soils and areas of rock outcrop are also included. The included soils make up about 40 percent of the map unit, but individual areas are generally less than 10 acres.

This soil is high in natural fertility and medium in organic matter content. It is slightly acid or neutral in the surface layer and neutral to moderately alkaline in the subsoil. The underlying material is mildly alkaline or moderately alkaline. Permeability is moderately rapid, runoff is rapid, and the available water capacity is medium. Erosion is a severe hazard if this soil is not protected by permanent pasture or native plant cover. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has low shrink-swell potential and low corrosion potential to steel and concrete.

This soil has low potential for row crops and small grains. The hazard of erosion, rapid runoff, and steepness of slopes make this soil unsuitable for cropland. Some areas of soils that are less sloping can be shaped and planted to permanent grasses.

This soil has low potential for hay and tame pasture. It has medium potential for rangeland and is best suited to this use. Excessive runoff, the hazard of erosion, and the available water capacity are the main limitations. Permanent tame pasture can be maintained or improved by adding fertilizer high in nitrogen and by overseeding with legumes. Proper stocking rates, pasture rotation, and timely deferment of grazing reduce runoff, help to control erosion, and increase water intake. Native grasses can be maintained and the quality of forage improved by controlling brush, using suitable grazing practices, and protecting the range from uncontrolled burning.

This Slaughterville soil has low potential for most urban uses. The steepness of slopes is a severe limitation for most uses. Seepage is a severe limitation for sewage lagoons and sanitary landfills. Seepage and piping are limitations for pond reservoirs and for embankments, dikes, and levees.

This soil has low potential for most recreational uses. Steepness of slopes is a severe limitation for most uses, but it is a moderate limitation for paths and trails.

This soil has medium to high potential for windbreak tree and shrub plantings. American plum, Austrian pine, Amur honeysuckle, black locust, lilac, skunkbush sumac, eastern redcedar, green ash, common hackberry, honeylocust, osageorange, redbud, Rocky Mountain juniper, and Chinese elm are best suited.

This soil has medium potential for use as habitat for openland and rangeland wildlife and low potential for wetland wildlife. Steepness of slopes and runoff reduce wildlife food production.

This Slaughterville soil is in capability subclass VIe and in Sandy Prairie range site.

74—Vanoss-Urban land-Norge complex, 0 to 3 percent slopes. This complex consists of deep, well drained Vanoss soils; deep, well drained Norge soils; and areas of Urban land. The soils and Urban land of this complex are so intermingled that they could not be separated at the scale selected for mapping. This complex is most extensive in the western and southern parts of Norman and throughout the town of Noble. It is less extensive in the extreme eastern part of Lexington. The soils of this complex are on broad, smooth uplands. Vanoss soil is mostly in nearly level areas of the landscape. Norge soil is mostly in convex, very gently sloping areas of the landscape. The mapped areas are elongated or irregular in shape, about 250 to 3,600 feet wide and 700 to 8,000 feet long, and range from about 5 to 400 acres.

The Vanoss soil makes up about 40 percent of the map unit. Typically, the surface layer is brown silt loam about 12 inches thick. The subsoil is brown silt loam to a depth of about 21 inches and brown silty clay loam to a depth of about 38 inches. The buried soil is brown silty clay loam to a depth of about 56 inches and brown loam to a depth of about 70 inches.

The Vanoss soil is high in natural fertility and medium in organic matter content. It is medium acid to neutral in the surface layer, slightly acid or neutral in the subsoil, and neutral to moderately alkaline in the buried layers. Permeability is moderate, runoff is slow or medium, and the available water capacity is high. The root zone is more than 60 inches deep and is readily penetrated by plant roots. This soil is susceptible to water erosion and slightly susceptible to wind erosion. It has moderate shrink-swell potential and moderate corrosion potential to steel and concrete.

Urban land makes up about 40 percent of the map unit. It consists of areas of soils that are covered with buildings or other urban structures. Typical structures are single family dwellings, small commercial business buildings, university housing, classrooms, schools, churches, parking lots of less than 10 acres, streets, driveways, sidewalks, and highways.

The Norge soil makes up about 15 percent of the map unit. Typically, the surface layer is brown silt loam about 10 inches thick. The subsoil is reddish brown silty clay loam to a depth of about 31 inches, yellowish red silty clay loam to a depth of about 56 inches, and red silty clay loam to a depth of 80 inches or more.

The Norge soil is high in natural fertility and medium in organic matter content. The surface layer is slightly acid or neutral. Where limed, it ranges from slightly acid to moderately alkaline. The subsoil is slightly acid or neutral in the upper part and slightly acid to moderately alkaline in the lower part. Permeability is moderately slow, runoff is slow or medium, and the available water capacity is high. The root zone is more than 60 inches deep and is readily penetrated by plant roots. Norge soil is moderately susceptible to water erosion and slightly susceptible to wind erosion. It has moderate shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

Included with this complex in mapping are areas of Bethany, Grant, and Teller soils. Also included are areas of soils similar to the Vanoss soil but having a buried silty clay or silty clay loam layer below a depth of 50 inches. The included soils have been altered in some areas. The slowly permeable Bethany soils are in nearly level to slightly concave areas. Grant soils are 40 to 60 inches thick, are underlain by shale, and are on high ridge crests. The moderately permeable Teller soils are intermingled with the Vanoss and Norge soils near the western edge of delineations. The included soils make up about 5 percent of the map unit.

This complex has low potential for cultivated crops, hay, tame pasture, and rangeland. Areas of unaltered Vanoss and Norge soils are too small for operation of most farm equipment and for livestock use.

This complex has medium potential for most urban uses. The moderate shrink-swell potential, texture of the subsoil, moderate and moderately slow permeability, and corrosion to steel are limitations. The soils in this complex have slight limitations for area type sanitary landfills and for lawns, shrubs, and golf fairways. Shrinking and swelling can be reduced by bedding concrete foundations, slab floors, driveways, and sidewalks with sand to cushion against soil contraction and expansion. The texture of the subsoil can be improved by excavating the soil to the desired depth and mixing with coarser soils. Increasing the size of the filter field or length of septic lines can overcome the permeability limitation. The installation of coated steel, noncorrosive copper tubing, or plastic pipe reduces corrosion, and bedding and covering pipelines with calcareous, sandy materials can prevent corrosion. Additions of organic materials, such as manure, peat moss, or plant residues, improves the organic matter content and reduces runoff and the hazard of erosion.

This complex has medium potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are well suited to these soils.

This complex is not assigned to a capability subclass or range site.

75—Vanoss silt loam, 0 to 1 percent slopes. This deep, well drained, nearly level soil is on ridge crests of upland terraces in the western part of the county. Slopes are smooth and slightly convex. The mapped areas are 50 to 200 acres.

Typically, the surface layer is brown silt loam about 11 inches thick. The subsoil is brown silt loam to a depth of about 19 inches, brown silty clay loam to a depth of about 42 inches, and light brown silty clay loam to a depth of about 53 inches. The underlying material is reddish brown loam to a depth of about 70 inches and light reddish brown sandy clay loam to a depth of about 90 inches or more.

Included with this soil in mapping are areas of Bethany, Slaughterville, and Teller soils in similar positions on the landscape. Also included are areas of soils similar to the Vanoss soil but having a thicker surface layer and soils that have a buried silty clay or silty clay loam layer below a depth of 50 inches. The included soils make up about 15 percent of the map unit, but individual areas are generally less than 2 acres.

This Vanoss soil is high in natural fertility and medium in organic matter content. It is medium acid to neutral in the surface layer and slightly acid or neutral in the subsoil. The underlying material is neutral to moderately alkaline. Permeability is moderate, runoff is slow, and the available water capacity is high. This soil has good tilth, but it is easily compacted if tilled when wet. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has moderate shrink-swell potential and moderate corrosion potential to steel and concrete.

This soil has high potential for row crops, small grains, and legumes. The fertility and tilth can be maintained by seeding legumes, adding fertilizer, minimum tillage, and returning crop residue to the soil. Compaction and plowpans can be prevented by tilling at variable depths under optimum moisture conditions.

This soil has medium potential for hay, tame pasture, and rangeland. The organic matter content and soil compaction are the main limitations. Compaction can be reduced by restricting livestock during wet periods and by rotation grazing. Timely weed control and deferment of grazing during the growing season improve the quality of forage and prevent encroachment of undesirable plants.

This Vanoss soil has medium potential for most urban uses. The moderate shrink-swell potential, permeability, and seepage can be reduced by special design and careful installation procedures. High grade concrete mix that has adequate reinforcement steel properly bedded over sand reduces cracking in foundations, slabs, and walls caused by shrinking and swelling. Increasing the size of the absorption field reduces the effect of moderate permeability.

This soil has high potential for recreational use. There are no significant limitations for recreational development.

This soil has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland wildlife and medium potential for rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Vanoss soil is in capability class I and in Loamy Prairie range site.

76—Vanoss silt loam, 1 to 3 percent slopes. This deep, well drained, very gently sloping soil is on side slopes and ridge crests of broad upland terraces in the western part of Cleveland County. Slopes are smooth and convex. The mapped areas are 10 to 100 acres.

Typically, the surface layer is brown silt loam about 19 inches thick. The subsoil is brown silt loam to a depth of about 27 inches, yellowish brown silty clay loam to a depth of about 43 inches, and strong brown silty clay loam to a depth of about 51 inches. The underlying material is yellowish red very fine sandy loam to a depth of 80 inches or more.

Included with this soil in mapping are areas of Bethany, Slaughterville, and Teller soils in similar positions on the landscape. Also included are areas of soils similar to the Vanoss soil but having a thicker surface layer and soils that have a buried silty clay or silty clay loam layer below a depth of 50 inches. The included soils make up about 15 percent of this map unit, but individual areas generally are less than 2 acres.

This Vanoss soil is high in natural fertility and medium in organic matter content. It is medium acid to neutral in the surface layer and slightly acid or neutral in the subsoil. The underlying material is neutral or mildly alkaline. Permeability is moderate, runoff is medium, and the available water capacity is high. This soil has good tilth, but it is easily compacted if tilled when too wet. This soil has moderate hazard of erosion. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has moderate shrink-swell potential and moderate corrosion potential to steel and concrete.

This soil has high potential for row crops, small grains, and legumes. The soil fertility and tilth are easily maintained by minimum tillage, adding fertilizer, and returning crop residue to the soil. Runoff and the hazard of erosion are moderate limitations if row crops are grown. Terracing, contour farming, and the use of cover crops, including grasses and legumes in the cropping system, reduce runoff and help to control erosion. Compaction and plowpans can be prevented by tilling at variable depths under optimum moisture conditions.

This soil has medium potential for hay, tame pasture, and rangeland. The organic matter content, runoff, and soil compaction are the main limitations. Restricting livestock during wet periods reduces compaction. Timely weed control, rotation grazing, and deferment of grazing during part of the growing season reduce runoff, improve quality of forage, and help to prevent encroachment of undesirable plants.

This Vanoss soil has medium potential for most urban uses. The moderate shrink-swell potential, permeability, and seepage can be reduced by special design and careful installation procedures. High grade concrete mix that has adequate reinforcement steel properly bedded over sand reduces cracking in foundations, slabs, and walls caused by shrinking and swelling. Seepage and slope are limitations for sewage lagoons.

This soil has high potential for camp areas and picnic areas. Steepness of slopes is a limitation for playgrounds. The hazard of erosion is the main limitation for paths and trails.

This soil has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland wildlife and medium potential for rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This soil is in capability subclass IIe and in Loamy Prairie range site.

77—Teller fine sandy loam, 1 to 3 percent slopes. This deep, well drained, very gently sloping soil is on broad, convex ridge crests and lower side slopes of uplands in the western part of the county. Slopes are smooth and convex. The mapped areas are 5 to more than 150 acres.

Typically, the surface layer is brown fine sandy loam about 13 inches thick. The subsoil is brown fine sandy loam to a depth of about 19 inches, reddish brown sandy clay loam to a depth of about 37 inches, and yellowish red fine sandy loam to a depth of about 60 inches. The buried layer is silty clay loam. It is brown to a depth of about 69 inches and yellowish brown to a depth of about 84 inches.

Included with this soil in mapping are areas of soils similar to Teller soil but having a lighter colored surface layer. Also included are a few areas of Grant, Norge, Slaughterville, and Vanoss soils in similar positions on the landscape as Teller soil and areas of soils similar to Teller soil but having buried layers that are more sandy than the subsoil. The included soils make up about 15 percent of this map unit, but individual areas generally are less than 2 acres.

This Teller soil is high in natural fertility and medium in organic matter content. It is medium acid to slightly acid in the surface layer, slightly acid or neutral in the subsoil, and neutral to moderately alkaline in the underlying buried layers. Permeability is moderate, runoff is slow, and the available water capacity is medium. This soil has good tilth and can be tilled throughout a wide range of moisture content. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil is moderately susceptible to erosion. It has low shrink-swell potential to a depth of 60 inches and moderate potential below that. This soil has low corrosion potential to steel and moderate corrosion potential to concrete.

This soil has high potential for row crops and small grains. The hazard of erosion, especially where row crops are grown, is the main limitation. Runoff and the hazard of erosion can be reduced by terracing, contour farming, stripcropping, minimum tillage, and returning crop residue to the soil. The tilth, fertility, and organic matter content can be maintained or improved by returning crop residue to the soil and by adding fertilizer.

This soil has high potential for hay and tame pasture and medium potential for rangeland. Proper stocking rates, pasture rotation, and timely deferment of grazing help keep the grasses and soil in good condition. The soil fertility and quality of forage can be improved or maintained by adding fertilizer high in nitrogen and by overseeding pastures with legumes. Timely weed control helps to maintain plant vigor and to conserve moisture for plant use.

This Teller soil has high potential for dwellings, small commercial buildings, lawns, golf fairways, local roads and streets, and shallow excavations. Permeability is a moderate limitation for septic tank absorption fields. Seepage is a severe limitation for sewage lagoon areas and trench type sanitary landfills. This soil is well suited to use as topsoil or for roadfill. Pocket gophers can cause damage to landscape plantings unless controlled.

This soil has high potential for most recreational uses. Steepness of slopes is a moderate limitation for playgrounds.

This soil has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland wildlife habitat and medium potential for rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Teller soil is in capability subclass IIe and in Loamy Prairie range site.

78—Teller fine sandy loam, 3 to 5 percent slopes. This deep, well drained, gently sloping soil is on convex side slopes and foot slopes of uplands in the western part of the county. Slopes are smooth and convex. The mapped areas are 5 to more than 50 acres.

Typically, the surface layer is brown fine sandy loam about 13 inches thick. The subsoil is reddish brown fine sandy loam to a depth of about 21 inches, reddish brown sandy clay loam to a depth of about 42 inches, and reddish yellow fine sandy loam to a depth of about 60 inches. The underlying material is light red very fine sandy loam to a depth of 80 inches or more.

Included with this soil in mapping are intermingled areas of soils similar to the Teller soil but having silty clay loam, loamy fine sand, or silty clay layers within a depth of 30 to 60 inches of the surface. Also included are small areas of Harrah soils on concave foot slopes, Grant and Norge soils near the upper side slopes, and Slaughterville soils that are intermingled with the Teller soil. The included soils make up 15 percent of the map unit, but individual areas are generally less than 2 acres.

This Teller soil is high in natural fertility and medium in organic matter content. It is medium acid or slightly acid in the surface layer and medium acid to neutral in the subsoil. The underlying material is medium acid to moderately alkaline. Permeability is moderate, runoff is medium, and the available water capacity is medium. The tilth is good, and the soil can be worked throughout a wide range of moisture content. This soil has moderate hazard of erosion. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has low shrink-swell potential, low corrosion potential to steel, and moderate corrosion potential to concrete.

This soil has medium potential for row crops and small grains. The hazard of erosion, especially where row crops are grown, is the main limitation. All crop residue needs to be returned to the soil. Minimum tillage and the use of cover crops, including grasses and legumes in the cropping system, help to maintain tilth, reduce runoff, improve fertility, and control erosion. Terraces, contour farming, and vegetated waterways help to control runoff and erosion and to maintain production potential.

This soil has high potential for hay and tame pasture and medium potential for rangeland. Steepness of slopes, runoff, and the available water capacity are the main limitations. Proper stocking, rotation grazing, additions of nitrogen fertilizers, and timely weed control help keep the grass and soil in good condition. The quality of native grasses can be maintained or improved by controlling brush, using suitable grazing practices, and protecting the vegetation from fire.

This Teller soil has high potential for dwellings, lawns, golf fairways, local roads and streets, and shallow excavations. Permeability is a limitation for septic tank absorption fields. Seepage is the main limitation for sewage lagoon areas, pond reservoirs, and trench type sanitary landfills. Steepness of slope is the only limitation for small commercial buildings. This soil is well suited to use as topsoil or for roadfill. Pocket gophers can cause damage to landscape plantings unless controlled.

This soil has high potential for most recreational uses. Steepness of slopes is a moderate limitation for playgrounds.

This soil has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland wildlife and medium potential for rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This soil is in capability subclass IIIe and in Loamy Prairie range site.

79—Teller fine sandy loam, 2 to 7 percent slopes, eroded. This deep, well drained, very gently sloping to sloping soil is on ridge crests and side slopes of eroded uplands in the western and southern part of the county. Slopes are smooth and convex. This soil has been eroded to the extent that the present plow layer over much of the area consists of part of the original surface layer mixed with material from the subsoil. This plow layer is thinner, less friable, lower in fertility, and has poorer tilth than the original surface layer. The mapped areas are 5 to more than 80 acres.

Typically, the surface layer is brown fine sandy loam about 8 inches thick. The subsoil is reddish brown fine sandy loam to a depth of about 14 inches, yellowish red sandy clay loam to a depth of about 36 inches, and yellowish red fine sandy loam to a depth of about 60 inches. The underlying material is reddish yellow fine sandy loam to a depth of about 70 inches.

Included with this soil in mapping are areas of soils similar to the Teller soil but having silty clay loam, loamy fine sand, or silty clay layers within a depth of 30 to 60 inches of the surface. Also included are small areas of Harrah soils on concave foot slopes, Grant and Norge soils near the upper side slopes, and Slaughterville soils that are intermingled with the Teller soil. The included soils make up about 15 percent of the map unit, but individual areas are generally less than 2 acres.

This Teller soil is medium in natural fertility and low in organic matter content. It is medium acid or slightly acid in the surface layer, slightly acid or neutral in the subsoil, and neutral to moderately alkaline in the underlying material. Permeability is moderate, runoff is medium or rapid, and the available water capacity is medium. This soil has fair tilth and can be tilled throughout a moderately wide range of moisture content. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil is moderately susceptible to water erosion. It has low shrink-swell potential, low corrosion potential to steel, and moderate corrosion potential to concrete.

This soil has low potential for row crops and small grains. The hazard of erosion, loss of fertility, low organic matter content, and thin surface layer are the main limitations. Minimum tillage and the use of cover crops, including grasses and legumes in the cropping system, reduce runoff, improve fertility and soil tilth, and help to control erosion. Terracing, farming on the contour, and vegetated waterways are needed to prevent excessive soil loss. The fertility, organic matter content, and tilth can be improved by generous applications of barnyard manure and commercial fertilizer and by growing green manure crops.

This soil has medium potential for hay, tame pasture, and rangeland. It is best suited to use as rangeland. The loss of topsoil has lowered the natural fertility and organic matter content and reduced the water infiltration rate. Seeding legumes, fertilizing, proper stocking, and leaving adequate plant cover late in summer and in fall help to control runoff, increase organic matter content, and improve fertility, tilth, and water infiltration.

This Teller soil has high potential for dwellings, local roads and streets, lawns, golf fairways, and area type landfills. Moderate permeability is a limitation for septic tank absorption fields. Seepage is a limitation for sewage lagoon areas and trench type sanitary landfills. Steepness of slopes is a limitation for small commercial buildings. Seepage and steepness of slopes are limitations for pond reservoir areas.

This soil has high potential for most recreational uses. Steepness of slopes is a limitation for construction of playgrounds.

This soil has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland wildlife and medium potential for rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Teller soil is in capability subclass IVe and in Loamy Prairie range site.

80—Teller fine sandy loam, 5 to 8 percent slopes. This deep, well drained, sloping soil is on side slopes and foot slopes of uplands in the western and central parts of the county. Slopes are smooth and convex. The mapped areas range from 5 to more than 50 acres.

Typically, the surface layer is dark brown fine sandy loam about 10 inches thick. The subsoil is dark brown fine sandy loam to a depth of about 16 inches, brown sandy clay loam to a depth of about 27 inches, yellowish red sandy clay loam to a depth of about 38 inches, and yellowish red fine sandy loam to a depth of about 63 inches. The buried layer is red silty clay to a depth of about 80 inches.

Included with this soil in mapping are areas of Norge and Teller Variant soils. Norge soils are in similar positions on slopes as Teller soil. The included soils make up about 10 percent of the map unit, but individual areas are generally less than 2 acres.

This Teller soil is high in natural fertility and medium in organic matter content. The surface layer is medium acid or slightly acid. Where limed, it ranges from medium acid to moderately alkaline. The subsoil is slightly acid or neutral, and the buried layer is mildly alkaline or moderately alkaline. Permeability is moderate, runoff is rapid, and the available water capacity is medium. This soil has good tilth and can be worked throughout a wide range of moisture content. It is moderately susceptible to erosion if not protected by adequate plant cover. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has low shrink-swell potential to a depth of 60 inches and moderate potential below that. It has low corrosion potential to steel and moderate corrosion potential to concrete.

This soil has medium potential for row crops and small grains. Runoff and the hazard of erosion are the main limitations. Minimum tillage and use of cover crops, including grasses and legumes in the cropping system, reduce runoff, maintain tilth and fertility, and help to control erosion. Terraces, contour farming, and vegetated waterways help to prevent excessive soil loss.

This soil has medium potential for rangeland, hay, and tame pasture. Runoff and the hazard of erosion are the main limitations. Adding fertilizer to tame pastures and overseeding pastures with legumes improve soil fertility and increase plant vigor and quality of forage. This helps to reduce runoff and the hazard of erosion. The quality of pasture plants and native grasses can be improved by controlling weeds and brush, using deferred and rotation grazing, and protecting the vegetation from fire.

This Teller soil has high potential for dwellings, local roads and streets, lawns, golf fairways, topsoil, and roadfill. Moderate permeability is a limitation for septic tank absorption fields. Seepage is a limitation for sewage lagoon areas and trench type sanitary landfills. Steepness of slopes is a limitation for small commercial buildings. Steepness of slopes and seepage are limitations for pond reservoir areas. Pocket gophers can cause major damage to lawns and shrubs unless controlled.

This soil has high potential for most recreational uses. Steepness of slopes is the main limitation for construction of playgrounds.

This soil has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland wildlife and medium potential for rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This soil is in capability subclass IVe and in Loamy Prairie range site.

81—Norge silt loam, 1 to 3 percent slopes. This deep, well drained, very gently sloping soil is on ridge crests of uplands in the central and western part of the county. Slopes are smooth and convex. The mapped areas are 5 to more than 50 acres.

Typically, the surface layer is brown silt loam about 10 inches thick. The subsoil is reddish brown silty clay loam to a depth of about 17 inches, yellowish red silty clay loam to a depth of about 56 inches, and red silty clay to a depth of about 72 inches.

Included with this soil in mapping are areas of Grant, Pawhuska, Teller, and Vanoss soils and soils similar to the Norge soil but having claybeds at a depth of 40 to 60 inches. The included soils make up about 15 percent of the map unit, but individual areas generally are less than 2 acres.

This Norge soil is high in natural fertility and medium in organic matter content. It is medium acid to neutral in the surface layer and upper part of the subsoil and slightly acid to moderately alkaline in the lower part. Permeability is moderately slow, runoff is medium, and the available water capacity is high. This soil has good tilth, but it is easily compacted if tilled when too wet. This soil is moderately susceptible to erosion. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has moderate shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

This soil has high potential for row crops, legumes, and small grains. The tilth and soil fertility are easily maintained and improved by minimum tillage and by returning crop residue to the soil. Terracing, contour farming, and the use of cover crops, including grasses and legumes in the cropping system, reduce runoff and help to control erosion.

This soil has medium potential for hay, tame pasture, and rangeland. Overgrazing causes excessive runoff, reduces soil fertility, and increases the number of undesirable plants. Additions of fertilizer high in nitrogen improves plant vigor, fertility, and organic matter content. Proper stocking rates, pasture rotation, timely weed control, and deferment of grazing help keep pasture grasses, rangeland, and soil in good condition.

This Norge soil has medium potential for most urban uses. The moderate shrink-swell potential and the clayey subsoil are moderate limitations for building site development, trench type landfills, and cover for landfills. Steepness of slopes is a moderate limitation for sewage lagoons. Moderately slow permeability is a severe limitation for septic tank absorption fields. These limitations can be reduced by special design and careful installation procedures.

This soil has low to high potential for recreational use. Steepness of slopes is a moderate limitation for construction of playgrounds. The hazard of erosion is severe for paths and trails. This soil has slight limitations for camp areas and picnic areas.

This soil has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland wildlife and medium potential for rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Norge soil is in capability subclass IIe and in Loamy Prairie range site.

82—Norge silt loam, 3 to 5 percent slopes. This deep, well drained, gently sloping soil is on side slopes of uplands in the western and central part of the county. Slopes are smooth and convex. The mapped areas are 5 to more than 50 acres.

Typically the surface layer is brown silt loam about 12 inches thick. The subsoil is reddish brown silty clay loam to a depth of about 36 inches, red silty clay loam to a depth of about 58 inches, and red silty clay to a depth of about 84 inches.

Included with this soil in mapping are areas of Grant, Pawhuska, and Teller soils and soils similar to the Norge soil but having claybeds at a depth of 40 to 60 inches. The included soils make up about 15 percent of the map unit, but individual areas generally are less than 2 acres.

This Norge soil is high in natural fertility and medium in organic matter content. It is slightly acid or neutral in the surface layer and upper part of the subsoil and neutral to moderately alkaline in the lower part. Permeability is moderately slow, runoff is rapid, and the available water capacity is high. Tilth is good, but the surface layer is easily compacted if tilled when too wet. This soil is moderately susceptible to erosion. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has moderate shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

This soil has medium potential for row crops and small grains. Steepness of slopes, the hazard of erosion, and the organic matter content are the main limitations. Terraces, contour farming, and use of crop residue reduce runoff and erosion, improve organic matter content, and maintain soil structure. Seeding legumes, adding fertilizer, using sown crops or crops that produce a large amount of residue, and minimum tillage are needed.

This soil has medium potential for hay, tame pasture, and rangeland. The organic matter content, steepness of slopes, and runoff are limitations. Rotation grazing, adding fertilizers high in nitrogen, and leaving adequate plant cover late in fall and in winter improve the organic matter content and reduce runoff. The quality of the forage can be maintained or improved by controlling weeds, using suitable grazing practices, and protecting the vegetation from fire.

This Norge soil has medium potential for most urban uses. Steepness of slopes is a moderate limitation for sewage lagoons. The moderate shrink-swell potential and clayey subsoil are moderate limitations for building site development, trench type sanitary landfills, and cover for landfills. Moderately slow permeability is a severe limitation for septic tank absorption fields. High grade concrete mix that has adequate reinforcement steel properly bedded over sand reduces cracking in foundations, slabs, and walls caused by shrinking and swelling. Increasing the size of the absorption field reduces the effect of moderately slow permeability.

This soil has low to high potential for recreational use. The hazard of erosion is severe for paths and trails. Steepness of slopes is a moderate limitation for playgrounds. This soil has slight limitations for camp areas and picnic areas.

This soil has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland wildlife and medium potential for rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Norge soil is in capability subclass IIIe and in Loamy Prairie range site.

83—Norge silt loam, 2 to 7 percent slopes, eroded. This deep, well drained, very gently sloping to sloping, eroded soil is on side slopes and foot slopes of uplands in the central and western part of the county. Slopes are smooth and convex. This soil has been eroded to the extent that the present plow layer over much of the area consists of part of the original surface layer mixed with material from the subsoil. This soil is less fertile, and the plow layer is less friable, thinner, and has poorer tilth than the original surface layer. The mapped areas are 10 to more than 80 acres.

Typically, the surface layer is brown silt loam about 7 inches thick. The subsoil is silty clay loam. It is reddish brown to a depth of about 24 inches, yellowish red and reddish yellow to a depth of about 72 inches, and red to a depth of 80 inches or more.

Included with this soil in mapping are areas of Grant, Pawhuska, Renfrow, and Teller soils and soils similar to Norge soil but having claybeds at a depth of 40 to 60 inches. Grant soils are near the upper part of the side slopes, and Renfrow and Teller soils are in lower positions on side slopes than Norge soil. The Pawhuska soils are intermingled with Norge soil. The included soils make up about 15 percent of the map unit, but individual areas are generally less than 2 acres.

This Norge soil is medium in natural fertility and low in organic matter content. It is slightly acid or neutral in the surface layer and upper part of the subsoil and neutral to moderately alkaline in the lower part. Permeability is moderately slow, runoff is rapid, and the available water capacity is high. This soil has fair tilth and needs to be worked within a narrow range in moisture content. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has moderate shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

This soil has low potential for row crops and small grains. The severe hazard of erosion, loss of fertility and organic matter, and the thin surface layer are the main limitations. Erosion can be reduced by terracing, contour farming, minimum tillage, and use of crop residue. The fertility and organic matter content can be maintained or improved by returning crop residue to the soil, by adding fertilizer, and by including grasses and legumes in the cropping system.

This soil has medium potential for hay, tame pasture, and rangeland. Loss of natural fertility, low organic matter content, and slow water infiltration are the main limitations. The soil fertility, organic matter content, and water infiltration rate can be improved by seeding legumes, adding fertilizer, using proper stocking rates, rotation grazing, timely deferment of grazing, and leaving adequate plant cover to reduce runoff. Areas in native range can be improved by proper stocking rates, rotation grazing, timely deferment of grazing, and restricting use during dry periods to help keep the grass and soil in good condition.

This Norge soil has medium potential for most urban uses. The moderate shrink-swell potential is a limitation for building site development. The moderately slow permeability is a severe limitation for septic tank absorption fields. Steepness of slopes is a moderate limitation for sewage lagoon areas and small commercial buildings. High grade concrete mix that has adequate reinforcement steel properly bedded over sand reduces cracking in foundations, slabs, and walls caused by shrinking and swelling. Increasing the size of the absorption field reduces the effects of moderately slow permeability.

The soil has low to high potential for recreational use. Steepness of slopes is a severe limitation for playgrounds. The hazard of erosion is a severe limitation for paths and trails. The limitations for camp areas and picnic areas are slight.

This soil has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland wildlife and medium potential for rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Norge soil is in capability subclass IVe and in Loamy Prairie range site.

84—Grant-Huska complex, 1 to 5 percent slopes. This complex consists of deep, well drained Grant soil and deep, moderately well drained Huska soil. The soils of this complex were so intermingled they could not be separated at the scale selected for mapping. These soils are in the central and western part of the county. The Grant soil is in smooth, slightly convex, and darker colored areas of ridge crests and side slopes on uplands, and the Huska soil is in slightly concave, lighter colored areas surrounded by Grant soil. Individual areas of Huska soil are 1/8 acre to 5 acres. The mapped areas are elongated and are 10 to more than 250 acres.

The Grant soil makes up about 60 percent of the map unit. Typically, the surface layer is brown silt loam about 9 inches thick. The subsoil is reddish brown silt loam to a depth of about 15 inches, reddish brown and yellowish red silty clay loam to a depth of about 32 inches, and red silty clay loam to a depth of about 50 inches. The underlying material is light reddish brown, weakly laminated, calcareous sandstone or siltstone.

The Grant soil is high in natural fertility and medium in organic matter content. Permeability is moderate, runoff is medium or rapid, and the available water capacity is medium. This soil is slightly acid or neutral in the surface layer and upper part of the subsoil and slightly acid to moderately alkaline in the lower part. The underlying material is mildly alkaline or moderately alkaline. This soil is friable and is easily tilled. The root zone is 40 to 60 inches deep and is easily penetrated by plant roots. This soil has low shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

The Huska soil makes up about 15 percent of the map unit. Typically, the surface layer is brown silt loam about 7 inches thick. The subsoil is silty clay. It is brown to a depth of about 29 inches and is coarsely mottled. Mottles are yellowish red to a depth of about 52 inches. The underlying material is light reddish brown, weakly laminated, calcareous sandstone or siltstone to a depth of 60 inches or more.

The Huska soil is low in natural fertility and organic matter content. Permeability is very slow, runoff is slow to medium, and the available water capacity is low. This soil is slightly acid or neutral in the surface layer and mildly alkaline or moderately alkaline and calcareous in the subsoil and underlying material. This soil slakes and erodes easily if wet and crusts over if dry. The root zone is 40 to 60 inches deep, but plant root development is somewhat restricted because of the high clay content and presence of sodium in the subsoil. This soil has high shrink-swell potential, high corrosion potential to steel, and moderate corrosion potential to concrete.

Included with this complex in mapping are small areas of Kingfisher, Norge, Renfrow, and Teller soils. The moderately deep Kingfisher soils and the deep Norge soils are intermingled with the Grant soil on ridge crests. The very slowly permeable Renfrow soils are on side slopes. The deep, well drained Teller soils are in lower positions on side slopes than the soils of this complex. The included soils make up about 25 percent of the map unit, but individual areas are generally less than 2 acres.

This complex has medium potential for row crops or small grains. The very high sodium content, very slow permeability, and low available water capacity of the Huska soil and the hazard of erosion of both soils are the main limitations. Improving soil structure, reducing crusting, and controlling water erosion are management concerns. The cropping system needs to include crops that produce large amounts of residue. Returning residue to the soil improves soil structure, increases fertility and water intake, and helps to prevent surface crusting. Contour farming, minimum tillage, and use of crop residue protect the soils from erosion.

This complex has medium potential for hay, tame pasture, and rangeland. The crusting of the surface layer limits water infiltration of the Huska soil and reduces the potential productivity of the soils in this complex. Removing livestock during wet periods and rotation grazing reduce compaction of the surface layer and improve plant vigor. Adding fertilizers high in nitrogen and leaving considerable plant cover late in fall and in winter to slow runoff and increase infiltration can increase productivity. Controlling brush, using suitable grazing practices, and protecting the range from fire help to maintain or improve the vigor and the quality of native grasses.

This complex has medium potential for most urban uses. The Grant soil has moderate limitations for sanitary facilities and small commercial buildings because of depth to bedrock, steepness of slopes, and moderate permeability. It has slight limitations for dwellings, local roads and streets, and landscaping. The Huska soil has severe limitations for most urban uses because of high shrink-swell potential, depth to bedrock, excess sodium, and very slow permeability. These limitations are difficult and expensive to overcome.

This complex has low to high potential for recreational use. The Grant soil has slight limitations for camp areas and picnic areas and moderate limitations for playgrounds because of steepness of slopes. The Huska soil has severe limitations for all uses because of excess sodium and excess salt. These soils have severe limitations for paths and trails because of the hazard of erosion.

This complex has medium potential for windbreak tree and shrub plantings. The Grant soil has high potential, and the Huska soil has low potential for production of trees. Amur honeysuckle, redbud, eastern redcedar, osageorange, skunkbush sumac, and lilac are suited to these soils. Austrian pine, common hackberry, honeylocust, silver maple, American plum, and Chinese elm are well suited to Grant soil. Oriental arborvitae, Arizona cypress, and Rocky Mountain juniper are well suited to Huska soil. The high sodium content, low available water capacity, and very slow permeability of the Huska soil are severe limitations for trees and shrubs.

This complex has medium potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This complex is in capability subclass IVs. Grant soil is in Loamy Prairie range site, and Huska soil is in Shallow Claypan range site.

85—Norge silt loam, 5 to 8 percent slopes. This deep, well drained, sloping soil is on side slopes and foot slopes of uplands in the western part of the county. Slopes are smooth and convex. The mapped areas are 5 to more than 50 acres.

Typically, the surface layer is brown silt loam about 9 inches thick. The subsoil is reddish brown silty clay loam to a depth of about 26 inches and yellowish red and reddish yellow silty clay loam to a depth of 80 inches.

Included with this soil in mapping are areas of Grant, Pawhuska, Renfrow, and Teller soils and soils similar to the Norge soil but having shale, sandstone, or claybeds at a depth of 60 to 80 inches. The included soils make up about 15 percent of the map unit, but individual areas generally are less than 2 acres.

This soil is high in natural fertility and medium in organic matter content. It is slightly acid or neutral in the surface layer and upper part of the subsoil and neutral to moderately alkaline in the lower part. Permeability is moderately slow, runoff is rapid, and the available water capacity is high. Tilth is good, but the surface layer is easily compacted if tilled when too wet. This soil is easily eroded by water. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has moderate shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

This soil has medium potential for row crops and small grains. The organic matter content and the hazard of erosion caused by steepness of slopes and runoff are the main limitations. Terraces, contour tillage, minimum tillage, and the use of cover crops, including grasses and legumes in the cropping system, are needed. The organic matter content and soil structure can be maintained and improved by returning crop residue to the soil, tilling the soil under optimum moisture conditions, and adding fertilizer.

This soil has medium potential for hay, tame pasture, and rangeland. Runoff and the organic matter content are the main limitations. Generous applications of fertilizer to hay crops and tame pastures, rotation grazing, and leaving adequate amounts of forage on the soil during periods of heavy rainfall improve organic matter content and plant vigor and reduce runoff. Reducing runoff provides more moisture for plant use. Areas of soils used for pasture or range can be improved by controlling weeds, using suitable grazing practices, and protecting the vegetation from fire.

This Norge soil has medium potential for most urban uses. The clayey subsoil and moderate shrink-swell potential are moderate limitations for building sites, sanitary landfills, and cover for landfills. Steepness of slopes is a moderate limitation for sewage lagoons. The moderately slow permeability is a severe limitation for septic tank absorption fields. High grade concrete mix that has adequate reinforcement steel properly bedded over sand reduces cracking in foundations, slabs, and walls caused by shrinking and swelling. Increasing the size of the absorption field reduces the effects of moderately slow permeability.

The soil has low to high potential for recreational use. The hazard of erosion is a severe limitation for paths and trails. Steepness of slopes is a severe limitation for playgrounds. This soil has slight limitations for camp areas or picnic areas.

The soil has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland wildlife and medium potential for rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Norge soil is in capability subclass IVe and in Loamy Prairie range site.

86—Norge-Urban land complex, 3 to 8 percent slopes. This complex consists of deep, well drained Norge soil and Urban land. The soil and Urban land of this complex are so intermingled that they could not be separated at the scale selected for mapping. They are most extensive in eastern Norman and throughout Noble, and small areas of this soil and Urban land are in southern Moore and southwestern Oklahoma City. The gently sloping to sloping Norge soil is on side slopes of uplands bordering intermittent streams. The mapped areas are long and narrow, range from 150 to 600 feet wide and from 500 to 4,000 feet long, and are from 5 to 60 acres.

The Norge soil makes up about 45 percent of the map unit. Typically, the surface layer is brown silt loam about 10 inches thick. The subsoil is silty clay loam to a depth of about 55 inches. It is reddish brown in the upper part and yellowish red in the lower part. The underlying buried layer is reddish brown silty clay loam to a depth of 80 inches or more.

The Norge soil is high in natural fertility and medium in organic matter content. It is slightly acid or neutral in the surface layer. Where limed, it ranges from slightly acid to moderately alkaline. The subsoil is slightly acid or neutral, and the buried layer ranges from neutral to moderately alkaline. Permeability is moderately slow, runoff is medium or rapid, and the available water capacity is high. The root zone is more than 60 inches deep and is readily penetrated by plant roots. This soil is moderately susceptible to water erosion and slightly susceptible to wind erosion. It has moderate shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

Urban land makes up about 45 percent of the map unit. It consists of areas of soils that have been covered with buildings or other urban structures. Typical structures are single family homes, apartment dwellings, municipal buildings, parking lots of less than 5 acres, streets, sidewalks, and driveways.

Included with this complex in mapping are a few areas of Grant, Renfrow, Pawhuska, and Teller soils. These soils are intermingled with the Norge soil. The included soils make up about 10 percent of the map unit.

This complex has low potential for cropland, rangeland, hay, or tame pasture. Areas of the Norge soil are too small for operation of most farm implements and for livestock use.

This complex has medium potential for most urban uses. It has high potential for lawns, landscaping, and golf fairways and low potential for septic tank absorption fields. The steepness of slopes, moderate shrink-swell potential, texture of subsoil, and corrosion to steel are moderate limitations for other urban uses. Steepness of slopes is the main limitation for sewage lagoons and small commercial buildings. Deep cuts and fills are needed to obtain a desirable building site. Concrete foundations, slab floors, sidewalks, and driveways can be bedded with several inches of sand to reduce structural damage from shrinking and swelling. Excavating the soil down to the desired depth, mixing it with sandy soils, and backfilling the area improve the soil texture and permeability of the subsoil for septic tank filter fields. Septic lateral lines can be lengthened to overcome the effects of moderately slow permeability in some areas. Copper tubing or plastic pipe can be substituted for steel to prevent corrosion in areas where the building codes permit this alternative. Bedding and covering pipelines with calcareous sandy soils, such as those found in the South Canadian River bed, reduce corrosion and stress from shrinking and swelling. Runoff can be reduced and the hazard of erosion can be controlled by adding organic materials, planting temporary cover crops, or solid sodding with perennial grasses. Topsoil needs to be removed and stockpiled for later use in covering cut and fill areas around building sites to provide a desirable media for plant growth.

This complex has high potential for windbreak tree and shrub plantings. American plum, Amur honeysuckle, Arizona cypress, Austrian pine, black locust, autumn-olive, bur oak, Chinese elm, common hackberry, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This complex is not assigned to a capability subclass or range site.

88—Grant-Urban land-Huska complex, 1 to 5 percent slopes. This complex consists of deep, well drained Grant soil; deep, moderately well drained Huska soil; and areas of Urban land. The soils and Urban land of this complex were so intermingled they could not be separated at the scale selected for mapping. These soils are on very gently to gently sloping uplands. They are most extensive in the eastern part of Norman, and small areas are in northern Moore and southwestern Oklahoma City. Grant soil is on convex relief in the unaltered areas of the landscape. Huska soil is in slightly concave, rounded or elongated, light colored unaltered areas of the landscape. The mapped areas are elongated, from about 150 to 1,200 feet wide and 700 to 3,500 feet long, and are about 3 to 80 acres.

The Grant soil makes up about 40 percent of the map unit. Typically, the surface layer is brown silt loam about 8 inches thick. The subsoil is brown silt loam to a depth of about 12 inches, yellowish red to red silty clay loam to a depth of about 37 inches, and light red silty clay loam to a depth of about 43 inches. The underlying material is soft, red, and light gray siltstone to a depth of 48 inches or more.

The Grant soil is high in natural fertility and medium in organic matter content. It is slightly acid or neutral in the surface layer and upper and middle parts of the subsoil and is neutral to moderately alkaline in the lower part. The underlying material is moderately alkaline and generally is calcareous. Permeability is moderate, runoff is slow or medium, and the available water capacity is high. The root zone is 40 to 60 inches deep and can be readily penetrated by plant roots. This soil is moderately susceptible to water erosion and slightly susceptible to wind erosion. It has moderate shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

Urban land makes up about 35 percent of the map unit. It consists of areas of soils covered with buildings or other urban structures. Typical structures are single family dwellings, apartment dwellings, parking lots of less than 3 acres, streets, driveways, and sidewalks.

The Huska soil makes up about 15 percent of the map unit. Typically, the surface layer is brown silt loam about 5 inches thick. The subsoil is silty clay. It is brown or light yellowish brown to a depth of about 28 inches, coarsely mottled light brownish gray and reddish yellow to a depth of about 38 inches, and reddish yellow to a depth of about 48 inches. The underlying material is soft, red siltstone or sandstone.

The Huska soil is low in natural fertility and organic matter content. It is slightly acid or neutral in the surface layer, mildly alkaline or moderately alkaline in the upper part of the subsoil, moderately alkaline or strongly alkaline in the middle and lower parts, and moderately alkaline in the underlying material. Permeability is very slow, runoff is slow to medium, and the available water capacity is low. The subsoil is moderate to high in soluble salt content and high in sodium content. The root zone is 40 to 60 inches deep, but plant root development is somewhat restricted because of the high clay content and presence of sodium and soluble salts in the subsoil.

This soil is highly susceptible to water erosion and slightly susceptible to wind erosion. It slakes easily if wet. Piping is common in cut and fill areas. This soil has high shrink-swell potential, high corrosion potential to steel, and moderate corrosion potential to concrete.

Included with this complex in mapping are areas of Kingfisher, Norge, and Renfrow soils. The included soils have been altered in places. The moderately deep, well drained, moderately slowly permeable Kingfisher soils and the well drained, very slowly permeable Renfrow soils are on similar topography as the Grant soil. The well drained, moderately slowly permeable Norge soils are in lower positions on side slopes than the Grant and Huska soils. The included soils make up about 10 percent of the map unit.

This complex is not suited to cultivated crops, hay, tame pasture, or rangeland. Areas of Grant and Huska soils are too small for operation of most farm equipment and for livestock use.

This complex has low potential for most urban uses. High shrink-swell potential, very slow permeability, high sodium content, high corrosion hazard to steel, and high susceptibility to water erosion are severe limitations of the Huska soil that are difficult to overcome. The Grant soil is better suited to urban uses. Depth to bedrock and moderate permeability are moderate limitations for septic tank absorption fields. The Grant soil has slight limitations for dwellings, lawns, landscaping, and golf fairways. Onsite investigations are needed to locate the best building site. Installing pier-and-beam type reinforced concrete foundations and bedding slab floors, sidewalks, and driveways with sand reduce cracking from shrinking and swelling. Corrosion can be reduced by installing coated steel, noncorrosive copper tubing, or plastic pipe. Water erosion can be reduced by planting temporary cover crops, such as rye or wheat, or by using plant residue for mulch until permanent vegetation can be established. Soil slaking and piping in the Huska soil can be prevented by stockpiling the topsoil cut from the Grant soil and covering the Huska soil with topsoil that is better suited to support plant life.

This complex has medium potential for windbreak tree and shrub plantings. The depth to rock in the Grant soil and the sodium content, very slow permeability, low available water capacity, low fertility, and clayey subsoil of the Huska soil restrict root growth and limit the kind of plants that will survive. Amur honeysuckle, eastern redcedar, lilac, osageorange, redbud, and skunkbush sumac are suited to these soils. American plum, Austrian pine, Chinese elm, common hackberry, honeylocust, and silver maple are suited to the Grant soil, and oriental arborvitae, Arizona cypress, and Rocky Mountain juniper are well suited to the Huska soil.

This complex is not assigned to a capability subclass or range site.

90—Keokuk very fine sandy loam, rarely flooded. This deep, well drained, nearly level to very gently sloping soil is on high flood plains along the South Canadian River. Slopes are less than 2 percent and are smooth to slightly undulating. This soil is subject to rare flooding. The mapped areas are elongated, from 200 to 2,500 feet wide and 500 to 10,000 feet long, and are 10 to more than 100 acres.

Typically, the surface layer is brown and dark grayish brown very fine sandy loam about 12 inches thick. The subsoil is brown very fine sandy loam to a depth of about 26 inches. The underlying material is light brown and brown very fine sandy loam to a depth of about 41 inches. The next layer is brown silty clay loam to a depth of about 48 inches. The next layer is light brown very fine sandy loam to a depth of about 54 inches, and the next layer is pink fine sandy loam to a depth of about 66 inches. The lower part of the underlying material is light brown very fine sandy loam to a depth of 84 inches or more.

Included with this soil in mapping are a few areas of Asher, Canadian, Goodnight, and Gracemont Variant soils. Also included are soils similar to Keokuk soil but having a high water table from 40 to 60 inches below the surface. The moderately well drained Asher soils are in slightly higher positions on flood plains than Keokuk soil. The excessively drained Goodnight soils are on higher dunes. The somewhat poorly drained Gracemont Variant soils are in slightly lower positions on flood plains than Keokuk soil. The included soils make up about 15 percent of the map unit, but individual areas are generally less than 2 acres.

This Keokuk soil is high in natural fertility and medium in organic matter content. It is slightly acid to moderately alkaline in the surface layer and moderately alkaline in the underlying material. Permeability is moderate, runoff is slow, and available water capacity is high. This soil has good tilth and can be worked throughout a wide range of moisture content. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has a high water table from 6 to 10 feet below the surface most of the year, and plant roots are limited mostly to the unsaturated zone above. This soil has low shrink-swell potential and low corrosion potential to steel and concrete.

This soil has high potential for row crops, small grains, hay, tame pasture, and rangeland. Installing diversions and dikes can help to prevent flooding, but damage from overflow is rare. The tilth and soil structure can be maintained or improved by minimum tillage, seeding legumes, and returning crop residue to the soil. The fertility and organic matter content and the quality of hay and tame pastures can be maintained or improved by adding fertilizer or manure or by overseeding with legumes. All grasses can be maintained by controlling brush and weeds and preventing fire.

This Keokuk soil has low potential for most urban uses. The hazard of flooding can be reduced only by major flood control measures. This soil is well suited to use as topsoil or for daily cover for landfill.

This soil has high potential for most recreational uses. The hazard of flooding is severe for camp areas.

The soil has high potential for windbreak tree and shrub plantings. American plum, American sycamore, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern cottonwood, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for rangeland and openland wildlife. It has low potential for use as habitat for wetland wildlife.

This Keokuk soil is in capability class I and in Loamy Bottomland range site.

91—Gracemont Variant silt loam, occasionally flooded. This deep, somewhat poorly drained, nearly level to very gently sloping soil is on low flood plains along the South Canadian River. Slopes are less than 2 percent and are smooth to slightly undulating. This soil is subject to occasional flooding for very brief to brief periods during the spring and summer. It has an apparent high water table from 1/2 foot to 3 1/2 feet below the surface from fall to spring. The mapped areas are long and narrow, from 100 to 1,500 feet wide and 900 to 9,000 feet long, and are 10 to more than 100 acres.

Typically, the surface layer is brown and reddish brown silt loam about 15 inches thick. The underlying material is mottled, light reddish brown and reddish brown very fine sandy loam and silt loam to a depth of about 36 inches and pink fine sand to a depth of 84 inches or more.

Included with this soil in mapping are small areas of Gaddy, Gracemore, and Lomill soils. The somewhat excessively drained Gaddy soils are in slightly lower positions on convex flood plains than Gracemont Variant soil. The Gracemore soils are in lower positions on concave flood plains than Gracemont Variant soil. The very slowly permeable Lomill soils are in higher positions on concave flood plains than Gracemont Variant soil. The included soils make up about 15 percent of the map unit, but individual areas of the included soils are generally less than 2 acres.

This Gracemont Variant soil is low in natural fertility and organic matter content. It is moderately alkaline and calcareous throughout. Permeability is moderate, runoff is slow, and the available water capacity is medium. It is easily tilled, but it is easily compacted if tilled when too wet. The root zone is more than 40 inches deep and is easily penetrated by plant roots. Root penetration is limited by the depth to the high water table. This soil has low shrink-swell potential, high corrosion potential to steel, and low corrosion potential to concrete.

This soil has medium potential for row crops and small grains. The hazard of flooding and the high water table are the main limitations that can be overcome only by major upstream flood control and drainage measures. Returning crop residues to the soil, minimum tillage, and including grasses and legumes in the cropping system improve or maintain the tilth and soil fertility and reduce compaction.

This soil has high potential for hay, tame pasture, and rangeland. The soil fertility and forage quality can be improved by overseeding with legumes and adding fertilizer high in nitrogen. Tame pasture grasses that are water tolerant, such as fescue and bermudagrass, do well except where sand is deposited following overflow.

This Gracemont Variant soil has low potential for urban use. Wetness, seepage, and the hazard of flooding are severe limitations that can be overcome only by major flood control measures.

This soil has low potential for most recreational uses. Wetness and the hazard of flooding are severe limitations that are difficult to overcome.

This soil has high potential for windbreak tree and shrub plantings. Eastern cottonwood, redbud, American plum, Amur honeysuckle, lilac, skunkbush sumac, honeylocust, green ash, common hackberry, osageorange, American sycamore, and silver maple are best suited to this soil.

This soil has high potential for use as habitat for openland and rangeland wildlife. It has medium potential for use as habitat for wetland wildlife.

This Gracemont Variant soil is in capability subclass 3w and in Subirrigated range site.

92—Port fine sandy loam, overwash, occasionally flooded. This deep, well drained, nearly level to very gently sloping soil is on flood plains along major and minor streams throughout the county. Slopes are less than 2 percent and are smooth to slightly undulating. This soil is subject to occasional flooding for very brief to brief periods from early in spring through late in summer. A thin layer of sediment is commonly deposited during floods. The mapped areas are 10 to more than 80 acres.

Typically, the surface overwash layer is reddish brown fine sandy loam about 19 inches thick. The next layer is dark reddish gray silt loam to a depth of about 37 inches. The next layer is reddish brown silt loam to a depth of about 44 inches. The subsoil is reddish brown silt loam to a depth of about 57 inches and reddish brown silty clay loam to a depth of about 78 inches. The underlying material is red silty clay to a depth of 80 inches or more.

Included with this soil in mapping are Pulaski and Weswood soils. Pulaski soils are near the stream channels, and Weswood soils are intermingled with the Port soil. The included soils make up about 15 percent of the map unit, but individual areas are generally less than 2 acres.

This Port soil is medium in natural fertility and low in organic matter content. It is medium acid to neutral in the surface overwash layer, neutral or mildly alkaline in the subsurface layers, neutral to moderately alkaline in the subsoil, and moderately alkaline in the underlying material. Permeability is moderate, runoff is slow, and the available water capacity is high. Tilth is good, and the soil can be tilled throughout a wide range of moisture content. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has moderate shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete. Rodents are common pests in this friable soil.

This soil has high potential for row crops, legumes, and small grains. Rodents and the hazard of flooding cause occasional crop damage and loss. The hazard of flooding can be prevented in many areas by constructing diversions and dikes to control runoff and confine water to stream channels. Rodents can be controlled with poison grain or by mechanical traps. The tilth and soil structure can be maintained and improved by minimum tillage, crop rotations, and returning crop residue to the soil. Adding fertilizer or manure and overseeding with legumes help to maintain and improve the fertility of the soil.

This soil has high potential for hay, tame pasture, or rangeland. Hay crops drying in windrows before baling can be damaged by flooding, but generally the additional moisture provided by flooding increases production and offsets any loss. Hay crops and tame pastures respond well to additions of fertilizer high in nitrogen. Overseeding legumes in pastures helps to maintain the soil fertility. Controlling livestock from overgrazing desirable plants and controlling invasion of weeds are management concerns. Timely deferment of grazing and rotation grazing improve plant vigor and protect the grasses and soil.

This Port soil has low potential for most urban uses. The hazard of flooding can be reduced only by major flood control measures. Small building sites can be protected from flooding by using dikes or constructing elevated pads of desirable soils.

This soil has low to high potential for recreational use. The hazard of flooding is severe for camp areas and moderate for playgrounds.

This soil has high potential for windbreak tree and shrub plantings. American plum, American sycamore, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, black walnut, bur oak, Chinese elm, common hackberry, eastern cottonwood, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, pecan, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Port soil is in capability subclass IIw and in Loamy Bottomland range site.

93—Port silt loam, occasionally flooded. This deep, well drained, nearly level to very gently sloping soil is on flood plains along major and minor streams throughout the county. Slopes are less than 2 percent and are smooth to slightly undulating. This soil is subject to occasional flooding for very brief to brief periods from early in spring through late in summer. The mapped areas are 10 to more than 150 acres.

Typically, the surface layer is brown silt loam about 14 inches thick. The next layer is reddish brown silt loam to a depth of about 23 inches. The subsoil is reddish brown silty clay loam to a depth of about 42 inches. The underlying material is yellowish red silty clay loam to a depth of about 65 inches, reddish brown silty clay to a depth of about 78 inches, and light red clay loam to a depth of 84 inches or more.

Included with this soil in mapping are areas of Lomill and Weswood soils, areas of Port soils that are fine sandy loam and are subject to occasional flooding and areas of soils similar to Port soil but having a dark surface layer less than 20 inches thick. The somewhat poorly drained Lomill soils and the Weswood soils are in slightly lower positions on flood plains than Port soil. The included Port soils are near the stream channel where overflow originates. The included soils make up about 15 percent of the map unit, but individual areas are generally less than 3 acres.

This Port soil is high in natural fertility and organic matter content. It is slightly acid to mildly alkaline in the surface layer and neutral to moderately alkaline in the subsoil. The underlying material is moderately alkaline. Permeability is moderate, runoff is slow, and available water capacity is high. This soil is friable and is easily tilled, but it is easily compacted if tilled when too wet. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has moderate shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

This soil has high potential for row crops, legumes, and small grains. The hazard of flooding causes occasional crop damage and loss. The hazard of flooding can be prevented in many areas by constructing diversions and dikes to control runoff and confine water to stream channels. The tilth and soil structure can be maintained or improved by minimum tillage, crop rotations, and returning crop residue to the soil. Refraining from tillage when the soil is too wet helps to prevent compaction. The fertility and organic matter content can be maintained by adding fertilizer or manure or by using legumes in the cropping system.

This soil has a high potential for hay, tame pasture, or rangeland. Hay crops can be damaged by floodwater while drying in windrows before baling, but generally the additional moisture provided by flooding increases production and offsets any loss. Hay crops and tame pastures respond well to additions of fertilizer high in nitrogen. Overseeding tame pastures with vetch, lespedeza, or clover helps to maintain soil fertility, improves the quality of forage, and reduces the need for commercial fertilizer. Controlling weeds and preventing soil compaction are management concerns. Compaction can be reduced by removing livestock during wet periods and by renovating tame pastures late in winter or early in spring with chisel type implements. Weeds can be controlled by timely mowing or by chemical sprays. Proper stocking, rotation grazing, timely deferment of grazing, and restricted use during dry periods help keep the plants vigorous and the soil in good condition.

This Port soil has low potential for most urban uses. The hazard of flooding is severe and can be overcome only by major flood control measures. It can be reduced by the use of dikes, levees, or elevated pads.

This soil has low to high potential for recreational use. The hazard of flooding is severe for camp areas and moderate for playgrounds.

This soil has high potential for windbreak tree and shrub plantings. American plum, American sycamore, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern cottonwood, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Port soil is in capability subclass IIw and in Loamy Bottomland range site.

94—Port silt loam, frequently flooded. This deep, well drained, nearly level to very gently sloping soil is on flood plains along narrow, deeply dissected stream channels. Slopes are less than 2 percent and are smooth to slightly undulating. This soil is subject to frequent flooding for very brief to brief periods from early in spring through late in summer. The mapped areas are 10 to 80 acres.

Typically, the upper part of the surface layer is reddish brown silt loam about 9 inches thick. The lower part of the surface layer is dark reddish gray silt loam to a depth of about 21 inches. The subsoil is reddish brown silt loam to a depth of 36 inches. The underlying material is red silt loam stratified with thin lenses of very fine sandy loam or silty clay loam to a depth of 80 inches or more.

Included with this soil in mapping are areas of Pulaski, Tribbey, and Weswood soils and Port soils that are fine sandy loam or are silt loam and are subject to occasional flooding. The included soils are intermingled with the Port soil at variable elevations; however, Tribbey soils are mostly in the lowest positions on flood plains. The included soils make up about 30 percent of the map unit.

This Port soil is high in natural fertility and organic matter content. It is medium acid to mildly alkaline in the surface layer, neutral to moderately alkaline in the subsoil, and moderately alkaline in the underlying material. Permeability is moderate, runoff is slow, and the available water capacity is high. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has moderate shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

This soil has low potential for crops, hay, or tame pasture. The inaccessibility to farm equipment because of the short, irregular, and steep slopes and the hazard of frequent flooding are the main limitations. Major landshaping, including smoothing and filling of the dissected areas, and removal of brush and trees are needed before the soil can be seeded to crops or grasses. Only small, protected areas would be suited to home gardens.

This soil has high potential for native rangeland, and it is best suited to this use. Removal of brush and mature trees, rotation grazing, and proper stocking improve plant vigor and help to protect the soil. Many native trees are harvested annually for posts or firewood.

This Port soil has low potential for most urban uses. The hazard of flooding is severe and can be overcome only by major flood control and land alteration measures.

This soil has low or medium potential for recreational use. The hazard of flooding is severe for camp areas and playgrounds and moderate for picnic areas and paths and trails.

This soil has high potential for windbreak tree and shrub plantings. American plum, American sycamore, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, black walnut, bur oak, Chinese elm, common hackberry, eastern cottonwood, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, pecan, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has medium potential for use as habitat for openland wildlife and rangeland wildlife. It has low potential for use as habitat for wetland wildlife. This soil is used mostly as habitat for wildlife.

This Port soil is in capability subclass Vw and in Loamy Bottomland range site.

95—Pulaski fine sandy loam, occasionally flooded. This deep, well drained, nearly level to very gently sloping soil is on flood plains of major and minor streams in the eastern part of the county. Slopes are less than 2 percent and are smooth to slightly undulating. This soil is subject to occasional flooding for very brief to brief periods from early in spring through late in summer. The mapped areas are 10 to more than 200 acres.

Typically, the surface layer is reddish brown fine sandy loam about 8 inches thick. The underlying material is red and yellowish red fine sandy loam to a depth of about 35 inches, red and light reddish brown loamy fine sand to a depth of about 53 inches, and stratified reddish yellow loamy very fine sand, yellowish red fine sandy loam, reddish brown loam, and loamy fine sand to a depth of more than 80 inches.

Included with this soil in mapping are small areas of Port, Tribbey, and Weswood soils. Tribbey soils are in slightly lower positions on flood plains than Pulaski soil, and Port and Weswood soils are intermingled with the Pulaski soil. The included soils make up about 15 percent of the map unit, but individual areas are generally less than 2 acres.

This Pulaski soil is medium in natural fertility and low in organic matter content. The surface layer is medium acid to neutral. Where limed, it ranges from medium acid to moderately alkaline. The underlying material is medium acid to moderately alkaline. Permeability is moderately rapid, runoff is slow, and available water capacity is medium. This soil has good tilth and can be worked throughout a wide range of moisture content. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil is slightly susceptible to water or wind erosion. It has low shrink-swell potential, low corrosion potential to steel, and moderate corrosion potential to concrete.

This soil has medium potential for row crops, legumes, and small grains. Fertility, organic matter content, the available water capacity, and the hazard of flooding are the main limitations. Occasional crop damage and loss is caused by flooding. Flooding can be prevented in many areas by constructing diversions and dikes to control runoff and confine water to stream channels. The tilth and soil structure can be maintained or improved by minimum tillage, crop rotations, and returning crop residue to the soil. The fertility and organic matter content can be improved by adding fertilizer or manure or by including grasses and legumes in the cropping system. Pocket gophers and moles can cause considerable damage to stands of alfalfa unless controlled.

This soil has high potential for hay, tame pasture, and rangeland and is best suited to these uses. Flooding causes occasional damage to hay crops that are left to dry in windrows before baling, but generally the additional moisture increases production and offsets any loss. Hay crops and tame pastures respond well to additions of fertilizer high in nitrogen. The soil fertility and quality of forage can be improved by overseeding pasture with legumes in the fall. Renovation, fertilization, weed control, and rotation grazing help to produce high quality forage. Pocket gophers are pests, but they can be partially controlled by baiting with poison grain or by mechanical traps. Native grasses can be improved by proper stocking, rotation grazing, timely deferment of grazing, restricted use during dry periods, weed control, and protection from burning.

This Pulaski soil has low potential for most urban uses. The hazard of flooding is severe and can be overcome only by major flood control measures. Dikes, levees, or elevated pads reduce overflow in some areas. This soil is well suited to use as topsoil in landscaping and for roadfill or daily cover for landfills.

This soil has low to high potential for recreational use. The hazard of flooding is severe for camp areas and moderate for playgrounds.

This soil has high potential for windbreak tree and shrub plantings. American plum, American sycamore, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, black walnut, bur oak, Chinese elm, common hackberry, eastern cottonwood, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, pecan, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, tamarisk, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife because of the scarcity of wetland plants and the depth to the high water table.

This Pulaski soil is in capability subclass IIw and in Loamy Bottomland range site.

96—Weswood silt loam, occasionally flooded. This deep, well drained, nearly level to very gently sloping soil is on flood plains along Little River and minor streams. Slopes are less than 2 percent and are smooth to slightly undulating. This soil is subject to occasional flooding for very brief to brief periods from early in spring through early in fall. The mapped areas are 20 to more than 300 acres.

Typically, the surface layer is reddish brown silt loam about 9 inches thick. The subsoil is reddish brown silt loam to a depth of about 20 inches. The underlying material is silt loam. It is reddish yellow to a depth of about 32 inches and reddish brown to a depth of about 49 inches. The buried soil is reddish brown silty clay loam to a depth of about 84 inches or more.

Included with this soil in mapping are areas of Port, Pulaski, and Lomill soils. Port soils are in lower, concave areas near stream channels. Pulaski soils are in slightly lower positions on flood plains than Weswood soil near stream channels. Lomill soils are in lower positions on concave flood plains than Weswood soils. Also included are soils similar to the Weswood soil but having a seasonal high water table 30 to 60 inches below the surface. The included soils make up about 15 percent of the map unit, but individual areas are generally less than 3 acres.

This Weswood soil is medium in natural fertility and medium to low in organic matter content. It is neutral to moderately alkaline in the surface layer and moderately alkaline and calcareous in the subsoil and underlying material. Permeability is moderate, runoff is slow, and available water capacity is high. This soil is easily compacted if tilled when too wet. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil has moderate shrink-swell potential, high corrosion potential to steel, and low corrosion potential to concrete.

This soil has high potential for row crops, small grains, legumes, tame pasture, hay, and rangeland. The fertility, organic matter content, and occasional crop damage and losses because of flooding are the main limitations. Maintaining soil structure, improving the fertility and organic matter content, and protecting crops from damage by overflow are management concerns. The hazard of flooding can be prevented in many areas by constructing diversions and dikes to control runoff and confine water to stream channels. The tilth and soil structure can be improved by minimum tillage, crop rotations, refraining from tillage when wet, and returning crop residue to the soil. The fertility and organic matter content can be improved by adding fertilizer or manure or by overseeding with legumes. Areas in pasture or range can be improved or maintained by timely weed and brush control, rotation grazing, deferment of grazing during part of the growing season, and protection from uncontrolled burning.

This Weswood soil has low potential for most urban uses. The hazard of flooding is severe and can be overcome only by major flood control measures. The moderate shrink-swell potential is a limitation for use for roadfill. This soil is suited to use as topsoil.

This soil has high potential for use in developing picnic areas and paths and trails. The hazard of flooding is severe for camp areas and playgrounds.

The soil has high potential for windbreak tree and shrub plantings. American plum, American sycamore, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern cottonwood, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are suited to this soil.

This soil has high potential for use as habitat for openland wildlife and rangeland wildlife. It has low potential for use as habitat for wetland wildlife because of the scarcity of wetland plants and the depth to ground water.

This Weswood soil is in capability subclass IIw and in Loamy Bottomland range site.

97—Canadian fine sandy loam, 1 to 3 percent slopes, rarely flooded. This deep, well drained, very gently sloping soil is on high flood plains along the South Canadian River. Slopes are slightly convex and range from 1 to 3 percent. This soil is subject to rare flooding. The mapped areas are 200 to 1,200 feet wide and 1,000 to 12,000 feet long, are parallel to the river, and range from 10 to 300 acres.

Typically, the surface layer is dark grayish brown and brown fine sandy loam about 18 inches thick. The subsoil is brown fine sandy loam to a depth of about 28 inches. The underlying material is light brown sandy loam to a depth of about 42 inches and reddish yellow loamy fine sand to a depth of 64 inches.

Included with this soil in mapping are Goodnight, Gracemore, and Slaughterville soils. The excessively drained Goodnight soils are on convex, low dunes. The somewhat poorly drained Gracemore soils are in lower, concave areas. The Slaughterville soils are on foot slopes of uplands. Also included are areas of soils that have short, narrow slopes that are up to 8 percent. The soils are along the edge of delineations in some areas that break to the lower flood plains. The included soils make up about 15 percent of the map unit, but individual areas are generally less than 3 acres.

This Canadian soil is high in natural fertility and organic matter content. It is medium acid to neutral in the surface layer and slightly acid to moderately alkaline in the subsoil and underlying material. Lime occurs below a depth of 30 inches in most areas. Permeability is moderately rapid, runoff is medium, and the available water capacity is medium. This soil has a high water table from 6 to 10 feet below the surface most of the year. This soil has good tilth and can be worked throughout a wide range of moisture content. Wind erosion is a hazard during extended dry periods. The root zone is more than 60 inches deep and is readily penetrated by plant roots. This soil has low shrink-swell potential and low corrosion potential to steel or concrete.

This soil has high potential for row crops, small grains, hay, tame pasture, and native rangeland. It is in areas where irrigation water is generally available. The fertility, organic matter content, and tilth can be maintained or improved by minimum tillage, returning crop residue to the soil, and adding fertilizer. Stripcropping, use of crop residue, and growing cover crops during windy seasons can help to prevent soil blowing. The quality of hay and tame pasture can be maintained or improved by overseeding with legumes, protecting from overgrazing, and by adding fertilizer high in nitrogen.

This Canadian soil has low potential for most urban uses. The hazard of flooding is severe and can be overcome only by major flood control measures. Seepage is a severe limitation for sewage lagoons and sanitary landfills.

This soil has high potential for picnic areas and paths and trails. The hazard of flooding is severe for camp areas. Steepness of slopes is a moderate limitation for playgrounds.

This soil has high potential for windbreak tree and shrub plantings. American plum, American sycamore, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, bur oak, Chinese elm, common hackberry, eastern cottonwood, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, ponderosa pine, redbud, red mulberry, Rocky Mountain juniper, Russian-olive, Scotch pine, silver maple, and skunkbush sumac are best suited to this soil.

This soil has high potential for use as habitat for openland and rangeland wildlife. It has low potential for use as habitat for wetland wildlife.

This Canadian soil is in capability subclass IIe and in Loamy Bottomland range site.

98—Port-Urban land complex, occasionally flooded. This complex consists of deep, well drained Port soil and Urban land. The soil and Urban land of this complex were so intermingled that they could not be separated at the scale selected for mapping. They are in urbanized areas in southern Moore, southern Norman, and eastern Lexington. The Port soil is on nearly level flood plains along small streams that dissect the upland prairies. It is subject to occasional flooding for very brief to brief periods during spring and summer. The mapped areas are long and narrow, from about 150 to 500 feet wide and 600 to 5,200 feet long, and range from about 3 to 30 acres.

The Port soil makes up about 45 percent of the map unit. Typically, the surface layer is brown and reddish brown silt loam to a depth of about 29 inches. The subsoil is reddish brown silty clay loam to a depth of about 54 inches. The underlying material is red silt loam that has thin, darker strata to a depth of 75 inches or more.

The Port soil is high in natural fertility and organic matter content. It is medium acid to mildly alkaline in the surface layer, slightly acid to moderately alkaline in the subsoil, and moderately alkaline and calcareous in the underlying material. Permeability is moderate, runoff is slow, and the available water capacity is high. The root zone is more than 60 inches deep and is easily penetrated by plant roots. This soil is moderately susceptible to water erosion and slightly susceptible to wind erosion. It has moderate shrink-swell potential, moderate corrosion potential to steel, and low corrosion potential to concrete.

Urban land makes up about 45 percent of the map unit. It consists of areas that have been covered with buildings or other urban structures. Typical structures are mostly single family dwellings, streets, driveways, and patios. A few small commercial buildings and small parking lots are in some areas.

Included with this complex in mapping are small areas of Asher, Lomill, and Pulaski soils. Asher soils are in higher positions on flood plains than Port soil, are subject to rare flooding, and have a thinner surface layer. The somewhat poorly drained, very slowly permeable Lomill soils are in slightly concave areas and remain wet for extended periods. The moderately rapidly permeable Pulaski soils are in slightly higher areas on flood plains than Port soil and are closer to the stream channels. The included soils make up about 10 percent of the map unit.

This complex is not suited to cultivated crops, hay, tame pasture, or rangeland. Areas of the Port soil are too small for operation of most farm equipment and for livestock use.

This complex has low potential for most urban uses. The hazard of flooding is severe for sanitary facilities, roads, streets, dwellings, and small commercial buildings and moderate for lawns, landscaping, and golf fairways. Port soils are good for topsoil for use in landscape work. Flooding can be reduced or prevented by constructing dikes around built-up areas or by elevating building sites on fill materials of sufficient height for protection against flooding. High grade concrete mix that has adequate reinforcement steel properly bedded over sand reduces cracking in foundations, slabs, and walls caused by shrinking and swelling. Increasing the size of the absorption field reduces the effects of moderate permeability. Bedding and covering steel pipelines with calcareous, sandy soils reduces the corrosion hazard, or copper tubing or plastic pipe can be substituted where building codes permit. The hazard of erosion can be reduced by mulching, growing temporary cover crops, or solid sodding with permanent, adapted grasses.

This complex has high potential for windbreak tree and shrub plantings. American plum, American sycamore, Amur honeysuckle, Arizona cypress, Austrian pine, autumn-olive, black locust, black walnut, bur oak, Chinese elm, common hackberry, eastern cottonwood, eastern redcedar, euonymus, green ash, honeylocust, lilac, oriental arborvitae, osageorange, pecan, ponderosa pine, red mulberry, redbud, Rocky Mountain juniper, Russian-olive, Scotch pine, and silver maple are well suited.

This complex is not assigned to a capability subclass or range site.

99—Urban land. The areas designated as Urban land on soil maps are within the city boundaries of Norman, Moore, Noble, and Lexington. Urban land is composed of areas of soils that are more than 85 percent covered with commercial businesses, shopping centers, parking lots, streets, sidewalks, and highway interchanges. Areas of soils not covered with structures are mostly altered soil materials where cuts and fills were made. Some areas of Urban land, like downtown Lexington, are subject to rare flooding, but most areas are on uplands.

This map unit is not assigned to a capability subclass or range site.

Prime Farmland

In this section, prime farmland is defined and discussed, and the prime farmland soils in Cleveland County are listed.

Prime farmland is one of several kinds of important farmland defined by the U.S. Department of Agriculture. It is of major importance in meeting the nation's short- and long-range needs for food and fiber. The acreage of high-quality farmland is limited, and the U.S. Department of Agriculture recognizes that government at local, state, and federal levels, as well as individuals, must encourage and facilitate the wise use of our nation's prime farmland.

Prime farmland soils, as defined by the U.S. Department of Agriculture, are soils that are best suited to producing food, feed, forage, fiber, and oilseed crops. Such soils have properties that are favorable for the economic production of sustained high yields of crops. The soils need only to be treated and managed using acceptable farming methods. The moisture supply, of course, must be adequate, and the growing season has to be sufficiently long. Prime farmland soils produce the highest yields with minimal inputs of energy and economic resources. Farming these soils results in the least damage to the environment.

Prime farmland soils may presently be in use as cropland, pasture, or woodland, or they may be in other uses. They either are used for producing food or fiber or are available for these uses. Urban or built-up land, public land, and water areas cannot be considered prime farmland. Urban or built-up land is any contiguous unit of land 10 acres or more in size that is used for such purposes as housing, industrial, and commercial sites, sites for institutions or public buildings, small parks, golf courses, cemeteries, railroad yards, airports, sanitary landfills, sewage treatment plants, and water control structures. Public land is land not available for farming in national forests, national parks, military reservations, and state parks.

Prime farmland soils usually get an adequate and dependable supply of moisture from precipitation or irrigation. The temperature and growing season are favorable. The acidity or alkalinity level of the soils is acceptable. The soils have few or no rocks and are permeable to water and air. They are not excessively erodible or saturated with water for long periods and are not subject to frequent flooding during the growing season. The slope ranges mainly from 0 to 5 percent.

About 73,526 acres, or nearly 21 percent of Cleveland County meets the soil requirements for prime farmland. Most of this prime farmland is used for crops or tame pasture.

The following map units, or soils, make up prime farmland in Cleveland County. The location of each map unit is shown on the detailed soil maps at the back of this publication. The extent of each unit is given in table 5. The soil qualities that affect use and management are described in the section "Detailed Soil Map Units." This list does not constitute a recommendation for a particular land use.

Soils that have limitations, such as a high water table or flooding, may qualify as prime farmland if these limitations are overcome by such measures as drainage or flood control. In the following list, the measures needed to overcome the limitations of a map unit, if any, are shown in parentheses after the map unit name. Onsite evaluation is necessary to determine if the limitations have been overcome by the corrective measures.

15 Littleaxe loamy fine sand, 1 to 3 percent slopes
30 Brewless silty clay loam, rarely flooded
32 Lomill silty clay, occasionally flooded
39 Asher silt loam, clayey substratum, rarely flooded
40 Asher silty clay loam, clayey substratum, rarely flooded
42 Canadian fine sandy loam, 0 to 1 percent slopes, rarely flooded
60 Bethany silt loam, 0 to 1 percent slopes
61 Bethany silt loam, 1 to 3 percent slopes
62 Renfrow silt loam, 1 to 3 percent slopes
63 Renfrow silt loam, 3 to 5 percent slopes
67 Newalla fine sandy loam, 1 to 5 percent slopes
70 Slaughterville fine sandy loam, 1 to 3 percent slopes
71 Slaughterville fine sandy loam, 3 to 5 percent slopes
75 Vanoss silt loam, 0 to 1 percent slopes
76 Vanoss silt loam, 1 to 3 percent slopes
77 Teller fine sandy loam, 1 to 3 percent slopes
78 Teller fine sandy loam, 3 to 5 percent slopes
81 Norge silt loam, 1 to 3 percent slopes
82 Norge silt loam, 3 to 5 percent slopes
90 Keokuk very fine sandy loam, rarely flooded
92 Port fine sandy loam, overwash, occasionally flooded

93 Port silt loam, occasionally flooded
95 Pulaski fine sandy loam, occasionally flooded
96 Weswood silt loam, occasionally flooded

97 Canadian fine sandy loam, 1 to 3 percent slopes, rarely flooded

Use and Management of the Soils

This soil survey is an inventory and evaluation of the soils in the survey area. It can be used to adjust land uses to the limitations and potentials of natural resources and the environment. Also, it can help avoid soil-related failures in land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavior characteristics of the soils. They collect data on erosion, droughtiness, flooding, and other factors that affect various soil uses and management. Field experience and collected data on soil properties and performance are used as a basis for predicting soil behavior.

Information in this section can be used to plan the use and management of soils for crops and pasture; as rangeland and windbreaks; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreation facilities; and for wildlife habitat. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties.

Planners and others using soil survey information can evaluate the effect of specific land uses on productivity and on the environment in all or part of the survey area. The survey can help planners to maintain or create a land use pattern that is in harmony with nature.

Contractors can use this survey to locate sources of sand and gravel, roadfill, and topsoil. They can use it to identify areas where bedrock, wetness, or very firm soil layers can cause difficulty in excavation.

Health officials, highway officials, engineers, and others may also find this survey useful. The survey can help them plan the safe disposal of wastes and locate sites for pavements, sidewalks, campgrounds, playgrounds, lawns, and trees and shrubs.

Crops and Pasture

Keith Vaughan and Kenneth R. Awtrey, conservation agronomists, Soil Conservation Service, helped to prepare this section.

More than 112,000 acres in Cleveland County was used for crops and pasture in 1983, according to the Soil Conservation Service land use inventory. Of this total, about 75,000 acres was used for permanent pasture, such as bermudagrass, lovegrass, fescue, and old world bluestems, and about 37,000 acres was used for cropland.

General management needed for crops and pasture is suggested in this section. The crops or pasture plants best suited to the soils, including some not commonly grown in the survey area, are identified; the system of land capability classification used by the Soil Conservation Service is explained; and the estimated yields of the main crops and hay and pasture plants are listed for each soil.

Planners of management systems for individual fields or farms should consider the detailed information given in the description of each soil under "Detailed Soil Map Units." Specific information can be obtained from the local office of the Soil Conservation Service or the Cooperative Extension Service.

Crops

In 1978, Cleveland County had 36,307 acres of cropland. Of this total, 8,349 acres was planted to wheat; 4,231 acres to alfalfa; 1,867 acres to oats; 864 acres to corn; 733 acres to cotton; 567 acres to sorghum silage; 256 acres to barley; 131 acres to peanuts; 293 acres to orchard crops; and 19,016 acres to other hay crops *(11)*. About 1,300 acres was irrigated.

The acreage in cropland has decreased rapidly as more and more land is used for urban development. It has decreased at a rate of about 1,544 acres per year since 1976. Land used for urban development increased from 13,533 acres in 1973 to 27,561 in 1983, about 1,403 acres per year.

The average farm size increased from about 168 acres in 1950 to a high of about 235 acres in 1969. Since then, the average size has steadily declined to about 200 acres in 1978. The number of farms has dropped from about 1,555 in 1950 to 908 farms in 1978.

The soils in Cleveland County have medium potential for increased production of food. Some cropland with medium to high potential is used as rangeland or pastureland. Food production can be increased by using these diverted lands and by using the latest crop production technology on all cropland. This soil survey can help to facilitate the application of such technology.

Wheat is the most common close-growing crop. Oats and barley are grown on a limited scale. Grain sorghum, soybeans, cotton, corn, and peanuts are the main row crops. Corn is grown mostly for silage and used in dairy and feedlot operations. Some corn is produced for grain. Alfalfa and hybrid sudan are the main hay crops. Hay is also harvested from bermudagrass and lovegrass pastures. Native grass hay is cut from hay meadows in some areas. Plains bluestem and other old world bluestems are being harvested for seed or cut for hay on some soils on uplands that were formally eroded and abandoned. Cowpeas, mungbeans, rye, and millet can be grown if economic conditions are favorable.

Special crops grown in the survey area are vegetables, small fruits, tree fruits, and nursery plants. Small garden plots are used for melons, asparagus, potatoes, sweet corn, tomatoes, green beans, peas, okra, squash, cucumbers, radishes, lettuce, carrots, beets, and other vegetables and small fruits. Pecans, peaches, apples, and pears are the most important tree fruits. Wild blackberries and sand plums are abundant in the eastern part of the county in favorable years. Nursery plants and orchard trees grow best on the deep, well drained Canadian, Keokuk, Slaughterville, Teller and Vanoss soils. Pecans grow best on soils on flood plains, such as Asher, Brewless, Canadian, Keokuk, Lomill, Port, and Weswood soils, and on soils on uplands, such as Bethany and Vanoss soils. Melons are better adapted to the deep, somewhat excessively drained or well drained Derby, Dougherty, Gaddy, Konawa, Slaughterville, and Teller soils. Wild blackberries grow best on acid, well drained soils, such as Harrah and Stephenville soils, particularly in areas on foot slopes where moisture accumulates from runoff or underground seepage. Wild sand plums do best on deep, well drained or somewhat excessively drained soils, such as Derby, Dougherty, Harrah, Konawa, Littleaxe, Slaughterville, and Stephenville soils.

Latest information and suggestions for growing special crops can be obtained from local offices of the Cooperative Extension Service and the Soil Conservation Service.

Soil erosion is a major concern on about 74 percent of the cropland, rangeland, and pastureland in Cleveland County. If slope is more than 1 percent, erosion is a hazard. Loss of the surface layer through erosion is damaging for two reasons. First, as the surface layer is lost and part of the subsoil is incorporated into the plow layer, productivity is reduced. Loss of the surface layer is especially damaging on soils that have a clayey subsoil, on soils that have a layer in or below the subsoil that limits the depth of the root zone and the available water capacity, and on soils that tend to be droughty. Second, soil erosion results in sedimentation of streams. Control of erosion minimizes the pollution of streams by sediment and improves the quality of water for municipal use, for recreation, and for fish and wildlife.

A cropping system that keeps vegetative cover on the soil for extended periods can hold soil erosion losses to amounts that will maintain the productive capacity of the soils. Conservation tillage that leaves crop residue on the soil helps to increase infiltration and reduces the hazards of runoff and erosion.

Terraces and diversions reduce the length of slope, reduce runoff, and help to control erosion. They are not practical, however, on deep sandy soils, such as Derby and Dougherty soils. Teller, Norge, Grant, Harrah, and Renfrow soils, for example, are suitable for terraces. Darsil and Lucien soils are not suited to terraces and diversions because bedrock is at a depth of less than 20 inches.

Contouring and contour stripcropping are methods to control erosion. They are best adapted to soils that have smooth, uniform slopes. This includes most areas of Harrah, Norge, Teller, Renfrow, and Grant soils. Contour stripcropping is used mostly on the Derby, Littleaxe, and Slaughterville soils that are most susceptible to wind erosion.

In many sloping fields, tilling or preparing a good seedbed is difficult because the friable surface layer has eroded away leaving the less friable subsoil exposed. Such spots are common in areas of moderately eroded Harrah, Doolin, Norge, Newalla, Teller, and Stephenville soils.

Soil blowing is a hazard on Derby, Doughterty, Gaddy, Goodnight, Konawa, Littleaxe, and Slaughterville soils. Soil blowing can damage these soils if winds are strong and the soils are dry and bare of vegetation or surface mulch. Maintaining a vegetative cover, surface mulch, or rough surface through proper tillage minimizes soil blowing. Windbreaks of adapted trees are effective in reducing soil blowing.

Information for the design of erosion controls for each kind of soil is available in local offices of the Soil Conservation Service.

About a fourth of the cropland in Cleveland County consists of loamy soils on uplands that have slopes ranging from 1 to 8 percent. These soils are subject to the most damage from runoff and water erosion. They consist mainly of the Harrah, Norge, Pawhuska, Renfrow, and Teller soils. Terracing, waterways, contour farming, minimum tillage, and crop residue use help to control erosion and reduce runoff.

Soil drainage is needed on about 18,000 acres or 5 percent of the acreage used for crops and pasture in Cleveland County. The somewhat poorly drained Gracemore, Lomill, and Tribbey soils and part of the acreage of the moderately well drained Brewless and Doolin soils are so wet that production of crops is generally not possible or is reduced in some years.

Subsurface drainage can be used successfully in loamy and sandy soils. Drains have to be more closely spaced in slowly permeable soils. Adequate outlets for subsurface drainage systems are difficult to find in many areas of the Brewless, Gracemore, Lomill, and Tribbey soils. In areas where outlets are not available, sump pumps can be installed. Surface drainage systems can be used successfully in most areas of Brewless and

Doolin soils and in some areas of Lomill soils where outlets are available. This system consists of a main ditch or channel that has lateral ditches radiating into the wet area. In some areas, a system, locally referred to as "w" ditching, is constructed with a molboard plow or one-way disk. It is the least expensive system to construct.

Information on drainage and the design of drainage systems is available in local offices of the Soil Conservation Service.

Soil fertility is low on soils on uplands that are forested or were forested and on soils on low lying flood plains. These soils are mostly fine sandy loam or loamy fine sand, which are easily leached of nutrients. The organic matter content is low on these soils. Historically, vegetation that is predominately forest produces less organic matter content in soils than prairie grasses. Soils that have high organic matter content produce more nitrogen and have good tilth, fast water intake, and a high available water capacity.

The soils in the eastern part of the county are mostly acid throughout, except in areas where the surface layer has been limed. They generally become more acid with increasing depth. The soils on uplands in the western part of the county are, for the most part, high in natural fertility and medium to high in organic matter content. These soils are forming from alkaline materials under prairie grasses. Most of the soils along the South Canadian River and the silty soils in the eastern part of the county are alkaline and are naturally higher in plant nutrients than many of the soils on uplands. These soils formed in alluvium. Pulaski and Tribbey soils are acid soils that formed in alluvium in the eastern part of the county; however, they are low in natural fertility and organic matter content.

The available nitrogen and phosphorus levels are highest mainly in the soils on uplands and bottom lands in the western part of the county. Potassium levels are low to medium in all soils, but they are lowest in the upper layers of the soils in the eastern part of the county. Grain crops and tame pasture grasses generally respond well to fertilizer high in nitrogen. Legumes, such as alfalfa, lespedeza, and vetch, respond well to phosphorus applications. On all soils, additions of fertilizer should be based on the results of soil tests, on the need of the crop, and on the expected level of yields. The Cooperative Extension Service can help in determining the proper kinds and amounts of fertilizer to apply.

In Cleveland County, most of the soils used for crops have a silt loam, silty clay loam, or fine sandy loam surface layer. The silt loam and silty clay loam soils have weak to moderate structure. Intense rainfall causes the soil peds to deteriorate, forming a crust on the soil surface. The crust is hard when dry and nearly impervious to water. Once the crust forms, it reduces infiltration and increases runoff. Regular additions of crop residue, manure, and other organic materials can help to improve soil structure and reduce crust formation. These same soils tend to compact and form a plowpan if tilled when too wet or when trampled by livestock during wet periods. The Asher, Bethany, Brewless, Doolin, Norge, and Vanoss soils are most likely to develop a plowpan. Conservation tillage, deep chiseling, tilling at variable depths, including grasses and legumes in the crop rotation, or refraining from tilling or grazing during wet periods help to reduce compaction. Plowpans reduce the soil percolation rate, reduce root development and penetration, increase runoff, and require more horsepower when tilling.

The Brewless and Lomill soils need to be tilled only under optimum moisture conditions. The clay content in the surface layer of these soils is high. Tillage must be done when the soil is not too dry or too moist, otherwise huge clods form and the natural structure is destroyed. Freezing and thawing during the wetter winter months improve and restore the granular structure that these soils naturally have.

In general, the soils in the survey area that are well suited to crops are also well suited to urban development. Soils well suited to farming and fairly well suited to nonfarm development are identified as map units 4 and 5 on the general soil map at the back of this publication. This area is where urbanization is replacing farmland most rapidly. The major soils in these two map units are the most productive soils for farmland in Cleveland County. They consist mostly of the the Bethany, Doolin, Norge, Teller, and Vanoss soils. Development on these soils is the result of their location being in close proximity to established urban areas.

In some areas, soils are well suited to farming but poorly suited to nonfarm development. These areas are identified as map units 6, 7, 8, 9, and 10 on the general soil map. In these areas, the dominant soils are Asher, Brewless, Canadian, Keokuk, Port, Pulaski, and Weswood soils. These soils are on flood plains and are subject to overflow, which creates serious hazards for nonfarm development.

Some soils are only fairly well suited to farming, but are generally well suited to nonfarm development. This area is identified as map unit 2, dominated by Stephenville, Littleaxe, and Darsil soils. These soils have a fine sandy loam or loamy fine sand surface texture and are mostly low in natural fertility and organic matter content. However, the rolling landscape, good soil drainage, and other soil qualities are favorable for residential and other urban uses.

The data about specific soils in this soil survey can be used in planning future land use patterns. Potential productive capacity in farming should be weighed against soil limitations and potential for non-farm development.

Management of Tame Pasture

Kenneth R. Awtrey, agronomist, Soil Conservation Service, helped to prepare this section.

Pasture plants grown in Cleveland County and guidelines for managing them are described in this section.

Most of the soils in the county are suited to tame pasture, but only about 21 percent of the county is used for this purpose. Many idle fields formerly used for crops and native scrub oak woodlands formerly used for native range have been converted or are being converted to tame pasture.

The principal tame pasture grasses in Cleveland county are improved bermudagrass (fig. 11) and weeping lovegrass (fig. 12). Bermudagrass pastures are most common because the grass is adapted to a wider variety of soils. Weeping lovegrass is best adapted to the sandier soils in the eastern part of the county. If properly managed, it provides good quantity and quality of forage on soils that were heavily infested with scrub oak. Weeping lovegrass provides excellent forage for livestock early in spring before bermudagrass breaks dormancy or when deferred grazing of the native grasses is needed. Where used as a pasture early in spring and summer, lovegrass needs to be fertilized and mowed to improve palatability. The cattle then should be rotated from one pasture to the next every two to three weeks to promote plant vigor and even distribution of grazing.

Bermudagrass is more productive and requires less management on the nearly level, loamy soils on flood plains, such as Asher, Keokuk, and Port soils. For maximum production, bermudagrass needs to be fertilized with 50 to 75 pounds per acre of actual nitrogen every 30 days through the growing season, or through August if moisture is available. Applications should begin about May 1 or when grass starts growing in the spring.

Hairy vetch, Korean lespedeza, and yellow hop clovers can be overseeded in bermudagrass to provide a higher quality forage during the grazing season. The legumes need to be innoculated to help provide some available nitrogen for the bermudagrass. Small grains, such as rye or wheat, overseeded in bermudagrass extends the grazing period and provides high quality forage late in fall and again during spring.

Overseeding bermudagrass pastures with fescue on nearly level soils on flood plains that have a water table or on soils that have more favorable moisture conditions provides additional high quality forage late in fall and early in spring. Asher, Asher Variant, Brewless, Gracemont Variant, Lomill, and Tribbey soils are best suited to bermudagrass and fescue combination. Moderate applications of nitrogen fertilizer applied in the fall and spring increase fescue yield and improve quality of forage. Fungus-free tall fescue seed is recommended to reduce the hazard of toxicity.

Caucasian and plains bluestem show high potential on most soils in the western part of the county. These strains of old world bluestems are best adapted to loamy and clayey soils. The sandier soils in the eastern part of the county dry out in the surface layer more quickly, making establishment more difficult. Caucusian and plains bluestem are desirable in a grazing system where additional forage is needed during the summer, because much of the forage is produced from July through September. These tame bluestems respond readily to fertilizer. For maximum production, a fertility program similar to that discussed for bermudagrass provides high quality forage. In years of favorable moisture, a seed crop can be harvested before it is used for pasture or hay.

Forage sorghums, or hybrid sedans, are used for supplemental forage for grazing or hay. Sorghums are adapted to all soils suited to cropland, but production is greater on the deep, loamy soils on flood plains and soils of medium to high natural fertility on uplands. Sorghums produce the greatest amount of forage in the least amount of time. Because of this, they require a high moisture content and high fertility.

All tame pastures and native grasses need to be fenced and managed in separate pastures. This allows efficient management of the grass for maximum production. Maximum utilization of the forage can be obtained without the cattle overgrazing one grass and undergrazing the others.

Proper grazing and rotation grazing help to lengthen the life of most pasture plants. Deferred grazing is

Figure 11.—Improved bermudagrass pasture on Keokuk very fine sandy loam, rarely flooded. Bermudagrass and native pecans are compatible on most loamy and clayey bottom land soils in the county.

Figure 12.—Weeping lovegrass pasture provides adequate forage for livestock, reduces runoff, and helps control erosion on this area of Stephenville-Darsil-Newalla complex, 3 to 8 percent slopes.

beneficial during periods of low food reserve. This allows plants to regain vigor by helping to maintaining a more adequate root system where food can be stored for the next growing season. Total production of forage will increase.

Increasing the fertility level of the soil results in more vigorous pasture plants and lengthens the lifespan of the plants. This increases forage production. Plant nutrients can be added by using commercial fertilizers. Legumes, such as vetch or clover, can be seeded in bermudagrass to furnish nitrogen to the plants. Large amounts of nitrogen are needed in areas where legumes are not grown with the grass.

The desired pasture plants can only be maintained if the invasion of undesirable plants is controlled. Brush and weed management is essential. Mowing, fertilizing, or spraying can help to reduce the problem created by weeds and brush.

A good pasture program provides the desired amount of forage every month of the year. A study of the growth habits of the different plants is necessary to ensure adequate forage each month. The percentage of growth of various forage plants that can be safely grazed each month without substantially reducing the total yields for each kind of plant is shown in figure 13. For example, 29 percent of the yearly growth of bermudagrass can be grazed during June.

Soils vary in their ability to produce forage for grazing. Norge soils produce more forage than Newalla soils, primarily because they furnish more available moisture to the plant. The total yearly production of various pasture plants for each soil is given in animal unit months (AUM) in table 6. For example, bermudagrass on Norge silt loam, 3 to 5 percent slopes, will furnish grazing for one animal unit 6 months during the year.

A well planned pasture program must consider the total yearly production of the pasture plant and the growth of the plant in a certain month. For example, bermudagrass furnishes 29 percent of its annual forage growth during June. Since 29 percent times 6 AUM equals 1.7 AUM, one acre of this Norge soil provides grazing for 1.7 animals in June. A 50-acre pasture of bermudagrass on this Norge soil would furnish grazing for 85 animals during June.

Periods of low rainfall are common. They may last for a month or more, or rainfall may be below normal for a year or more. Yields in table 6 are an average over a period of several years. To insure continuous, adequate forage during these dry periods, either numbers of livestock must fluctuate or a feed reserve is needed. This reserve can be provided in two ways: by harvesting part of the pasture for hay during periods of above normal moisture and by withholding areas from grazing until a later period. For example, use of a reserve pasture of bermudagrass grown in May and June can be delayed until a dry period in August and September. However, close grazing during August and September should be avoided, because storage roots are developed so plants can survive the winter.

Help in planning a pasture program can be obtained from local offices of the Soil Conservation Service or Cooperative Extension Service.

Yields Per Acre

The average yields per acre that can be expected of the principal crops under a high level of management are shown in table 7. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby counties and results of field trials and demonstrations are also considered.

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green manure crops; and harvesting that insures the smallest possible loss.

The estimated yields reflect the productive capacity of each soil for each of the principal crops. Yields are likely to increase as new production technology is developed. The productivity of a given soil compared with that of other soils, however, is not likely to change.

Crops other than those shown in table 7 are grown in the survey area, but estimated yields are not listed because the acreage of such crops is small. The local office of the Soil Conservation Service or of the Cooperative Extension Service can provide information about the management and productivity of the soils for those crops.

Land Capability Classification

Land capability classification shows, in a general way, the suitability of soils for use as cropland. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major, and generally expensive, landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for pasture, and for engineering purposes.

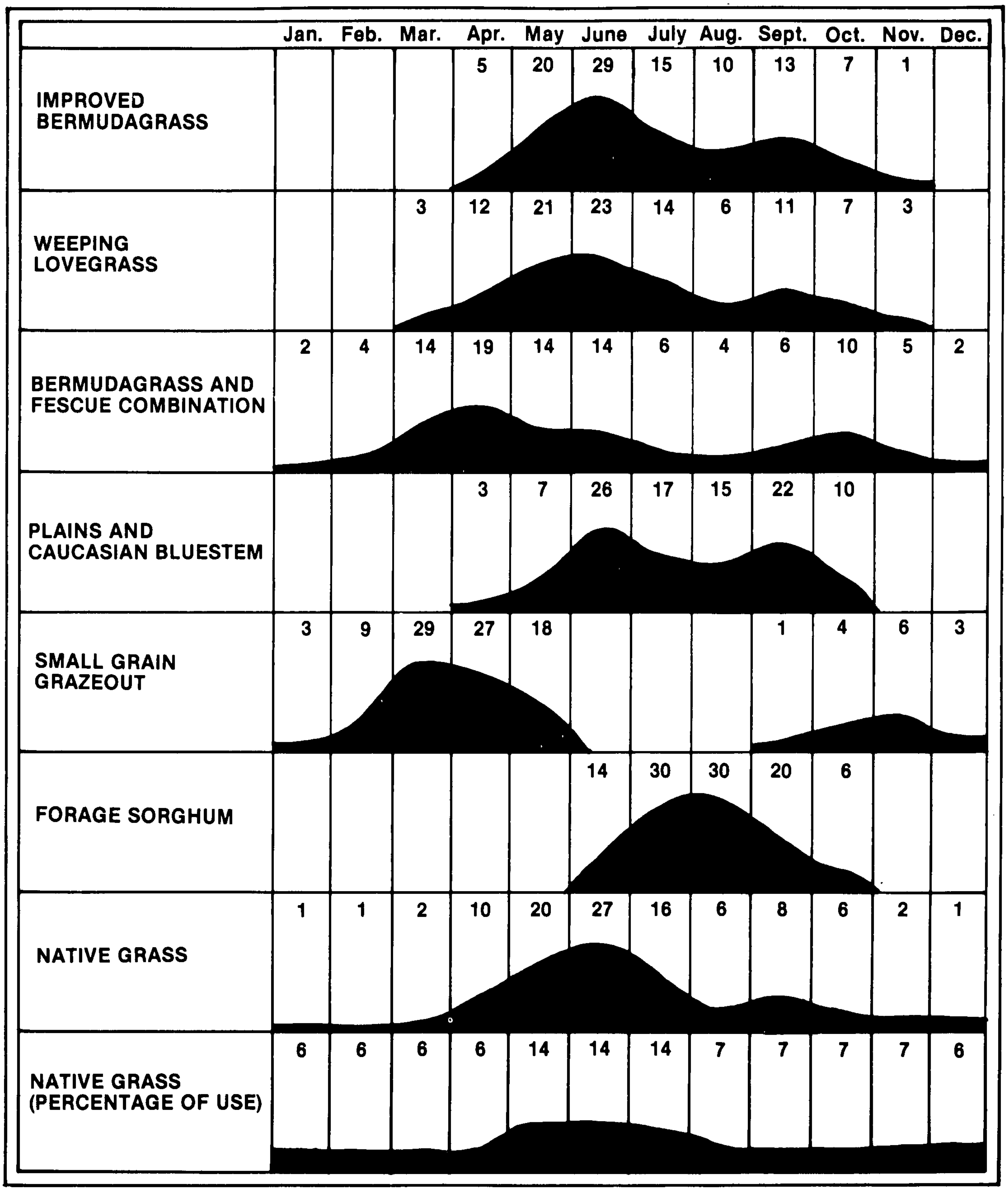


Figure 13.—Forage calendar showing monthly growth as a percentage of annual forage production.

In the capability system, soils are generally grouped at three levels: capability class, subclass, and unit. Only class and subclass are used in this survey. These levels are defined in the following paragraphs.

Capability classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I soils have few limitations that restrict their use.

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

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

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

Class V soils are not likely to erode, but they have other limitations, impractical to remove, that limit their use.

Class VI soils have severe limitations that make them generally unsuitable for cultivation.

Class VII soils have very severe limitations that make them unsuitable for cultivation.

Class VIII soils and miscellaneous areas have limitations that nearly preclude their use for commercial crop production.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e, w, s,* or *c,* to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless a close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or saline; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

There are no subclasses in class I because the soils of this class have few limitations. The soils in class V are subject to little or no erosion, but they have other limitations that restrict their use to pasture, rangeland, woodland, wildlife habitat, or recreation. Class V contains only the subclasses indicated by *w, s,* or *c*.

The acreage of soils in each capability class and subclass is shown in table 8. The capability classification of each map unit is given in the section "Detailed Soil Map Units."

Rangeland

Ernest C. Snook, range conservationist, Soil Conservation Service, helped to prepare this section.

Rangeland is land on which the native vegetation is a variety of grasses, grasslike plants, forbs, shrubs, and trees. The vegetation is generally suitable for grazing and occurs in sufficient amount to be used for grazing. Rangeland, or native grassland, does not receive regular or frequent cultural treatment. The composition and production of the plant community is determined by the soil, climate, topography, overstory canopy, and grazing management. Rangeland originally produced a wide variety of tall and mid grasses interspersed with abundant forbs.

More than 199,000 acres, or about 56 percent of Cleveland County is rangeland. Of this, about 32 percent presently is open prairie range and 24 percent is wooded range. Cow-calf operations are dominant in the county. Stocker-feeder and dairy operations make up a lesser part of the cattle industry. Cattle numbers fluctuate from year to year depending on market and forage production, but they ranged between 28,000 and 40,000 during the last decade. The number of horses and hogs has increased dramatically during this period and dairy animal numbers have decreased.

In the eastern part of the county, most of the soils are loamy and are deep to shallow over red sandstone and shale. These soils support an oak overstory with an understory of mid and tall grasses. The potential productivity for rangeland is low to high, depending on the root zone and the available water capacity of the soil. In much of the central and western part of the county, the soils are loamy and are shallow to deep over shale, or are loamy and clayey sediment. Areas of steep slopes and escarpments are along the breaks adjacent to the streams. These areas support tall, mid, and short grasses, and potential productivity is medium to high. In the western part of the county, the soils on uplands paralleling the South Canadian River are sandy and deep over sandy sediment. There are areas of hummocks, and soil blowing is a hazard. These soils support an oak-hickory overstory with an understory of tall grasses, and potential productivity for rangeland is much greater than on shallow soils. In the extreme western and southern part of the county, the soils on flood plains are loamy, sandy, or clayey and are deep over loamy and sandy stratified alluvium. This area supports mid and tall grasses and mixed bottom land hardwoods. The potential productivity for rangeland is high.

The vegetative community of Cleveland County rangeland has changed drastically over the past 50 years. The concentration of animals on native vegetation has deteriorated most of the grasslands, and much of the high quality vegetation has been reduced. Now, tall grasses flourish in only a few places. Areas that were once open rangeland are now covered with post oak, blackjack oak, and hickory and a mixture of short, mid, and tall grasses and poor quality forbs. The amount of forage presently produced may be less than half of that originally produced. However, remnants of the original plant species are still found in protected areas on most rangelands, and, in most cases, good grazing management will allow these high quality plants to reestablish themselves.

Livestock operations generally supplement the grazing of native grassland with the grazing of pastureland and cropland. Bermudagrass and weeping lovegrass are commonly grown supplemental pasture grasses. Protein supplement, hay, and grazing of small grain are used to supplement livestock feeding throughout the winter.

About 75 percent of the annual growth of forage takes place in April, May, and June, when spring rains and moderate temperatures favor the growth of warm-season plants. A secondary growth period for some grasses generally occurs in September and October, when fall rains and gradually cooling temperatures are common.

Droughts of varying length are frequent. Some are short, midsummer droughts. Longer periods of drought sometimes last for several months.

Table 9 shows, for each soil, the range site and the potential annual production of vegetation in favorable, average, and unfavorable years. Only those soils that are used as rangeland or are suited to use as rangeland are listed. Explanation of the column headings in table 9 follows.

A *range site* is a distinctive kind of rangeland that produces a characteristic natural plant community that differs from natural plant communities on other range sites in kind, amount, and proportion of range plants. The relationship between soils and vegetation was established during this survey; thus, range sites generally can be determined directly from the soil map. Soil properties that affect moisture supply and plant nutrients have the greatest influence on the productivity of range plants. Soil reaction, salt content, and a seasonal high water table are also important.

Potential forage production depends on the range site. Current forage production depends on the range condition and the moisture available to plants during the growing season. *Potential annual production* is the amount of vegetation that can be expected to grow annually on well managed rangeland that is supporting the potential natural plant community. It is expressed in pounds per acre of air-dry vegetation for favorable, average, and unfavorable years. In a favorable year, the amount and distribution of precipitation and the temperatures make growing conditions substantially better than average. In an average year, growing conditions are about average. In an unfavorable year, growing conditions are well below average, generally because of low available soil moisture.

Dry weight is the total annual yield per acre reduced to a common percent of air-dry moisture.

Range Condition Classes

Climax vegetation is the stabilized plant community that a range site is capable of producing. It consists of the plant composition that grew there before settlement of the region. This climax plant community reproduces itself and changes very little, as long as the environment remains unchanged. If cultivated crops are not grown, the most productive combination of forage plants on a range site is generally the climax vegetation.

Decreasers, or *preferred forage plants*, are plants in the climax vegetation that tend to decrease in relative amount under continued close grazing. They generally are the tallest and most productive perennial grasses and forbs, and they are the most palatable to livestock. Increasers, or *desirable forage plants*, are plants that increase in relative amount as the more desirable decreaser plants are reduced by close grazing. They are commonly shorter than decreasers, and they are generally less palatable to livestock. Invaders, or *undesirable forage plants*, are plants that cannot compete with decreaser plants in the climax plant community for moisture, nutrients, and light. However, invaders grow along with increasers after the grazing value of the climax vegetation has been reduced. Some invaders have little value for grazing.

Range condition is judged according to the standards that apply to the particular range site. It expresses the present kind and amount of vegetation in relation to the climax plant community for that site. Four range condition classes are used to indicate the degree of departure from the potential, or climax vegetation. A range is in excellent condition if 76 to 100 percent of the vegetation is of the same kind as that in the climax stand, 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 25 or less.

A primary objective of good range management is to maintain range in excellent or good condition. On a well managed range, water is conserved, yields are improved, and the soils are protected. The main management concern is recognizing important changes in the kind of cover on a range site. These changes take place gradually and can be misinterpreted or overlooked. Growth encouraged by heavy rainfall can lead to the conclusion that the range is in good condition, whereas actually the cover is weedy and the long-term trend is toward lower production. On the other hand, rangeland that has been closely grazed for short periods under the supervision of a careful manager can have a degraded appearance that temporarily conceals its quality and ability to recover. Years of prolonged overuse of rangeland can eliminate seed sources of the desirable vegetation. If this happens, the vegetation needs to be reestablished for management to be effective.

Range management practices that are important for Cleveland county are proper grazing use, deferred grazing, and a planned grazing system. Other beneficial practices are stock water development, fencing, and proper location of salting and feeding facilities. When regression has occurred and undesirable plants dominate, such accelerating practices as range seeding, brush management, weed management, and prescribed burning need to be considered, singly or in combination with grazing management or facilitating practices.

These practices, properly applied and maintained, generally result in the optimum production of vegetation, reduction of undesirable species, conservation of water, and control of erosion. Sometimes a range condition somewhat below the potential meets grazing needs, provides wildlife habitat, and protects soil and water resources.

Potential Annual Utilization

The following guidelines are for potential annual utilization on a broad scale. Consult the Soil Conservation Service for more detailed information on a particular area or situation.

To maintain or improve the quality and quantity of native vegetation, the amount of removal needs to be adjusted based on the potential productivity and condition of the site. As a rule of thumb, approximately 50 percent of the annual season's growth should be left on the soil surface. About one-third of the height of tall and mid grasses equals 50 percent of annual production at maturity. If 50 percent of annual season growth remains on the site, the balance of nature protects the natural resources of soil, plant, animal, and environment. The other 50 percent of annual season growth may or may not be removed from the site. The removal can be in a number of ways, such as by living organisms, rodents, insects, or mammals or by deterioration because of climatic variations.

Generally, livestock removes about 50 percent of the growth from the site, or 25 percent of the total annual seasons growth, by weight. For example, the forage available for livestock on a Loamy Prairie range site in excellent condition would be 3,500 pounds of air dry vegetative material per acre in an average growing season. This 3,500 pounds includes all plant production, such as grasses, forbs, and woody species. The percentage of grasses, forbs, and woody species are listed in each range site description.

Approximately 25 percent or 875 pounds of the average productivity of grasses and forbs are available for livestock forage. Generally woody species would not be considered livestock forage. A 1,000 pound cow (equivalent to an animal unit) will consume 2 1/2 to 3 percent of its body weight of forage per day. If one animal unit consumes 25 to 30 pounds of forage per day, in one month (30 days), an animal consumes from 750 to 900 pounds of native vegetation forage. The amount consumed will vary depending on the quality of the forage and its stage of growth.

To convert available forage from one acre of Loamy Prairie range site in excellent condition, divide 875 pounds of forage production by the 25 to 30 pounds required per day by one animal unit. This shows that one acre of the Loamy Prairie Range site will produce sufficient forage for one animal unit 29 to 35 days.

To convert the available forage production from one acre into animal unit months, divide the available forage (875 lbs.) by the monthly requirement of one animal unit (750 to 900 lbs.). Thus in the example given, one acre of the range site would produce between 0.97 AUM and 1.16 AUM.

To sustain one animal unit for one year on a Loamy Prairie range site in excellent condition would require from 10.3 to 12.3 acres.

Range Site Plant Communities

There are 17 range sites in Cleveland County. The following paragraphs describe the common preferred, desirable, and undesirable plants for each range site.

Claypan Prairie range site. The Doolin and Renfrow soils in map units 50, 51, 53, 62, 63, 64, 65, and 66 are in this site. The potential plant community is a mid and tall grass aspect. Species composition, by weight, is 80 percent grasses, 15 percent forbs, and 5 percent woody plants.

Big bluestem, little bluestem, indiangrass, switchgrass, leadplant, bundleflower, compassplant, and perennial sunflower are preferred plants. They make up 70 percent of livestock forage production if the range is in excellent condition. The preferred plants disappear first under continuous or heavy grazing and are replaced by desirable plants, such as sideoats grama, blue grama, buffalograss, fall witchgrass, wild alfalfa, dotted gayfeather, heath aster, goldenrod, and prairie coneflower.

Continued overgrazing and extreme climatic conditions can cause a decline in the desirable plants. As this occurs, the undesirable plants, such as annual threeawn, silver bluestem, ragweed, croton, pricklypear, curlycup gumweed, partridge pea, and other annual grasses and forbs, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Deep Sand range site. The Goodnight soil in map unit 19 is in this site. The potential plant community is a tall grass aspect. Species composition, by weight, is 80 percent grasses, 15 percent forbs, and 5 percent woody plants.

Little bluestem, indiangrass, sand bluestem, sand lovegrass, wildrye, and pitchers sage are preferred plants. They make up 60 percent of livestock forage production if the range is in excellent condition. The preferred plants disappear first under continuous or heavy grazing and are replaced by desirable plants, such as tall dropseed, blue grama, sideoats grams, Scribner panicum, purpletop, wildindigo, heath aster, and goldenrod.

Continued overgrazing and extreme climatic conditions can cause a decline in the desirable plants. As this occurs, the undesirable plants, such as sand dropseed, silver bluestem, annual threeawn, windmillgrass, sandbur, ironweed, ragweed, broomweed, and other annual grasses and forbs, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Deep Sand Savannah range site. The Derby, Dougherty, Konawa, and Littleaxe soils in map units 11, 12, 13, and 15 are in this site. The potential plant community is a tall grass aspect. Species composition, by weight, is 50 percent grasses, 25 percent forbs, and 25 percent woody plants.

Big bluestem, sand bluestem, indiangrass, little bluestem, switchgrass, broadleaf uniola, perennial lespedeza, tickclover, and hairy sunflower are preferred plants. They make up 80 percent of livestock forage production if the range is in excellent condition. The preferred plants disappear first under continuous or heavy grazing and are replaced by desirable plants, such as purpletop. tall dropseed, Scribner panicum, sand lovegrass, wild alfalfa, heath aster, goldenrod, hickory, post oak, red oak, blackjack oak, redbud, and sumac.

Continued overgrazing and extreme climatic conditions can cause a decline in the desirable plants. As this occurs, the undesirable plants, such as splitbeard bluestem, showy partridge pea, ragweed, white snakeroot, annual threeawn, witchgrass, persimmon, red cedar, and other annual grasses and forbs, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Eroded Sandy Savannah range site. The Harrah, Newalla, and Stephenville soils in map units 5, 8, and 68 are in this site. The potential plant community is a tall grass aspect. Species composition, by weight, is 65 percent grasses, 25 percent forbs, and 10 percent woody plants.

Little bluestem, indiangrass, big bluestem, switchgrass, wildrye, and sand lovegrass are preferred plants. They make up 50 percent of livestock forage production if the range is in excellent condition. The preferred plants disappear first under continuous or heavy grazing and are replaced by desirable plants, such as sideoats grama, hairy grama, tall and meadow dropseed, Scribner panicum, purpletop, purple lovegrass, wild alfalfa, and prairie coneflower.

Continued overgrazing and extreme climatic conditions can cause a decline in the desirable plants. As this occurs, the undesirable plants, such as annual threeawn, splitbeard bluestem, silver bluestem, little barley, witchgrass, sandbur, broomsedge bluestem, red lovegrass, western ragweed, persimmon, post oak, red cedar, and other annual grasses and forbs, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Eroded Shallow Savannah range site. The Darsil soil in map unit 8 is in this site. The potential plant community is a tall grass aspect. Species composition, by weight, is 65 percent grasses, 20 percent forbs, and 15 percent woody plants.

Little bluestem, indiangrass, big bluestem, switchgrass, wildrye, and sand lovegrass are preferred plants. They make up 50 percent of livestock forage production if the range is in excellent condition. The preferred plants disappear first under continuous or heavy grazing and are replaced by desirable plants, such as sideoats grama, hairy grama, Scribner panicum, purpletop. purple lovegrass, arrowfeather threeawn, wildindigo, wild alfalfa, and heath aster.

Continued overgrazing and extreme climatic conditions can cause a decline in the desirable plants. As this occurs, the undesirable plants, such as broomsedge bluestem, splitbeard bluestem, annual threeawn, windmillgrass, witchgrass, ragweed, croton, persimmon, post oak, and other annual grasses and forbs, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Heavy Bottomland range site. The Brewless and Lomill soils in map units 30 and 32 are in this site. The potential plant community is a mid and tall grass aspect. Species composition, by weight, is 70 percent grasses, 20 percent forbs, and 10 percent woody plants.

Big bluestem, indiangrass, switchgrass, prairie cordgrass, little bluestem, eastern gamagrass, wildrye, Florida paspalum, leadplant, perennial lespedeza, compassplant, wholeleaf rosinweed, and Maximilian sunflower are preferred plants. They make up 65 percent of livestock forage production if the range is in excellent condition. The preferred plants disappear first under continuous or heavy grazing and are replaced by desirable plants, such as tall dropseed, sideoats grama, Scribner panicum, meadow dropseed, longspike tridens, beaked panicum, and scurfpea.

Continued overgrazing and extreme climate conditions can cause a decline in the desirable plants. As this occurs, the undesirable plants, such as windmillgrass, tumblegrass, silver bluestem, buffalograss, threeawn, inland saltgrass, barnyardgrass, curly dock, smartweed, and other annual grasses and forbs, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Loamy Bottomland range site. The Asher, Canadian, Keokuk, Port, Pulaski, and Weswood soils in map units 3, 33, 39, 40, 42, 90, 92, 93, 94, 95, 96, and 97 are in this site. The potential plant community is a tall grass aspect. Species composition, by weight, is 80 percent grasses, 15 percent forbs, and 5 percent of woody plants.

Big bluestem, indiangrass, switchgrass, little bluestem, eastern gamagrass, Florida paspalum, prairie cordgrass, wildrye, leadplant, compassplant, and Maximilian sunflower are preferred plants. They make up 75 percent of livestock forage production if the range is in excellent condition. The preferred plants disappear first under continuous or heavy grazing and are replaced by desirable plants, such as tall and meadow dropseed, sideoats grama, buffalograss, Scribner panicum, longspike tridens, beaked panicum, wild alfalfa, and greenbrier.

Continued overgrazing and extreme climatic conditions can cause a decline in the desirable plants. As this occurs, the undesirable plants, such as silver bluestem, fall witchgrass, threeawn, partridge pea, ragweed, curly dock, ironweed, persimmon, roughleaf dogwood, and other annual grasses and forbs, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Loamy Prairie range site. The Bethany, Grant, Kingfisher, Norge, Norge Variant, Teller, Teller Variant, and Vanoss soils in map units 9, 10, 29, 33, 52, 60, 61, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, and 85 are in this site. The potential plant community is a mid and tall grass aspect. Species composition, by weight, is 75 percent grasses, 20 percent forbs, and 5 percent woody plants.

Big bluestem, little bluestem, indiangrass, switchgrass, leadplant, compassplant, pitchers sage, and perennial sunflowers are preferred plants. They make up 75 percent of livestock forage production if the range is in excellent condition. The preferred plants disappear first under continuous or heavy grazing and are replaced by desirable plants, such as sideoats grama, bluegrama, tall and meadow dropseed, Scribner panicum, longspike tridens, wild alfalfa, yellow neptunia, and wild indigos.

Continued overgrazing and extreme climatic conditions can cause a decline in the desirable plants. As this occurs, the undesirable plants, such as broomsedge bluestem, silver bluestem, splitbeard bluestem, tumblegrass, annual threeawn, broomweed, western ragweed, persimmon, plum, and other annual grasses and forbs, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Sandy Bottomland range site. The Gaddy soil in map unit 4 is in this site. The potential plant community is a tall grass aspect. Species composition, by weight, is 75 percent grasses, 20 percent forbs, and 5 percent woody plants.

Switchgrass (bottom land and upland varieties), sand bluestem, indiangrass, little bluestem, prairie cordgrass, big sandreed, Illinois bundleflower, and Maximilian sunflower are preferred plants. They make up 60 percent of livestock forage production if the range is in excellent condition. The preferred plants disappear first under continuous or heavy grazing and are replaced by desirable plants, such as tall and meadow dropseed, sand paspalum, beaked panicum, sideoats grama, wild senna, queensdelight, sand plum, and skunkbush.

Continued overgrazing and extreme climatic conditions can cause a decline in the desirable plants. As this occurs, the undesirable plants, such as sand dropseed, silver bluestem, fall witchgrass, red lovegrass, windmillgrass, threeawn, sandbur, purple sandgrass, ragweed, ironweed, greenbrier, tamarix, and other annual grasses and forbs, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Sandy Prairie range site. The Slaughterville and Slaughterville Variant soils in map units 70, 71, 72, and 73 are in this site. The potential plant community is a tall grass aspect. Species composition, by weight, is 80 percent grasses, 15 percent forbs, and 5 percent woody plants.

Little bluestem, sand bluestem, switchgrass, indiangrass, wildrye, sand lovegrass, sessileleaf tickclover, slender lespedeza, pitchers sage, and halfshrub sundrop are preferred plants. They make up 70 percent of livestock forage production if the range is in excellent condition. The preferred plants disappear first under continuous or heavy grazing and are replaced by desirable plants, such as sideoats grama, blue grama, hairy grama, Scribner panicum, sand paspalum, tall dropseed, purple lovegrass, wild indigo, wild alfalfa, sand plum, sumac, and skunkbush.

Continued overgrazing and extreme climatic conditions can cause a decline in the desirable plants. As this occurs, the undesirable plants, such as silver bluestem, windmillgrass, tumblegrass, red lovegrass, little barley, threeawn, witchgrass, sand dropseed, sandbur, partridge pea, western ragweed, nightshade, oak, hickory, and other annual grasses and forbs, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Sandy Savannah range site. The Harrah, Newalla, and Stephenville soils in map units 1, 2, 7, 35, 36, 37, and 67 are in this site. The potential plant community is a tall grass aspect. Species composition, by weight, is 70 percent grasses, 15 percent forbs, and 15 percent woody plants.

Little bluestem, big bluestem, indiangrass, switchgrass, sand lovegrass, wildrye, leadplant, tephrosia, tickclover, sensitivebrier, perennial lespedeza, and perennial sunflowers are preferred plants. They make up 60 percent of livestock forage production if the range is in excellent condition. The preferred plants are replaced by desirable plants, such as tall dropseed, sideoats grama, sand paspalum, Scribner panicum, purple lovegrass, wild indigo, wild alfalfa, redbud, and sumac.

Continued overgrazing and extreme climatic conditions can cause a decline in the desirable plants. As this occurs, the undesirable plants, such as broomsedge bluestem, splitbeard bluestem, threeawn, sandbur, partridge pea, yarrow, ragweed, snake cotton, persimmon, hawthorn, hickory, post oak, blackjack oak, ash, and other annual grasses and forbs, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Shallow Claypan range site. The Huska and Pawhuska soils in map units 51, 52, 53, 65, 66, and 84 are in this site. The potential plant community is a short and mid grass aspect. Species composition, by weight, is 65 percent grasses and 35 percent forbs.

Little bluestem, switchgrass, tall dropseed, big bluestem, sideoats grama, Illinois bundleflower, and dotted gayfeather are preferred plants. They make up 55 percent of livestock forage production if the range is in excellent condition. The preferred plants disappear first under continuous or heavy grazing and are replaced by desirable plants, such as blue grama, buffalograss, longspike tridens, meadow dropseed, fall witchgrass, Scribner panicum, wild alfalfa, wild indigo, heath aster, sagewort, and prairie coneflower.

Continued overgrazing and extreme climatic conditions can cause a decline in the desirable plants. As this occurs, the undesirable plants, such as threeawn, windmillgrass, tumblegrass, little barley, partridge pea, ironweed, yarrow, pricklypear, curlycup gumweed, and other annual grasses and forbs, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Shallow Prairie range site. The Grainola and Lucien soils in map units 3, 6, 9, and 29 are in this site. The potential plant community is a mid and tall grass aspect. Species composition, by weight, is 75 percent grasses, 20 percent forbs, and 5 percent woody plants.

Little bluestem, big bluestem, indiangrass, switchgrass, tephrosia, sensitivebrier, leadplant, perennial sunflowers, and compassplant are preferred plants. They make up 65 percent of livestock forage production if the range is in excellent condition. The preferred plants disappear first under continuous or heavy grazing and are replaced by desirable plants, such as tall and meadow dropseed, sideoats grama, blue grama, hairy grama, Scribner panicum, longspike tridens, wild indigo, scurfpea, prairie coneflower, and sumac.

Continued overgrazing and extreme climatic conditions cause a decline in the desirable plants. As this occurs, the undesirable plants, such as splitbeard bluestem, annual threeawn, little barley, windmillgrass, tumblegrass, partridge pea, ragweed, yarrow, ironweed, persimmon, oak, and other annual grasses and forbs, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Shallow Savannah range site. The Darsil soils in map units 1, 7, 35, and 36 are in this site. The potential plant community is a mid and tall grass aspect. Species composition, by weight, is 65 percent grasses, 20 percent forbs, and 15 percent woody plants.

Little bluestem, big bluestem, indiangrass, switchgrass, perennial lespedeza, tickclover, tephrosia, and hairy sunflower are preferred plants. They make up 60 percent of livestock forage production if the range is in excellent condition. The preferred plants disappear first under continuous or heavy grazing and are replaced by desirable plants, such as tall dropseed, sideoats grama, Scribner panicum, sand paspalum, purple lovegrass, hairy grama, wild indigo, wild alfalfa, heath aster, sagewort, sumac, post oak, blackjack oak, hickory, greenbrier, and redbud.

Continued overgrazing and extreme climatic conditions can cause a decline in the desirable plants. As this occurs, the undesirable plants, such as splitbeard bluestem, windmillgrass, threeawn, puffsheath dropseed, witchgrass, partridge pea, ragweed, yarrow, ironweed, snake cotton, persimmon and other annual grasses and forbs, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Subirrigated range site. The Gracemore and Gracemont Variant soils in map units 4, 18, and 91 are in this site. The potential plant community is a mid and tall grass aspect. Species composition, by weight, is 97 percent grass, 2 percent forbs, and 1 percent woody plants.

Big bluestem, switchgrass, indiangrass, and western wheatgrass are preferred plants. They make up 70 percent or more of livestock forage production if the range is in excellent condition. Other preferred plants, such as little bluestem and alkali sacaton, are present but are confined largely to the high islands in the irregular microrelief topography. The preferred plants disappear first under continuous or heavy grazing and are replaced by desirable plants, such as inland saltgrass, silver bluestem, annual brome, and buffalograss.

Continued overgrazing and extreme climatic conditions can cause a decline in the desirable plants. As this occurs, the undesirable plants, such as whorled dropseed, western ragweed, annual grasses and weeds, kochia, and tamarish, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Subirrigated Saline range site. The Asher Variant and Gracemore soils in map units 17 and 41 are in this site. The potential plant community is a tall grass aspect.

Species composition, by weight, is 80 percent grasses, 15 percent forbs, and 5 percent woody plants.

Switchgrass, sand bluestem, little bluestem, indiangrass, prairie cordgrass, wildrye, bundleflower, perennial sunflowers, and wild grape are preferred plants. They make up 75 percent of livestock forage production if the range is in excellent condition. The preferred plants are replaced by desirable plants, such as western wheatgrass, alkali sacaton, tall and meadow dropseed, Scribner panicum, knotroot bristlegrass, willow, baccharis, buttonbush, seacoast sumpweed, and smartweed.

Continued overgrazing and extreme climatic conditions can cause a decline in the desirable plants. As this occurs, the undesirable plants, such as inland saltgrass, silver bluestem, threeawn, ragweed, kochia, ironweed, tamarix, cottonwood, roughleaf dogwood, and other annual grasses and forbs, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Wetland range site. The Tribbey soil in map unit 20 is in this site. The potential plant community is a tall grass aspect. Species composition, by weight, is 50 percent grasses, 10 percent forbs, and 40 percent woody plants.

Switchgrass, indiangrass, big bluestem, little bluestem, prairie cordgrass, wildrye, and western wheatgrass are preferred plants. They make up 50 percent of livestock forage production if the range is in excellent condition. The preferred plants disappear first under continuous or heavy grazing and are replaced by desirable plants, such as beaked panicum, bushy bluestem, sedge, rush, willow, smartweed, curly dock, barnyardgrass, and Florida paspalum.

Continued grazing and extreme climatic conditions can cause a decline in the desirable plants. As this occurs, the undesirable plants, such as cattails, seacoast sumpweed, tamarix, cottonwood, and green ash, annual bluegrass, sandbur, plains coreopsis, water hemlock, and six weeks fescue, dominate the site. If undesirable plants dominate, the potential forage production is greatly reduced.

Native Woodlands

Native woodlands protect the soils from erosion, provide wildlife habitat, and have high esthetic values for homesites, but they have only limited value for grazing land or commercial wood production. The upland woodlands in eastern Cleveland County make up 71,413 acres, or about 20 percent of the county. They produce ample quantities of firewood for local use as fuel. Some of the better species are harvested for fence posts. The bottom land hardwoods make up 15,467 acres, or about 4 percent of the county. They are selectively harvested for the manufacture of furniture and for their nut production. Stands of post oak, blackjack oak, and hickory grow on the Darsil, Stephenville, Littleaxe, Newalla, and Harrah soils in the eastern part of the county. Chinquapin oak, northern red oak, red mulberry, persimmon, and redbud are on Harrah soils.

Eastern cottonwood and tamarisk are on low flood plains of the South Canadian River. American elm, green ash, hackberry, and pecan are dominant on high flood plains. American elm, black walnut, bur oak, eastern redcedar, northern red oak, red mulberry, pecan, green ash, hackberry, chittamwood, and redbud are on well drained flood plains near Little River and other smaller creeks. Eastern cottonwood, willow, American elm, and buttonbush are on soils that have a high water table and poor drainage and are near small creeks and tributaries.

Eastern red cedar has encroached on many of the loamy prairie uplands in the last 30 years. This has reduced the value for use as grazing land, but has increased its value for small acreage homesite development.

Use of Soils for Town and Country Planning

In Cleveland County, the development of residential subdivisions and the accompanying extension of public utilities create a need for soils information somewhat different from that needed for agriculture. Soil information is also needed where individual residential tracts, summer homes, and recreational facilities are well beyond public utilities. Land appraisers, realtors, city planners, builders, and individuals can use this information to help distinguish between sites that are suitable for houses or other buildings and those that should be reserved for other uses.

This section discusses soils in relation to site selection, foundations, sewage disposal systems, underground utility lines, control of erosion and runoff, and gardening and landscaping.

Site Selection

In selecting a site for the construction of buildings and other urban structures, planners, builders, and maintenance workers need to carefully investigate the soil. If the soil is poorly suited to the intended use, there is little that can be done unless costly changes are made. In most instances, the structure can be designed to offset the limitations of the soil if the problem has been identified before construction begins.

A major consideration in selecting a site is susceptibility to flooding. The Asher Variant, Gaddy, Gracemore, Gracemont Variant, Lomill, Port, Pulaski, Tribbey, and Weswood soils are subject to occasional or frequent flooding and should not be considered as sites for permanent structures. These soils should be reserved for greenbelts, sound barriers, habitat for wildlife, recreational trails, picnicking, and other recreational uses. Table 20 shows flooding frequency, duration, and months that flooding is likely to occur for each soil.

Areas of soils formed in alluvium and areas that are within the intermediate regional flood plains (flooded once in a hundred years) are not necessarily the same. Areas within the intermediate regional flood plain include all soils formed in alluvium and, in some instances, soils on uplands adjacent to the flood plain. These areas flood because most soils in the watershed are covered with urban structures that cause an increase in surface runoff. Information on the flood plains along all major streams in the county is available from the Cleveland County Conservation District. Additional information on areas of soils subject to flooding is available from the U.S. Geological Survey.

Other soil features that affect site selection are soil depth, permeability, the available water capacity, drainage, reaction, shrink-swell potential, and corrosivity to steel and concrete. Also considered are hydrologic classification, suitability as septic tank absorption fields, suitability as sites for foundations and low-cost streets and roads, problems of erosion and runoff, potential for recreational use, and suitability for grasses, flowers, vines, shrubs, and trees.

Foundations

In Cleveland County, many of the soils have montmorillonitic clay, which swells when wet and shrinks and cracks when dry. The pressure can be so great that walls and foundations crack even when specially reinforced. Damage because of shrinking and swelling is most likely to occur on Bethany, Brewless, Doolin, Grainola, Huska, Lomill, Newalla, Pawhuska, and Renfrow soils.

Flooding, ponding, poor drainage, and high corrosivity to concrete are limitations to the use of soils for foundations. Table 20 shows the risk of corrosion to concrete for each soil.

Sewage Disposal Systems

Many new houses in Cleveland County are built in areas beyond municipal sewerlines where onsite sewage disposal systems must be established. The effectiveness of a sewer system depends largely on the absorptive capacity, soil depth, permeability, percolation rate, wetness, flood hazard, seepage, and slope of the soils within the filter field. Generally the soils of Cleveland County are severely limited for use as septic tank absorption fields. In several areas of the county, the soils are dominantly silty clay, which is very slowly permeable (fig. 14). In other areas, the depth to rock is a severe limitation.

Underground Utility Lines

Water mains, gas pipelines, communication lines, and sewer pipes that are buried in the soil may corrode and break unless protected against certain electrobiochemical reactions resulting from inherent properties of the soil. All metals corrode to some degree when buried in soil, and some metals corrode more rapidly in some soils than in others. The corrosion potential depends on the physical, chemical, electrical, and biological characteristics of the soil. For example, the conductivity of soil solution, the reaction (pH) of anaerobic bacteria, the moisture content, and external factors, such as manmade electrical currents, affect corrosion potential. In a few places, the risk of corrosion is intensified by connecting two dissimilar metals, by burying metal structures at varying depths, and by extending pipelines through different kinds of soils. Table 20 shows the risk of corrosion to uncoated steel for each soil.

Shrinking and swelling can affect buried utility lines (see table 19). In soils that have high shrink-swell potential, the stress can break cast-iron pipe. To keep the pipes from breaking, cushion them with sand.

Control of Runoff and Erosion

Runoff generally increases and the pattern of runoff changes in areas where the natural vegetation is removed and is replaced with pavement, concrete, or buildings. After a heavy rain, the runoff may be several times greater than it was when the same soils were used for farming. It accumulates in streets and gutters instead of flowing into natural waterways. This results in flooding, erosion, and deposition of sediments in the lower areas.

Mechanical control of erosion and runoff and establishment of plants need to be planned and designed before construction starts. Thus, the problems caused by erosion, runoff, and sedimentation can be avoided or lessened.

Mechanical measures used to intercept, divert, convey, or retard the flow of water or to otherwise control erosion and runoff are grading, bench terraces, subsurface drainage, diversions, storm sewers, and outlets, such as grassed waterways. Only areas to be used immediately for construction should be graded. Bench terraces break up long slopes and slow the flow of runoff. They need to be constructed across the slopes and made to fit the natural terrain. If natural drainage channels are filled, subsurface drains need to be

Figure 14.—Sewage lagoon constructed on Renfrow silt loam, 1 to 3 percent slopes. Septic tank absorption fields do not function well because of the very slow permeability of Renfrow soil.

installed to remove excess ground water. Diversions intercept and divert runoff, and they need a stable outlet to dispose of water safely. Berms are diversions that consist of compacted temporary or permanent earth ridges on slight grades and do not have channels. Storm sewers dispose of runoff from streets and adjacent lots. Constructing small sediment basins next to sewer outlets can prevent deposition of sediments downstream or in storm sewers. Grassed waterways or other outlets dispose of water safely from water disposal structures, parking lots, streets, and other areas.

Grade stabilization structures, special culverts, and different kinds of pipe, generally in combination with special vegetation, can be used to help control erosion on soils so steep that a plant cover cannot be established. In areas where the soils are too steep or too unstable for erosion control, plastic or fiberglass mats can be used to temporarily line ditches and channels.

Hay, straw from small grains, and certain processed materials can be used as mulch to protect sloping soils and other critical areas if the grading is completed at an unfavorable time for seeding. These areas can be seeded later without removing the mulch. The mulch has to be anchored with asphalt or by using straight blade disks, netting, or some other method. Hydromulching, in which seeds, fertilizer, and mulch are applied as a slurry, is a rapid, all-in-one operation that requires little labor.

Rapidly growing plants, such as rye and wheat, can be used as cover for only a few months or for a year or two. Bermudagrass, weeping lovegrass, adapted legumes, trees, shrubs, and certain vines make good, permanent ground cover. Most grasses and legumes need weeding, fertilizing, mowing, and other maintenance. Jute netting, cotton netting, paper netting, and fiberglass matting are used only temporarily to hold mulches in place or to control soil blowing or washing while the seedlings are getting established.

Measures that control runoff and erosion at a homesite need to be designed to fit in well with the homesite. Grading, contouring, small diversions, waterways, and ditches or drain tile can be used.

The surface of the soil needs to be graded so that it is level or gently sloping. Where the surface layer is loamy, the topsoil can be removed and stockpiled until it can be replaced on the graded surface.

Driveways, walks, fences, retaining walls, and raised flower beds can be constructed on the contour or, where that is not feasible, straight across the slope. Small diversions can be built to intercept runoff before it flows across erodible soils. They need to be protected by permanent plant cover. Waterways can help to control gullying and drain soils where water stands. They must be shaped, smoothed, and established with sod. In places, waterways can be small ditches along property lines. They generally empty into bar ditches or paved and curbed streets. Seep spots, waterlogged soils, and small ponded areas can generally be drained by using ditches or tile drains. Some low areas need to be filled with good topsoil.

Selected Environmental Plantings

Landscaping needs to be included in the basic planning of urban construction. Potential of the native soils for the production of plants needs to be considered when sites are selected for urban construction. Table 10 furnishes a guide to the plants that are adapted to each soil in Cleveland County. The more common flowers and ground covers and the most commonly grown vines, shrubs, and trees are listed in the table. Some of these plants are native to the county. A local nurseryman or the Cooperative Extension Service horticulturist can supply the names of plants suited to the soils of Cleveland County.

Careful evaluation of the total landscape site, such as soil depth, flood hazard, high water table, saline or alkali spots, and surface drainage, should be made before selecting plants. Soil and site conditions can vary greatly within a few feet. Soil texture, depth, drainage, permeability, structure, and other characteristics are given in the map unit descriptions in the section "Detailed Soil Map Units" and the series descriptions in "Soil Series and Their Morphology." Soil reaction (pH), permeability, and the available water capacity are given in table 19.

Soils that are well suited to environmental plantings have a deep root zone, loamy texture, balanced supply of plant nutrients, large amount of organic matter in various stages of decomposition, adequate water supplying capacity, good drainage, and granular structure that allows free movement of water, air, and roots. Many soils are low in natural fertility, organic matter content, and plant nutrients. Before planting, a soil analysis needs to be made and any deficiency corrected. Contact the Oklahoma State University Extension Center in Norman for sampling instructions and costs for testing the sample.

Other than fertility deficiency correction, no additional commercial fertilizer is needed until the plants are established. Some plants can be damaged or killed if commercial fertilizer is applied too early. Plant establishment takes from one to three years, depending on plant size and species. When the plants begin to grow several inches per season, they need supplemental fertilization. All plants, whether grown in natural soil or in disturbed soil, require careful maintenance, especially during establishment. Good management practices include fertilizing, watering, and controlling weeds and insects.

A minimum of two pounds of Canadian or sphagnum peat moss mixed with a cubic foot or gallon size container of the soil when planting increases the water holding capacity and improves the physical condition of the soil and the chances of transplant survival. If the soil is sticky or clayey, add two to three pounds of agricultural gypsum and the peat moss to the planting soil for each cubic foot of soil. The gypsum makes the soil more friable, workable, and permeable to water and air.

Mulches of 2 to 4 inches of cottonseed hulls, wood chips, bark, straw, or weed-free grass clippings reduce evaporation, runoff, and soil temperature variations and improve infiltration. This provides a more uniform and desirable microclimate environment for plants.

Roses, azaleas, pin oaks, and other trees and shrubs have soil pH and micronutrient requirements that differ from many other plants. If an acid soil is needed, sulfur needs to be incorporated. Soil that is too acid can be neutralized by adding bonemeal, lime, wood ashes, or topsoil from a calcareous soil, such as Keokuk or Gracemont Variant soils.

In some areas of the county, the soils are so clayey, shallow, or poorly drained that raised beds are needed to grow environmental plantings. Brick, tile, metal, cedar, or redwood makes a good retainer along the edge of the bed. Beds need to be filled with soil material that has well balanced physical and chemical amendments.

Existing trees need to be protected during construction. In wooded areas, large healthy trees are a valuable asset to the property. Many trees are killed or damaged beyond restoration because of carelessness in excavation, filling, and construction. The Soil Conservation Service or Cooperative Extension Service can supply guidelines for the protection of existing trees.

Windbreaks

Windbreaks protect livestock, buildings, and yards from wind and snow. They also protect fruit trees and gardens, and they furnish habitat for wildlife. Several rows of low- and high-growing broadleaf and coniferous trees and shrubs provide the most protection.

Field windbreaks are narrow plantings made at right angles to the prevailing wind and at specific intervals across the field. The interval depends on the erodibility of the soil. Field windbreaks protect cropland and crops from wind, help to keep snow on the fields, and provide food and cover for wildlife.

Table 11 shows the height that locally grown trees and shrubs are expected to reach in 20 years on various soils. The estimates in table 11 are based on measurements and observation of established plantings that have been given adequate care. They can be used as a guide in planning windbreaks and screens.

On most soils, preparation for windbreaks can be the same as for ordinary field crops. Many of the plants adapted for windbreaks are native to the county. They grow naturally; however, they need special care. Soils that do not have a severe hazard of erosion can be prepared in advance of planting so that they will have time to settle. Alfalfa and grass sod need to be summer fallowed at least one year before planting. Cropland can be fall plowed. Adequate cover crops or crop residue help to protect soils that have a severe hazard of erosion. They also protect young tree seedlings.

Available soil moisture, soil fertility, tree spacing, tree adaptability to the soil, and care given to the tree all affect the growth of the tree. Trees that grow best on the soils at the planting location are needed. Plant late in winter or early in spring, protect the seedlings from drying out during planting, and pack the ground so it will be firm around the roots. Weeds need to be controlled so that they do not compete for moisture, and the trees need to be protected from livestock and fire.

Trees normally grow best on deep, loamy soils. Only fair to poor growth is made on clayey soils because these soils absorb and release moisture too slowly. Deep soils store more moisture for use during droughty periods. Hardwoods require deeper soils than conifers, although conifers make their best growth on the better farming soils. Conifers, such as pine and eastern redcedar, at first grow more slowly than hardwoods, but their growth is likely to equal that of most hardwoods as they mature. Conifers live longer than hardwoods, and they are more effective in a windbreak or a screen.

Additional information on design of windbreaks and on planting and care of trees is available from the Soil Conservation Service and the Cooperative Extension Service.

Recreation

In table 12, the soils of the survey area are rated according to the limitations that affect their suitability for recreation. The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewerlines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreational use by the duration and intensity of flooding and the season when flooding occurs. In planning recreation facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

In table 12, the degree of soil limitation is expressed as slight, moderate, or severe. *Slight* means that soil properties are generally favorable and that limitations are minor and easily overcome. *Moderate* means that limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 12 can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 15 and interpretations for dwellings without basements and for local roads and streets in table 14.

Camp areas require site preparation such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils have gentle slopes and are not wet or subject to flooding during the period of use. The surface has few or no stones or boulders, absorbs rainfall readily but remains firm, and is not dusty when dry. Strong slopes and stones or boulders can greatly increase the cost of constructing campsites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use, and do not have slopes, stones, or boulders that increase the cost of shaping sites or of building access roads and parking areas.

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and are not wet or subject to flooding during the season of use. The surface is free of stones and boulders, is firm after rains, and is not dusty when dry. If grading is needed, the depth of the soil over bedrock or a hardpan should be considered.

Paths and trails for hiking and horseback riding should require little or no cutting and filling. The best soils are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once a year during the period of use. They have moderate slopes and few or no stones or boulders on the surface.

Golf fairways are subject to heavy foot traffic and some light vehicular traffic. Cutting or filling may be required. The best soils for use as golf fairways are firm when wet, are not dusty when dry, and are not subject to prolonged flooding during the period of use. They have moderate slopes and no stones or boulders on the surface. The suitability of the soil for tees or greens is not considered in rating the soils.

Wildlife Habitat

Billy M. Teels, biologist, Soil Conservation Service, helped to prepare this section.

Wildlife is abundant in all areas of Cleveland County, but species and populations vary from one area to another.

Important wildlife in the county are bobwhite quail, mourning dove, fox squirrel, deer, cottontail, jack rabbit, mink, opposum, skunk, armadillo, muskrat, and beaver. Small flocks of Rio Grande wild turkey have been released in the county and appear to be successfully established. Predatory animals include coyote, bobcat, red fox, and gray fox. Predatory birds are mainly hawks and owls. They are protected by law because they help to control harmful rodents. The large lakes in the county attract waterfowl during the migration season. Many songbirds live in the county throughout the year. They are protected because of their esthetic value and because they help to control some harmful insects.

Where habitat is adequate and reproduction of wildlife is normal, most game can be hunted each year and still maintain their numbers. Bobwhite quail are the most popular game bird. Mourning dove are hunted in stubble fields, weed fields, and around ponds, but the number of dove taken is limited. Squirrels and deer are hunted in the more heavily wooded areas. Coyotes are hunted for sport, and a few pelts are sold. A few opposum, skunk, muskrat, and mink are trapped for their pelts. Mink are the most valuable furbearing animal in the county. Farm ponds, Lake Thunderbird, Lake Stanley Draper, and the South Canadian River provide good habitat for wintering waterfowl. Most farm ponds and lakes have been stocked with bass, catfish, and bluegill sunfish.

Soils affect the kind and amount of vegetation that is available to wildlife as food and cover. They also affect the construction of water impoundments. The kind and abundance of wildlife depend largely on the amount and distribution of food, cover, and water. Wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant cover, or by promoting the natural establishment of desirable plants.

In table 13, the soils in the survey area are rated according to their potential for providing habitat for various kinds of wildlife. This information can be used in planning parks, wildlife refuges, nature study areas, and other developments for wildlife; in selecting soils that are suitable for establishing, improving, or maintaining specific elements of wildlife habitat; and in determining the intensity of management needed for each element of the habitat.

The potential of the soil is rated good, fair, poor, or very poor. A rating of *good* indicates that the element or kind of habitat is easily established, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected. A rating of *fair* indicates that the element or kind of habitat can be established, improved, or maintained in most places. Moderately intensive management is required for satisfactory results. A rating of *poor* indicates that limitations are severe for the designated element or kind of habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and must be intensive. A rating of *very poor* indicates that restrictions for the element or kind of habitat are very severe and that unsatisfactory results can be expected. Creating, improving, or maintaining habitat is impractical or impossible.

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

Grain and seed crops are domestic grains and seed-producing herbaceous plants. Soil properties and features that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flood hazard. Soil temperature, soil moisture, and soil fertility are also considerations. Examples of grain and seed crops are corn, wheat, grain sorghum, oats, barley, millet, cowpeas, and sunflowers.

Grasses and legumes are domestic perennial grasses and herbaceous legumes. Soil properties and features that affect the growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, flood hazard, and slope. Soil temperature and soil moisture are also considerations. Examples of grasses and legumes are fescue, plains bluestem, lovegrass, bermudagrass, clover, lespedeza, and alfalfa.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds. Soil properties and features that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of wild herbaceous plants are bluestem, indiangrass, switchgrass, goldenrod, beggarweed, Illinois bundleflower, croten, and grama.

Hardwood trees and woody understory produce nuts or other fruit, buds, catkins, twigs, bark, and foliage. Soil properties and features that affect the growth of hardwood trees and shrubs are depth of the root zone, the available water capacity, and wetness. Examples of these plants are oak, cottonwood, pecan, black walnut, mulberry, American elm, hawthorn, dogwood, hickory, blackberry, and persimmon.

Coniferous plants furnish browse and seeds. Soil properties and features that affect the growth of coniferous trees, shrubs, and ground cover are depth of the root zone, available water capacity, and wetness. Examples of coniferous plants are pine, spruce, fir, cedar, and juniper.

Shrubs are bushy woody plants that produce fruit, buds, twigs, bark, and foliage. Soil properties and features that affect the growth of shrubs are depth of the root zone, available water capacity, salinity, and soil moisture. Examples of fruit-producing shrubs are crabapple, American plum, skunkbush sumac, Chickasaw plum, sand plum, and buckbrush.

Wetland plants are annual and perennial, wild herbaceous plants that grow on moist or wet sites. Submerged or floating aquatic plants are excluded. Soil properties and features affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness. Examples of wetland plants are smartweed, wild millet, saltgrass, cordgrass, rushes, sedges, cattails, and reeds.

Shallow water areas have an average depth of less than 5 feet. Some are naturally wet areas. Others are created by dams, levees, dugouts, or other water-control structures. Soil properties and features affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. Examples of shallow water areas are marshes, waterfowl feeding areas, and ponds.

The habitat for various kinds of wildlife is described in the following paragraphs.

Habitat for openland wildlife consists of cropland, pasture, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The wildlife attracted to these areas include bobwhite quail, mourning dove, meadowlark, field sparrow, cottontail, and red fox.

Habitat for woodland wildlife consists of areas of deciduous plants or coniferous plants or both and associated grasses, legumes, and wild herbaceous plants. Wildlife attracted to these areas include wild turkey, crows, thrushes, woodpeckers, squirrels, raccoon, armadillo, and deer.

Habitat for wetland wildlife consists of open, marshy or swampy shallow water areas. Some of the wildlife attracted to such areas are ducks, geese, herons, shore birds, muskrat, mink, and beaver.

Habitat for rangeland wildlife consists of areas of shrubs and wild herbaceous plants. Wildlife attracted to rangeland include coyote, deer, bobwhite quail, jackrabbit, dove, meadowlark, and prairie dog.

Engineering

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. The ratings are given in the following tables: Building site development, Sanitary facilities, Construction materials, and Water management. The ratings are based on observed performance of the soils and on the estimated data and test data in the "Soil Properties" section.

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil within a depth of 5 or 6 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations must be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 5 to 6 feet of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to: evaluate the potential of areas for residential, commercial, industrial, and recreational uses; make preliminary estimates of construction conditions; evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; plan detailed onsite investigations of soils and geology; locate potential sources of gravel, sand, earthfill, and topsoil; plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

The information in the tables, along with the soil maps, the soil descriptions, and other data provided in this survey can be used to make additional interpretations.

Some of the terms used in this soil survey have a special meaning in soil science and are defined in the Glossary.

Building Site Development

Table 14 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for basements, graves, utility lines, open ditches, and other purposes. The ratings are based on soil properties, site features, and observed performance of the soils. The ease of digging, filling, and compacting is affected by the depth to bedrock, a cemented pan, or a very firm dense layer; stone content; soil texture; and slope. The time of the year that excavations can be made is affected by the depth to a seasonal high water table and the susceptibility of the soil to flooding. The resistance of the excavation walls or banks to sloughing or caving is affected by soil texture and the depth to the water table.

Dwellings and small commercial buildings are structures built on shallow foundations on undisturbed soil. The load limit is the same as that for single-family dwellings no higher than three stories. Ratings are made for small commercial buildings without basements, for dwellings with basements, and for dwellings without basements. The ratings are based on soil properties, site features, and observed performance of the soils. A high water table, flooding, shrink-swell potential, and organic layers can cause the movement of footings. A high water table, depth to bedrock or to a cemented pan, large stones, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 5 to 6 feet are not considered.

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material, a base of gravel, crushed rock, or stabilized soil material, and a flexible or rigid surface. Cuts and fills are generally limited to less than 6 feet. The ratings are based on soil properties, site features, and observed performance of the soils. Depth to bedrock or to a cemented pan, a high water table, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil), shrink-swell potential, frost-action potential, and depth to a high water table affect the traffic-supporting capacity.

Lawns and landscaping require soils on which turf, ornamental trees, shrubs, ground cover, and vines can be established and maintained. The ratings are based on soil properties, site features, and observed performance of the soils. Soil reaction, a high water table, depth to bedrock or to a cemented pan, the available water capacity in the upper 40 inches, and the content of salts, sodium, and sulfidic materials affect plant growth. Flooding, wetness, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer affect trafficability after vegetation is established.

Soils that are well suited to yard and garden plants have a deep root zone, a loamy texture, a balanced supply of plant nutrients, plenty of organic matter in various stages of decomposition, adequate water-supplying capacity, good drainage, and a granular structure that allows free movement of water, air, and roots. The degree of acidity or alkalinity suitable for the particular plants to be grown is also important. For example, roses and most annual flowers, most vegetables, and most grasses generally grow best in soils that are neutral or only slightly acid. Azaleas, camellias, and other similar plants grow in acid soils. Some plants that are grown in soils, such as Weswood soils, that contain a large amount of lime develop chlorosis, a yellowing of the leaves. The limy soils in Cleveland County are well suited to many flowers, shrubs, and trees, including shasta daisies, hollyhocks, petunias, zinnias, gladiolus, and other flowers and crapemyrtle, dogwood, pecan, fruitless mulberry, and other shrubs and trees.

Table 10 lists soils in the county and some of the ground cover, vines, shrubs, and trees that are suited to each. In general the plants selected as suited to each soil can grow only in soils that have certain properties. For example, a plant that needs good drainage is suited only to moderately well drained or well drained soils, so such a plant is not listed for other soils. If that plant is grown in other soils, drainage, tile drains, or raised beds, must be provided.

It is generally less expensive and more advisable to condition the natural soil than to replace it with manmade soil material. Lime and fertilizer should be added according to the results of soil tests and the needs of the plant. The most important amendment to the soil is organic matter, which can be grass clippings, straw, cottonseed hulls, peat moss, compost, rotted sawdust, or manure. At least 2 inches of organic matter should be added to the soil. For clayey soils, at least 2 inches of sand, perlite, or vermiculite should be added. In addition, 5 pounds of a complete fertilizer (10-20-10) and 10 pounds of gypsum per 100 square feet should be broadcast. All of these materials should then be spaded or tilled into the upper 8 inches of the natural soil. If an acid soil is desired, 1 to 2 pounds of sulfur should be incorporated. If soil is too strongly acid, it may be neutralized by adding bonemeal, lime, wood ashes, or calcareous sand from the South Canadian River bed.

In some areas of the county, the soils are so clayey or so poorly drained that it may be necessary to construct raised beds to grow flowers and some shrubs. Brick, tile, metal, cedar, or redwood make good retainers along the edge of beds. Beds should be filled with good soil material and well balanced physical and chemical amendments.

All plants whether grown in natural soil or manmade soil require careful maintenance, especially during the period of establishment. Good management practices include fertilizing, watering, controlling weeds, and controlling insects.

Gardening and landscaping should be included in the basic plans for urban construction. The potential of the natural soil for the growing of plants should be considered when selecting the site. Also important is the protection of existing trees during construction. In timbered areas, large healthy trees are valuable and in places an irreplaceable asset to the property. Many trees that have a potential in landscaping are killed because of carelessness in excavation, filling, and construction. For guidelines for protecting trees, consult the nearest office of the Soil Conservation Service or the Agricultural Extension Service.

Sanitary Facilities

Table 15 shows the degree and the kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

Table 15 also shows the suitability of the soils for use as daily cover for landfills. A rating of *good* indicates that soil properties and site features are favorable for the use and that good performance and low maintenance can be expected; *fair* indicates that soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than the soils rated good; and *poor* indicates that one or more soil properties or site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 72 inches is evaluated. The ratings are based on soil properties, site features, and observed performance of the soils. Permeability, a high water table, depth to bedrock or to a cemented pan, and flooding affect absorption of the effluent. Large stones and bedrock or a cemented pan interfere with installation.

Unsatisfactory performance of septic tank absorption fields, including excessively slow absorption of effluent, surfacing of effluent, and hillside seepage, can affect public health. Ground water can be polluted if highly permeable sand and gravel or fractured bedrock is less than 4 feet below the base of the absorption field, if slope is excessive, or if the water table is near the surface. There must be unsaturated soil material beneath the absorption field to filter the effluent effectively. Many local ordinances require that this material be of a certain thickness.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Lagoons generally are designed to hold the sewage within a depth of 2 to 5 feet. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water.

Table 15 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 1 or 2 feet of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock or to a cemented pan, flooding, large stones, and content of organic matter.

Excessive seepage due to rapid permeability of the soil or a water table that is high enough to raise the level of sewage in the lagoon causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock, and cemented pans can cause construction problems, and large stones can hinder compaction of the lagoon floor.

Sanitary landfills are areas where solid waste is disposed of by burying it in soil. There are two types of landfill—trench and area. In a trench landfill, the waste is placed in a trench. It is spread, compacted, and covered daily with a thin layer of soil excavated at the site. In an area landfill, the waste is placed in successive layers on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil from a source away from the site.

Both types of landfill must be able to bear heavy vehicular traffic. Both types involve a risk of ground water pollution. Ease of excavation and revegetation needs to be considered.

The ratings in table 15 are based on soil properties, site features, and observed performance of the soils. Permeability, depth to bedrock or to a cemented pan, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench type landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 6 feet. For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

Daily cover for landfill is the soil material that is used to cover compacted solid waste in an area type sanitary landfill. The soil material is obtained offsite, transported to the landfill, and spread over the waste.

Soil texture, wetness, coarse fragments, and slope affect the ease of removing and spreading the material during wet and dry periods. Loamy or silty soils that are free of large stones or excess gravel are the best cover for a landfill. Clayey soils are sticky or cloddy and are difficult to spread; sandy soils are subject to soil blowing.

After soil material has been removed, the soil material remaining in the borrow area must be thick enough over bedrock, a cemented pan, or the water table to permit revegetation. The soil material used as final cover for a landfill should be suitable for plants. The surface layer generally has the best workability, more organic matter, and the best potential for plants. Material from the surface layer should be stockpiled for use as the final cover.

Construction Materials

Table 16 gives information about the soils as a source of roadfill, sand, gravel, and topsoil. The soils are rated *good, fair,* or *poor* as a source of roadfill and topsoil. They are rated as a probable or improbable source of sand and gravel. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 5 or 6 feet.

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 6 feet high and less exacting in design than higher embankments.

The ratings are for the soil material below the surface layer to a depth of 5 or 6 feet. It is assumed that soil layers will be mixed during excavating and spreading. Many soils have layers of contrasting suitability within their profile. The table showing engineering index properties provides detailed information about each soil layer. This information can help determine the suitability of each layer for use as roadfill. The performance of soil after it is stabilized with lime or cement is not considered in the ratings.

The ratings are based on soil properties, site features, and observed performance of the soils. The thickness of suitable material is a major consideration. The ease of excavation is affected by large stones, a high water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the engineering classification of the soil) and shrink-swell potential.

Soils rated *good* contain significant amounts of sand or gravel or both. They have at least 5 feet of suitable material, low shrink-swell potential, few cobbles and stones, and slopes of 15 percent or less. Depth to the water table is more than 3 feet. Soils rated *fair* are more than 35 percent silt- and clay-sized particles and have a plasticity index of less than 10. They have moderate shrink-swell potential, slopes of 15 to 25 percent, or many stones. Depth to the water table is 1 to 3 feet. Soils rated *poor* have a plasticity index of more than 10, a high shrink-swell potential, many stones, or slopes of more than 25 percent. They are wet, and the depth to the water table is less than 1 foot. They may have layers of suitable material, but the material is less than 3 feet thick.

Sand and gravel are natural aggregates suitable for commercial use with a minimum of processing. Sand and gravel are used in many kinds of construction. Specifications for each use vary widely. In table 16, only the probability of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material.

The properties used to evaluate the soil as a source of sand or gravel are gradation of grain sizes (as indicated by the engineering classification of the soil), the thickness of suitable material, and the content of rock fragments. Kinds of rock, acidity, and stratification are given in the soil series descriptions. Gradation of grain sizes is given in the table on engineering index properties.

A soil rated as a probable source has a layer of clean sand or gravel or a layer of sand or gravel that is up to 12 percent silty fines. This material must be at least 3 feet thick and less than 50 percent, by weight, large stones. All other soils are rated as an improbable source. Coarse fragments of soft bedrock, such as shale and siltstone, are not considered to be sand and gravel.

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 40 inches of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area.

Plant growth is affected by toxic material and by such properties as soil reaction, available water capacity, and fertility. The ease of excavating, loading, and spreading is affected by rock fragments, slope, a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, a water table, rock fragments, bedrock, and toxic material.

Soils rated *good* have friable, loamy material to a depth of at least 40 inches. They are free of stones and cobbles, have little or no gravel, and have slopes of less than 8 percent. They are low in content of soluble salts, are naturally fertile or respond well to fertilizer, and are not so wet that excavation is difficult.

Soils rated *fair* are sandy soils, loamy soils that have a relatively high content of clay, soils that have only 20 to 40 inches of suitable material, soils that have an appreciable amount of gravel, stones, or soluble salts, or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

Soils rated *poor* are very sandy or clayey, have less than 20 inches of suitable material, have a large amount of gravel, stones, or soluble salts, have slopes of more than 15 percent, or have a seasonal water table at or near the surface.

The surface layer of most soils is generally preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and releases a variety of plant-available nutrients as it decomposes.

Water Management

Table 17 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas; embankments, dikes, and levees; and aquifer-fed ponds. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and are easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increase in construction costs, and possibly increased maintenance are required.

This table also gives the restrictive features that affect each soil for irrigation, terraces and diversions, and grassed waterways.

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the permeability of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

Embankments, dikes, and levees are raised structures of soil material, generally less than 20 feet high, constructed to impound water or to protect land against overflow. In this table, the soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of about 5 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Figure 15.—Soil piping and dispersion are severe limitations for use of Huska and Pawhuska soils for fill material, such as pond embankment or road fill.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics (fig. 15). Unfavorable features include less than 5 feet of suitable material and a high content of stones or boulders, organic matter, or salts or sodium. A high water table affects the amount of usable material. It also affects trafficability.

Aquifer-fed excavated ponds are pits or dugouts that extend to a ground-water aquifer or to a depth below a permanent water table. Excluded are ponds that are fed only by surface runoff and embankment ponds that impound water 3 feet or more above the original surface. Excavated ponds are affected by depth to a permanent water table, permeability of the aquifer, and the salinity of the soil. Depth to bedrock and the content of large stones affect the ease of excavation.

Irrigation is the controlled application of water to supplement rainfall and support plant growth. The design and management of an irrigation system are affected by depth to the water table, the need for drainage, flooding, available water capacity, intake rate, permeability, erosion hazard, and slope. The construction of a system is affected by large stones and depth to bedrock or to a cemented pan. The performance of a system is affected by the depth of the root zone, the amount of salts or sodium, and soil reaction.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to reduce erosion and conserve moisture by intercepting runoff. Slope, wetness, large stones, and depth to bedrock or to a cemented pan affect the construction of terraces and diversions. A restricted rooting depth, a severe hazard of wind or water erosion, an excessively coarse texture, and restricted permeability adversely affect maintenance.

Grassed waterways are natural or constructed channels, generally broad and shallow, that conduct surface water to outlets at a nonerosive velocity. Large stones, wetness, slope, and depth to bedrock or to a cemented pan affect the construction of grassed waterways. A hazard of wind erosion, low available water capacity, restricted rooting depth, toxic substances such as salts or sodium, and restricted permeability adversely affect the growth and maintenance of the grass after construction.

Soil Properties

Data relating to soil properties are collected during the course of the soil survey. The data and the estimates of soil and water features, listed in tables, are explained on the following pages.

Soil properties are determined by field examination of the soils and by laboratory index testing of some benchmark soils. Established standard procedures are followed. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine grain-size distribution, plasticity, and compaction characteristics. These results are reported in table 23.

Estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. Tests verify field observations, verify properties that cannot be estimated accurately by field observation, and help characterize key soils.

The estimates of soil properties shown in the tables include the range of grain-size distribution and Atterberg limits, the engineering classifications, and the physical and chemical properties of the major layers of each soil. Pertinent soil and water features also are given.

Engineering Index Properties

Table 18 gives estimates of the engineering classification and of the range of index properties for the major layers of each soil in the survey area. Most soils have layers of contrasting properties within the upper 5 or 6 feet.

Depth to the upper and lower boundaries of each layer is indicated. The range in depth and information on other properties of each layer are given for each soil series under "Soil Series and Their Morphology."

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is as much as 15 percent, an appropriate modifier is added, for example, "gravelly." Textural terms are defined in the Glossary.

Classification of the soils is determined according to the Unified soil classification system *(2)* and the system adopted by the American Association of State Highway and Transportation Officials *(1)*.

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, SP-SM.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20, or higher, for the poorest. The AASHTO classification for soils tested, with group index numbers in parentheses, is given in table 23.

Rock fragments larger than 3 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area, or from nearby areas, and on field examination.

Physical and Chemical Properties

Table 19 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Clay as a soil separate, or component, consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each major soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The amount and kind of clay greatly affect the fertility and physical condition of the soil. They influence the soil's absorption of cations, moisture retention, shrink-swell potential, permeability, plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3 bar moisture tension. Weight is determined after drying the soil at 105 degrees C. In this table, the estimated moist bulk density of each major soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. A bulk density of more than 1.6 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Permeability refers to the ability of a soil to transmit water or air. The estimates indicate the rate of downward movement of water when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems, septic tank absorption fields, and construction where the rate of water movement under saturated conditions affects behavior.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage in each major soil layer is stated in inches of water per inch of soil. The capacity varies, depending on soil properties that affect the retention of water and the depth of the root zone. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Soil reaction is a measure of acidity or alkalinity and is expressed as a range in pH values. The range in pH of each major horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

Shrink-swell potential is the potential for volume change in a soil with a loss or gain in moisture. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. Laboratory measurements of swelling of undisturbed clods were made for many soils. For others, swelling was estimated on the basis of the kind and amount of clay minerals in the soil and on measurements of similar soils.

If the shrink-swell potential is rated moderate to very high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special design is often needed.

Shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to field capacity. The change is based on the soil fraction less than 2 millimeters in diameter. The classes are *low*, a change of less than 3 percent; *moderate*, 3 to 6 percent; and *high*, more than 6 percent. *Very high*, greater than 9 percent, is sometimes used.

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion. Losses are expressed in tons per acre per year. These estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.02 to 0.69. The higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind or water that can occur over a sustained period without affecting crop productivity. The rate is expressed in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their resistance to wind erosion in cultivated areas. The groups indicate the susceptibility of soil to wind erosion and the amount of soil lost. Soils are grouped according to the following distinctions:

1. Sands, coarse sands, fine sands, and very fine sands. These soils are generally not suitable for crops. They are extremely erodible, and vegetation is difficult to establish.

2. Loamy sands, loamy fine sands, and loamy very fine sands. These soils are very highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

3. Sandy loams, coarse sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

4L. Calcareous loamy soils that are less than 35 percent clay and more than 5 percent finely divided calcium carbonate. These soils are erodible. Crops can be grown if intensive measures to control wind erosion are used.

4. Clays, silty clays, clay loams, and silty clay loams that are more than 35 percent clay. These soils are moderately erodible. Crops can be grown if measures to control wind erosion are used.

5. Loamy soils that are less than 20 percent clay and less than 5 percent finely divided calcium carbonate and sandy clay loams and sandy clays that are less than 5 percent finely divided calcium carbonate. These soils are slightly erodible. Crops can be grown if measures to control wind erosion are used.

6. Loamy soils that are 20 to 35 percent clay and less than 5 percent finely divided calcium carbonate, except silty clay loams. These soils are very slightly erodible. Crops can easily be grown.

7. Silty clay loams that are less than 35 percent clay and less than 5 percent finely divided calcium carbonate. These soils are very slightly erodible. Crops can easily be grown.

8. Stony or gravelly soils and other soils not subject to wind erosion.

Organic matter is the plant and animal residue in the soil at various stages of decomposition.

In table 19, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter of a soil can be maintained or increased by returning crop residue to the soil. Organic matter affects the available water capacity, infiltration rate, and tilth. It is a source of nitrogen and other nutrients for crops.

Soil and Water Features

Table 20 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils are assigned to one of four groups. They are grouped according to the intake of water when the soils are thoroughly wet and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Flooding, the temporary covering of the soil surface by flowing water, is caused by overflowing streams, by runoff from adjacent slopes, or by inflow from high tides. Shallow water standing or flowing for short periods after rainfall or snowmelt is not considered flooding. Standing water in swamps and marshes or in a closed depression is considered ponding.

Table 20 gives the frequency and duration of flooding and the time of year when flooding is most likely to occur.

Frequency, duration, and probable dates of occurrence are estimated. Frequency generally is expressed as *none, rare, occasional,* or *frequent. None* means that flooding is not probable. *rare* means that flooding is unlikely but possible under unusual weather conditions (there is a near 0 to 5 percent chance of flooding in any year). *Occasional* means that flooding occurs infrequently under normal weather conditions (there is a 5 to 50 percent chance of flooding in any year). *Frequent* means that flooding occurs often under normal weather conditions (there is more than a 50 percent chance of flooding in any year). *common* is used when classification as occasional or frequent does not affect interpretations. Duration is expressed as *very brief* (less than 2 days), *brief* (2 to 7 days), *long* (7 days to 1 month), and *very long* (more than 1 month). The time of year that floods are most likely to occur is expressed in months. November-May, for example, means that flooding can occur during the period November through May. About two-thirds to three-fourths of all flooding occurs during the stated period.

The information on flooding is based on evidence in the soil profile, namely, thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and absence of distinctive horizons, which are characteristic of soils that are not subject to flooding.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. The depth to a seasonal high water table applies to undrained soils. The estimates are based mainly on the evidence of a saturated zone, namely grayish colors or mottles in the soil. Indicated in table 20 are the depth to the seasonal high water table; the kind of water table, that is, *perched*, *artesian*, or *apparent;* and the months of the year that the water table commonly is highest. A water table that is seasonally high for less than 1 month is not indicated in table 20.

An *apparent* water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil. An *artesian* water table is under hydrostatic head, generally below an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole. A *perched* water table is water standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

The two numbers in the "High water table-Depth" column indicate the normal range in depth to a saturated zone. Depth is given to the nearest half foot. The first numeral in the range indicates the highest water level. A plus sign preceding the range in depth indicates that the water table is above the surface of the soil. "More than 6.0" indicates that the water table is below a depth of 6 feet or that the water table exists for less than a month.

Depth to bedrock is given if bedrock is within a depth of 5 feet. The depth is based on many soil borings and on observations during soil mapping. The rock is specified as either soft or hard. If the rock is soft or fractured, excavations can be made with trenching machines, backhoes, or small rippers. If the rock is hard or massive, blasting or special equipment generally is needed for excavation.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors creates a severely corrosive environment. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than steel in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low*, *moderate*, or *high*, is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion is also expressed as *low*, *moderate*, or *high*. It is based on soil texture, acidity, and the amount of sulfates in the saturation extract.

Physical and Chemical Analyses of Selected Soils

The results of physical analysis of several typical pedons in the survey area are given in table 21 and the results of chemical analysis in table 22. The data are for soils sampled at carefully selected sites. The pedons are typical of the series and are described in the section "Soil Series and Their Morphology." Soil samples were analyzed by Soil Morphology, Genesis, and Classification Laboratory, Department of Agronomy, Oklahoma State University.

Most determinations, except those for grain-size analysis and bulk density, were made on soil material smaller than 2 millimeters in diameter. Measurements reported as percent or quantity of unit weight were calculated on an oven-dry basis. The methods used in obtaining the data are indicated in the list that follows. The codes in parentheses refer to published methods *(12)*.

Sand—(0.05-2.0 mm fraction) weight percentages of materials less than 2 mm (3A1).

Silt—(0.002-0.05 mm fraction) pipette extraction, weight percentages of all materials less than 2 mm (3A1).

Clay—(fraction less than 0.002 mm) pipette extraction, weight percentages of materials less than 2 mm (3A1).
Organic matter—peroxide digestion (6A3).
Extractable cations—ammonium acetate pH 7.0, uncorrected; calcium (6N2), magnesium (602), sodium (6P2), potassium (6Q2).
Cation-exchange capacity—sum of cations (5A3a).
Base saturation—sum of cations, TEA, pH 8.2 (5C3).
Reaction (pH)—1:1 water dilution (8C1a).
Total phosphorus—perchloric acid; colorimetry (6S1a).

Engineering Index Test Data

Table 23 shows laboratory test data for one pedon sampled at a carefully selected site in the survey area. The pedon is typical of the series and is described in the section "Soil Series and Their Morphology." The soil samples were tested by the Oklahoma Department of Transportation, Materials Division.

The testing methods generally are those of the American Association of State Highway and Transportation Officials (AASHTO) or the American Society for Testing and Materials (ASTM).

The tests and methods are: AASHTO classification—M 145 (AASHTO), D 3282 (ASTM); Unified classification—D 2487 (ASTM); Mechanical analysis—T 88 (AASHTO), D 2217 (ASTM); Liquid limit—T 89 (AASHTO), D 423 (ASTM); Plasticity index—T 90 (AASHTO), D 424 (ASTM); D 1883 (ASTM); Shrinkage—T 92 (AASHTO), D 427 (ASTM);

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories *(10)*. Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or on laboratory measurements. Table 24 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol*. An example is Mollisol.

SUBORDER. Each order is divided into suborders, primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Ustolls (*Ust*, meaning dry, plus *oll*, from Mollisols).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Argiustolls (*Argi*, meaning argillic horizon, plus *ustoll*, the suborder of the Mollisols that have an ustic moisture regime).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other known kind of soil. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Typic* identifies the subgroup that typifies the great group. Udic identifies an intergrade to Udolls. An example is Udic Argiustolls.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Mostly the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineral content, temperature regime, depth of the root zone, consistence, moisture equivalent, slope, and permanent cracks. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is fine-loamy, mixed, thermic Udic Argiustolls.

SERIES. The series consists of soils that have similar horizons in their profile. The horizons are similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. There can be some variation in the texture of the surface layer or of the substratum within a series.

Soil Series and Their Morphology

In this section, each soil series recognized in the survey area is described. The descriptions are arranged in alphabetic order.

Characteristics of the soil and the material in which it formed are identified for each series. The soil is compared with similar soils and with nearby soils of other series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the *Soil Survey Manual (9)*. Many of the technical terms used in the descriptions are defined in *Soil Taxonomy (10)*. Unless otherwise stated, colors in the descriptions are for dry soil. Following the pedon description is the range of important characteristics of the soils in the series.

The map units of each soil series are described in the section "Detailed Soil Map Units."

Asher Series

Soils of the Asher series are deep, moderately well drained, and slowly permeable. These nearly level to very gently sloping soils formed in loamy Pleistocene alluvium. They are on high flood plains along the South Canadian River. Slopes are less than 2 percent. The soils of the Asher series are fine-silty, mixed, thermic Fluventic Haplustolls.

Asher soils are associated with Asher Variant, Brewless, Canadian, Gaddy, Goodnight, Gracemont Variant, Gracemore, Keokuk, and Lomill soils. Asher

Variant, Gaddy, Gracemont Variant, and Gracemore soils are in lower positions on flood plains than Asher soils. Asher Variant soils have sandy stratified sediments and a high water table within 3.5 feet of the surface. Gaddy and Gracemore soils do not have a mollic epipedon and have a sandy control section. Gracemore soils have a high water table near the surface. Gracemont Variant soils have a coarse-silty over sandy control section. Brewless and Keokuk soils are in slightly lower positions on the landscape than Asher soils. Brewless soils have a fine control section, a mollic epipedon more than 20 inches thick, and an argillic horizon. Keokuk soils have a coarse-silty control section. Canadian soils are in slightly higher positions on the convex landscape than the Asher soils and have a coarse-loamy control section. Lomill soils are in slightly lower concave areas and have a clayey surface horizon and a clayey over loamy control section.

Typical pedon Asher silt loam, clayey substratum, rarely flooded; about 2,440 feet south and 1,260 feet west of the northeast corner of sec. 18., T. 6 N., R. 1 W.

Ap—0 to 6 inches; dark grayish brown (10YR 4/2) silt loam, very dark brown (10YR 3/2) moist; weak medium platy structure parting to weak medium granular; hard, friable; many very fine roots; neutral; clear smooth boundary.

A1—6 to 11 inches; brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; moderate medium granular structure; hard, friable; many very fine roots; mildly alkaline; clear smooth boundary.

B2—11 to 20 inches; brown (7.5YR 4/2) silty clay loam, dark brown (7.5YR 3/2) moist; weak medium subangular blocky structure; very hard, firm; many very fine roots; common wormcasts; moderately alkaline; gradual smooth boundary.

B3ca—20 to 30 inches; brown (7.5YR 5/4) silt loam, brown (7.5YR 4/4) moist; weak fine subangular blocky structure; hard, friable; common very fine roots; few wormcasts; common threads of calcium carbonate; violently effervescent; moderately alkaline; clear smooth boundary.

IIC—30 to 44 inches; light reddish brown (5YR 6/4) very fine sandy loam, reddish brown (5YR 5/4) moist; massive; slightly hard, very friable; few very fine roots; few wormcasts; violently effervescent; moderately alkaline; clear wavy boundary.

IIIC—44 to 69 inches; reddish brown (5YR 5/3) silty clay, reddish brown (5YR 4/3) moist; many fine distinct light brownish gray (2.5Y 6/2) mottles and few fine distinct yellowish red (5YR 5/6) mottles; massive; extremely hard, very firm; few very fine roots; few fine black concretions; few calcium carbonate concretions; violently effervescent; moderately alkaline; clear wavy boundary.

IVC—69 to 80 inches; light reddish brown (5YR 6/4) loamy fine sand, reddish brown (5YR 5/4) moist; massive; soft, very friable; violently effervescent; moderately alkaline.

Thickness of the solum and depth to the IIC horizon range from 20 to 40 inches. The depth to secondary carbonates ranges from 13 to 34 inches. A high water table is generally 3.5 to 10 feet below the surface. Depth to fine sand or loamy fine sand is 60 inches or more.

The A horizon is 8 to 20 inches thick. It has hue of 5YR to 10YR, value of 4 or 5, and chroma of 2 or 3. The A horizon is silt loam or silty clay loam. It ranges from slightly acid to moderately alkaline.

The B2 horizon is 7 to 24 inches thick. It has hue of 5YR or 7.5YR, value of 4 to 6, and chroma of 2 to 4. The B2 horizon is silt loam, silty clay loam, or clay loam. The clay content ranges from about 20 to 40 percent. This horizon ranges from neutral to moderately alkaline.

The B3ca horizon is 0 to 15 inches thick. It has hue of 7.5YR, value of 5 or 6, and chroma of 2 to 4. The B3ca horizon is silt loam or silty clay loam. The clay content ranges from about 20 to 35 percent. The weighted average clay content of the 10- to 40-inch control section ranges from 18 to 35 percent.

The IIC, IIIC, and IVC horizons are generally stratified and variable in texture. Bedding planes are evident in some pedons. Buried horizons occur below a depth of 40 inches in some pedons. The IIC and IIIC horizons have hue of 5YR to 10YR, value of 4 to 7, and chroma of 3 to 6. In some pedons, they have strata with mottles in shades of red, brown, or gray. The IIC and IIIC horizons are dominantly very fine sandy loam stratified with 5- to 30-inch thick layers of loamy very fine sand, fine sandy loam, silt loam, loam, sandy clay loam, clay loam, silty clay loam, or silty clay. The weighted average clay content ranges from 18 to 33 percent.

The IVC horizon has hue of 5YR or 7.5YR, value of 4 to 7, and chroma of 3 to 6. It is loamy fine sand or fine sand and is stratified. The weighted average clay content ranges from 5 to 12 percent.

The Asher soils in this county differ from the Asher series because they have a high water table 3.5 to 10 feet below the surface and have horizons more than 40 inches deep that are slightly more clayey and horizons more than 60 inches deep that are slightly more sandy than allowed in the series. Use, behavior, and management are similar to those of the Asher soils.

Asher Variant

The Asher Variant soils are deep, somewhat poorly drained, and slowly permeable. These nearly level to very gently sloping soils formed in recent stratified loamy alluvium. They are on slightly concave, low flood plains along the South Canadian River. Slopes are less than 2 percent. The Asher Variant soils are fine-silty over sandy, mixed, thermic Fluvaquentic Haplustolls.

Asher Variant soils are associated with Asher, Brewless, Canadian, Gaddy, Goodnight, Gracemont Variant, Gracemore, Keokuk, and Lomill soils. Asher, Brewless, Canadian, Keokuk, and Lomill soils are in higher positions on flood plains than the Asher Variant soils. Asher soils have a fine-silty control section and a high water table more than 3.5 feet below the surface, and they are non-saline. Brewless soils have a mollic epipedon more than 20 inches thick, an argillic horizon, and a fine control section. Canadian soils have a coarse-loamy control section. Keokuk soils have a coarse-silty control section, and Lomill soils have a clayey over loamy control section. Gaddy soils are on lower, convex landscapes, do not have a mollic epipedon, and have a sandy control section. Goodnight soils are in higher hummocky areas and have a sandy control section. Gracemont Variant soils are in similar positions on the landscape as Asher Variant soils, do not have a mollic epipedon, and have a coarse-silty over sandy control section. Gracemore soils are in lower positions on flood plains than the Asher Variant soils, have a sandy control section, and do not have a mollic epipedon.

Typical pedon of Asher Variant silty clay loam, saline, occasionally flooded; about 1,475 feet west and 650 feet north of the southeast corner of sec. 20, T. 6 N., R. 1 W.

Ap—0 to 6 inches; brown (7.5YR 4/2) silty clay loam, dark brown (7.5YR 3/2) moist; weak medium granular structure; hard, friable; many fine roots; strongly effervescent; moderately alkaline; clear smooth boundary.

A1—6 to 11 inches; brown (7.5YR 4/2) silty clay loam, dark brown (7.5YR 3/2) moist; moderate medium granular structure; very hard, friable; many fine roots; strongly effervescent; moderately alkaline; clear wavy boundary.

C1—11 to 21 inches; reddish brown (5YR 5/4) very fine sandy loam, reddish brown (5YR 4/4) moist; massive; slightly hard, very friable; many fine roots; few wormcasts; strongly effervescent; moderately alkaline; abrupt wavy boundary.

C2—21 to 28 inches; reddish brown (5YR 5/3) silty clay loam, reddish brown (5YR 4/3) moist; massive; hard, firm; common fine roots; violently effervescent; moderately alkaline; abrupt wavy boundary.

Cca—28 to 36 inches; light reddish brown (5YR 6/4) silty clay loam, reddish brown (5YR 5/4) moist; common fine distinct yellowish red (5YR 5/6) mottles; massive; hard, firm; few fine threads of calcium carbonate; violently effervescent; moderately alkaline; abrupt wavy boundary.

IIC—36 to 51 inches; pink (7.5YR 7/4) fine sand, brown (7.5YR 5/4) moist; single grained; loose; few fine roots; thin dark strata; strongly effervescent; moderately alkaline; abrupt wavy boundary.

IIIC1—51 to 59 inches; light reddish brown (5YR 6/4) very fine sandy loam, reddish brown (5YR 5/4) moist; few fine distinct yellowish red (5YR 5/6) mottles; massive; slightly hard, very friable; few fine roots; thin strata of coarser and finer textures; violently effervescent; moderately alkaline; clear wavy boundary.

IIIC2—59 to 78 inches; light reddish brown (5YR 6/4) very fine sandy loam, reddish brown (5YR 5/4) moist; many coarse distinct yellowish red (5YR 5/6) mottles and common fine distinct light brownish gray (10YR 6/2) mottles; massive; slightly hard, very friable; thin strata of coarser and finer textures; few fine threads of calcium carbonate; violently effervescent; moderately alkaline.

The Asher Variant soils have a mollic epipedon, an irregular decrease in organic matter content or stratification within 40 inches of the surface, and a high water table that is 1.5 to 3.5 feet below the surface. The soils are calcareous and moderately alkaline throughout and range from slightly saline to strongly saline. The salts are commonly more concentrated in the A horizons. The depth to the IIC horizon ranges from 20 to 40 inches.

The A horizon is 9 to 17 inches thick. It has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3.

The C1 horizon is 3 to 21 inches thick. It has hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 2 to 6. The C1 horizon is silty clay loam or very fine sandy loam. Finer textured strata occur in some pedons.

The C2 horizon is 0 to 10 inches thick. It has hue of 5YR, value of 5 or 6, and chroma of 3. The C2 horizon is silty clay loam or clay loam. Thin, darker, or finer strata occur in some pedons.

The Cca horizon is 0 to 11 inches thick. It has hue of 5YR or 7.5YR, value of 6, and chroma of 4. In some pedons, the Cca horizon has mottles in shades of red or brown. It is silty clay loam or silt loam. Thin, coarser, or finer textured strata occur in some pedons.

The IIC horizon is 9 to 28 inches thick. It has hue of 7.5YR, value of 6 or 7, and chroma of 4. Most pedons have mottles in shades of red, brown, or gray. The IIC horizon is fine sand or loamy fine sand. Bedding planes or thin strata of coarser or finer textures occur in some pedons.

The IIIC horizon has hue of 5YR to 10YR, value of 6 or 7, and chroma of 3 or 4. Most pedons have mottles in shades of red, brown, or gray. The IIIC horizon is stratified and ranges from fine sand to silty clay.

The Asher Variant soils differ from the soils of the Asher series because they are saline and have a fine-silty over sandy control section and a high water table that is 1.5 to 3.5 feet below the surface.

Bethany Series

Soils of the Bethany series are deep, well drained, and slowly permeable. These nearly level to very gently sloping soils formed in clayey material weathered from loess or Pleistocene alluvium. They are on mantled uplands. Slopes range from 0 to 3 percent. The soils of the Bethany series are fine, mixed, thermic Pachic Paleustolls.

Bethany soils are associated with Doolin, Norge, Pawhuska, Renfrow, and Vanoss soils. Doolin soils are in slightly lower positions on uplands than the Bethany soils, have an abrupt textural change between the A horizon and B horizon and have a natric horizon. Norge soils are slightly lower in elevation and have a fine-silty control section. Pawhuska soils are intermingled with Bethany soils. Pawhuska soils have a natric horizon and an abrupt textural change from the A horizon to the B horizon. Renfrow soils have a mollic epipedon less than 20 inches thick, COLE value more than 0.07, and they are on lower ridge crests and side slopes than the Bethany soils. Vanoss soils are in similar positions on the landscape and have a mollic epipedon less than 20 inches thick and a fine-silty control section.

Typical pedon of Bethany silt loam, 0 to 1 percent slopes; about 1,250 feet north and 2,100 feet east of the southwest corner of sec. 26, T. 9 N., R. 3 W.

Ap—0 to 8 inches; dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate fine granular structure; slightly hard, very friable; many very fine and few fine roots; medium acid; clear smooth boundary.

A1—8 to 13 inches; dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate medium granular structure; hard, friable; many very fine roots; slightly acid; gradual smooth boundary.

B1—13 to 21 inches; brown (10YR 4/3) silty clay loam, dark brown (10YR 3/3) moist; weak fine subangular blocky structure parting to moderate medium granular; hard, firm; common very fine roots; slightly acid; gradual smooth boundary.

B21t—21 to 30 inches; brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) moist; few fine faint strong brown mottles; weak medium prismatic structure parting to moderate medium blocky; very hard, very firm; common very fine roots; nearly continuous clay films on faces of peds; slightly acid; gradual smooth boundary.

B22t—30 to 43 inches; pale brown (10YR 6/3) silty clay, brown (10YR 5/3) moist; common fine and medium distinct yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to strong medium blocky; extremely hard, extremely firm; common very fine roots; nearly continuous clay films on faces of peds; few nonintersecting slickensides; neutral; gradual smooth boundary.

B23t—43 to 65 inches; grayish brown (2.5Y 5/2) silty clay, dark grayish brown (2.5YR 4/2) moist; many medium and coarse distinct brownish yellow (10YR 6/6) mottles; moderate medium blocky structure; extremely hard, extremely firm; few very fine roots; nearly continuous clay films on faces of peds; few fine black concretions; neutral; gradual smooth boundary.

B3—65 to 84 inches; coarsely mottled yellowish brown (10YR 5/6), dark grayish brown (2.5Y 4/2), and grayish brown (10YR 5/2) clay loam, dark yellowish brown (10YR 4/6), dark grayish brown (10YR 4/2), and grayish brown (10YR 5/2) moist; weak medium blocky structure; very hard, very firm; few fine roots; patchy clay films on faces of peds; mildly alkaline.

Thickness of the solum and depth to bedrock are more than 80 inches. Some pedons are calcareous in the lower part of the B2t horizon. Buried clayey horizons occur below a depth of 40 inches in some pedons.

The A horizon is 10 to 20 inches thick. It has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3. The A horizon ranges from medium acid to neutral.

The B1 horizon is 3 to 9 inches thick. It has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3. The B1 horizon is silty clay loam. The clay content ranges from about 27 to 32 percent. This horizon ranges from slightly acid to mildly alkaline.

The B21t horizon is 8 to 19 inches thick. It has hue of 10YR, value of 4 or 5, and chroma of 2 or 3. In some pedons, the B21t horizon has brownish or reddish mottles. The B21t horizon is silty clay loam or silty clay. The clay content ranges from about 32 to 45 percent. This horizon ranges from slightly acid to mildly alkaline.

The B22t horizon is 10 to 30 inches thick. It has hue of 7.5YR or 10YR, value of 5 or 6, and chroma of 2 or 3. Most pedons have brownish, reddish, yellowish, or grayish mottles. In some pedons, the B22t horizon is coarsely mottled. The B22t horizon is silty clay loam or silty clay. The clay content ranges from about 38 to 50 percent. This horizon ranges from neutral to moderately alkaline.

The B23t horizon is 0 to 22 inches thick. It has hue of 2.5YR to 2.5Y, value of 5 or 6, and chroma of 2 or 3. Most pedons have brownish, reddish, yellowish, or grayish mottles. In some pedons, the B23t horizon is coarsely mottled and has hue ranging from 2.5YR to 2.5Y, value of 4 or 6, and chroma of 1 or 6. The B23t horizon is silty clay, clay loam, or silty clay loam. The clay content ranges from about 32 to 50 percent. This horizon ranges from neutral to moderately alkaline.

The B3 horizon is mostly coarsely mottled and has hue ranging from 2.5YR to 2.5Y, value of 4 to 6, and chroma of 2 to 8. It is clay loam, silty clay loam, or silty clay. The clay content ranges from about 27 to 50 percent. The B3 horizon ranges from neutral to moderately alkaline.

The Bethany soils in this survey area are taxadjunct to the Bethany series because the upper part of the B2t horizon is slightly more acid, and they have mottles slightly higher in the profile than allowed in the Bethany series. Use, behavior, and management are similar to those of the Bethany series.

Brewless Series

Soils of the Brewless series are deep, moderately well drained, and slowly permeable. These nearly level soils formed in loamy and clayey Pleistocene alluvium. They are on smooth, high flood plains along the South Canadian River. Slopes range from 0 to 1 percent. The soils of the Brewless series are fine, mixed, thermic Pachic Argiustolls.

Brewless soils are associated with Asher, Asher Variant, Canadian, Gaddy, Goodnight, Gracemont Variant, Gracemore, Keokuk, and Lomill soils. Asher, Asher Variant, Canadian, Keokuk, and Lomill soils have a mollic epipedon less than 20 inches thick and do not have an argillic horizon. Asher soils are in slightly higher positions on the landscape than Brewless soils and have a fine-silty control section. Asher Variant soils are in lower positions on flood plains than Brewless soils, and have a fine-silty over sandy control section. Canadian soils are in slightly higher positions on the landscape than Brewless soils and have a coarse-loamy control section. Keokuk soils are in slightly lower positions on the landscape than Brewless soil and have a coarse-silty control section. Lomill soils are in slightly lower concave areas and have a clayey over loamy control section. Gaddy, Goodnight, Gracemont Variant, and Gracemore soils do not have a mollic epipedon or argillic horizon. Gaddy soils are on lower flood plains than the Brewless soils and have a sandy control section. Goodnight soils are in higher hummocky areas and have a sandy control section. Gracemont Variant soils are on lower flood plains than the Brewless soils and have a coarse-silty over sandy control section. Gracemore soils are on lower flood plains than the Brewless soils, have a high water table near the surface most of the time, and have a sandy control section.

Typical pedon of Brewless silty clay loam, rarely flooded; about 1,300 feet north and 50 feet east from the southwest corner of sec. 17, T. 6 N., R. 1 W.

Ap—0 to 9 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark brown (10YR 2/2) moist; weak medium granular structure; very hard, firm; many very fine and fine roots; slightly acid; clear smooth boundary.

B21t—9 to 16 inches; dark brown (7.5YR 4/2) silty clay, very dark brown (7.5YR 2/2) moist; moderate fine blocky structure; many very fine and fine roots; nearly continuous clay films on faces of peds; mildly alkaline; clear wavy boundary.

B22t—16 to 24 inches; brown (7.5YR 5/2) silty clay, dark brown (7.5YR 3/2) moist; moderate medium blocky structure; extremely hard, very firm; common very fine roots; nearly continuous clay films on faces of peds; few wormcasts; moderately alkaline; clear wavy boundary.

B31ca—24 to 36 inches; brown (7.5YR 5/3) silty clay loam, dark brown (7.5YR 4/3) moist; weak medium blocky structure; very hard, very firm; few very fine roots; patchy clay films on faces of peds; common soft masses and threads of calcium carbonate; violently effervescent; moderately alkaline; clear wavy boundary.

B32ca—36 to 44 inches; light reddish brown (5YR 6/4) silty clay loam; reddish brown (5YR 5/4) moist; weak medium subangular blocky structure; hard, firm; few very fine roots; patchy clay films on faces of peds; few fine black concretions; many soft masses and threads of calcium carbonate; violently effervescent; moderately alkaline; clear wavy boundary.

IIC—44 to 84 inches; stratified brown (7.5YR 5/3), reddish brown (5YR 5/4), and light reddish brown (5YR 6/4) silty clay loam, very fine sandy loam, and silty clay, brown (7.5YR 4/3) and reddish brown (5YR 4/4, 5/4) moist; common fine distinct yellowish red (5YR 4/6), dark brown (7.5YR 4/2), and grayish brown (2.5Y 5/2) mottles; massive; hard, friable; few fine black concretions; common soft masses and threads of calcium carbonate; violently effervescent; moderately alkaline.

Depth to stratified material ranges from 40 to 73 inches. Depth to soft powdery lime ranges from 12 to 28 inches. A high water table is between 5 and 10 feet below the surface most of the time.

The Ap or A1 horizon is 7 to 22 inches thick. It has hue of 5YR to 10YR, value of 3 to 5, and chroma of 2 or 3. The Ap or A1 horizon ranges from slightly acid to moderately alkaline.

Some pedons have a B1 horizon from 3 to 6 inches thick. The B1 horizon has colors and reaction similar to the A horizon. It is silty clay loam or silty clay.

The B21t horizon is 7 to 15 inches thick. It has hue of 5YR to 10YR, value of 3 to 5, and chroma of 2 or 3. The B21t horizon is silty clay. The clay content ranges from about 40 to 55 percent. This horizon ranges from neutral to moderately alkaline.

The B22t horizon is 0 to 36 inches thick. It has hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 2 to 4. The B22t horizon is silty clay or silty clay loam. The clay content ranges from about 36 to 50 percent. This horizon ranges from neutral to moderately alkaline.

The B31ca horizon is 0 to 24 inches thick. It has hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 3 or 4. In some pedons, the B31ca horizon has mottles in shades of brown or red. The B31ca horizon is silty clay loam, clay loam, or silty clay. The clay content ranges from about 28 to 45 percent.

The B32ca horizon is 0 to 14 inches thick. It has hue of 5YR or 7.5YR, value of 5 or 6, and chroma of 3 or 4.

In some pedons, the B32ca horizon has mottles in shades of brown or red. The B32ca horizon is silty clay loam or clay loam. The clay content ranges from about 27 to 36 percent.

The IIC horizon is stratified and variable in color and texture. It has hue of 5YR or 7.5YR, value of 5 to 8, and chroma of 3 to 6. Some strata have mottles in shades of gray, brown, or red. This horizon consists of thin strata that range from less than 1 inch to 20 inches in thickness. The IIC horizon ranges from silty clay to loamy fine sand. The clay content ranges from about 5 to 45 percent. The weighted average clay content ranges from 7 to 30 percent and typically ranges from 10 to 20 percent.

Canadian Series

Soils of the Canadian series are deep, well drained, and moderately rapidly permeable. These nearly level to very gently sloping soils formed in loamy Pleistocene alluvium. They are on slightly convex, high flood plains along the South Canadian River. Slopes range from 0 to 3 percent. The soils of the Canadian series are coarse-loamy, mixed, thermic Udic Haplustolls.

Canadian soils are associated with Asher, Asher Variant, Brewless, Derby, Gaddy, Goodnight, Gracemont Variant, Gracemore, Keokuk, Lomill, and Slaughterville soils. Asher soils are in slightly lower positions on the landscape than Canadian soils and have a fine-silty control section. Asher Variant soils are in lower positions on flood plains than Canadian soils and have a fine-silty over sandy control section and a high water table within 3.5 feet of the surface. Brewless soils are in slightly lower positions on the landscape than Canadian soils and have a mollic epipedon more than 20 inches thick, a fine control section, and an argillic horizon. Derby soils are on adjoining uplands, do not have a mollic epipedon, and have a sandy control section. Gaddy soils are on lower flood plains, do not have a mollic epipedon, and have a sandy control section. Goodnight soils are in higher hummocky areas and have a sandy control section. Gracemont Variant soils are on lower flood plains and have a coarse-silty over sandy control section. Gracemore soils are on lower flood plains, do not have a mollic epipedon, and have a sandy control section and a high water table near the surface most of the year. Keokuk soils are in slightly lower positions on the landscape than Canadian soils and have a coarse-silty control section. Lomill soils are on lower, concave landscapes and have a clayey over loamy control section. Slaughterville soils are on adjoining uplands.

Typical pedon of Canadian fine sandy loam, 0 to 1 percent slopes, rarely flooded; about 2,600 feet north and 2,300 feet east from the southwest corner of sec. 32, T. 10 N., R. 3. W.

Ap—0 to 9 inches; brown (10YR 5/3) fine sandy loam, dark brown (10YR 3/3) moist; weak fine granular structure; slightly hard, very friable; many very fine roots; medium acid; clear smooth boundary.

A1—9 to 19 inches; brown (10YR 5/3) fine sandy loam, very dark grayish brown (10YR 3/2) moist; moderate medium granular structure; slightly hard, very friable; many very fine roots; medium acid; gradual smooth boundary.

B2—19 to 32 inches; brown (7.5YR 5/3) fine sandy loam, dark brown (7.5YR 4/3) moist; weak medium subangular blocky structure; hard, very friable; common very fine roots; slightly acid; gradual smooth boundary.

C1—32 to 56 inches; brown (7.5YR 5/4) fine sandy loam, dark brown (7.5YR 4/4) moist; massive; hard, very friable; few very fine roots; slightly acid; gradual smooth boundary.

C2—56 to 84 inches; reddish yellow (7.5YR 6/6) fine sandy loam, brown (7.5YR 5/4) moist; massive; slightly hard, very friable; neutral.

Thickness of the solum ranges from 21 to 40 inches. Most of this soil has a high water table 6 to 10 feet below the surface, but in some pedons, it is more than 10 feet below the surface. Buried horizons or stratification occurs below a depth of 50 inches in some pedons.

The Ap and A1 horizon is 13 to 20 inches thick. It has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3. The Ap and A1 horizon ranges from medium acid to neutral.

The B2 horizon is 10 to 38 inches thick. It has hue of 7.5YR, value of 4 or 5, and chroma of 3 to 6. The B2 horizon is mainly fine sandy loam, but it is loam in some pedons. The clay content ranges from about 15 to 18 percent. This horizon ranges from slightly acid to moderately alkaline.

The C horizon has hue of 5YR or 7.5YR, value of 5 to 7, and chroma of 3 to 6. It is fine sandy loam or sandy loam above a depth of 40 inches. Below a depth of 40 inches, it is loamy fine sand and fine sand. Buried or stratified horizons occur in some pedons below a depth of 40 inches and range from fine sand to silty clay. The C horizon has quartz gravel from 2 mm to 10 mm in diameter that makes up from 0 to 15 percent by volume. This horizon ranges from slightly acid to moderately alkaline and, in some pedons, is calcareous.

Darsil Series

Soils of the Darsil series are shallow, excessively drained, and rapidly permeable. These very gently sloping to sloping soils formed in material weathered from weakly cemented Permian sandstone. They are on convex ridge crests and side slopes of uplands (fig. 16). Slopes range from 1 to 8 percent. The soils of the Darsil series are thermic, shallow, coated Typic Quartzipsamments.

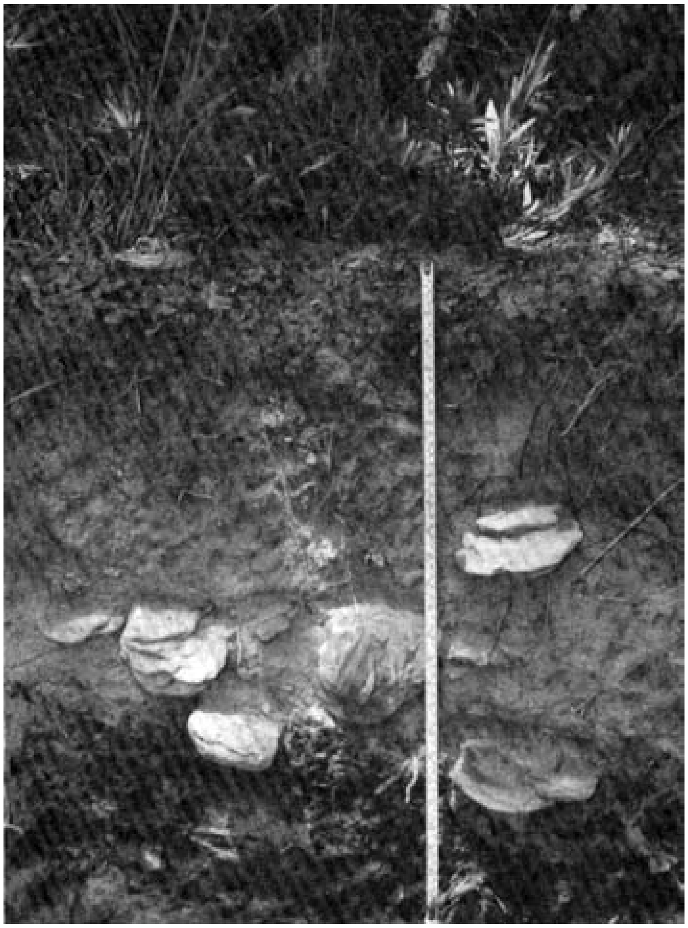


Figure 16.—A profile of Darsil loamy fine sand showing barite roserocks in the lower part of the AC horizon. The rocks were originally embedded in the soft weathered sandstone in lower part of profile.

Darsil soils are associated with Derby, Harrah, Littleaxe, Newalla, and Stephenville soils. The Derby, Harrah, Littleaxe, and Stephenville soils are more than 20 inches deep and have an argillic horizon. Derby soils are on higher ridge crests or on lower side slopes than Darsil soils. Harrah soils are on lower side slopes and on foot slopes and have a fine-loamy control section. Littleaxe soils are on higher, broad ridge crests and have a fine-loamy control section. Newalla soils formed in material weathered from sandstone and shales in similar positions on the landscape as Darsil soils. They have a fine-loamy over clayey control section and an argillic horizon. Stephenville soils are in similar positions on the landscape as Darsil soils and have a fine-loamy control section.

Typical pedon of Darsil loamy fine sand from an area of Stephenville-Darsil-Newalla complex, 3 to 8 percent slopes; about 700 feet east and 50 feet south of the northwest corner of sec. 32, T. 9 N., R. 1 W.

A1—0 to 5 inches; brown (7.5YR 5/2) loamy fine sand, dark brown (7.5YR 3/2) moist; weak fine granular structure; soft, very friable; slightly acid; clear smooth boundary.

AC—5 to 17 inches; pink (7.5YR 7/4) fine sand, brown (7.5YR 5/4) moist; weak fine granular structure; soft, very friable; 2 percent by volume coarse fragments from 2 mm to 76 mm in diameter; neutral; clear wavy boundary.

Cr—17 to 23 inches; red (2.5YR 5/8) weakly cemented fine grained sandstone, red (2.5YR 4/8) moist; medium acid.

Thickness of the solum and depth to bedrock range from 10 to 20 inches. The soils of the Darsil series range from strongly acid to mildly alkaline.

The A1 or Ap horizon is 3 to 9 inches thick. It has hue of 5YR to 10YR, value of 4 to 6, and chroma of 2 to 4.

The AC horizon is 6 to 15 inches thick. It has hue of 2.5YR to 10YR, value of 6 or 7, chroma of 3 to 6. The AC horizon is loamy fine sand or fine sand. It contains from 0 to 20 percent by volume of coarse sandstone or barite fragments from 2 mm to 76 mm in diameter.

The Cr horizon has hue of 2.5YR or 5YR, value of 3 to 6, and chroma of 4 to 8. It is weakly cemented, fine grained sandstone. In some pedons, the Cr horizon has streaks in shades of brown, gray, or yellow.

Derby Series

Soils of the Derby series are deep, somewhat excessively drained, and rapidly permeable. These nearly level to moderately steep soils formed in sandy eolian Pleistocene sediments. They are on undulating ridge crests and side slopes of uplands. Slopes range from 0 to 15 percent. The soils of the Derby series are mixed, thermic Alfic Ustipsamments.

Derby soils are associated with Canadian, Darsil, Dougherty, Harrah, Konawa, Littleaxe, Newalla, Norge, Slaughterville, Slaughterville Variant, Stephenville, Teller, and Vanoss soils. Canadian soils are on high flood plains and have a mollic epipedon. Darsil soils are on lower ridge crests and on higher side slopes than Derby soils. Dougherty, Konawa, Slaughterville, and Slaughterville Variant soils are in similar positions on the landscape as Derby soils. Dougherty soils have a loamy control section and an argillic horizon. Konawa soils have a fine-loamy control section, an argillic horizon, and an A horizon less than 20 inches thick. Slaughterville and Slaughterville Variant soils have a mollic epipedon and a coarse-loamy control section. Harrah soils are on foot slopes below the Derby soils and have a fine-loamy control section, an argillic horizon that does not decrease in clay content by 20 percent or more within a depth of 60 inches, and an A horizon less than 20 inches thick. Littleaxe soils are on broad, smoother ridge crests and side slopes. They have a 40- to 60-inch solum and a fine-loamy control section. Newalla soils are in lower positions on ridge crests than Derby soils and have a fine-loamy over clayey control section. Norge and Teller soils are on smoother ridge crests and side slopes than Derby soils and have a mollic epipedon. Norge soils have a fine-silty control section and Teller soils have a fine-loamy control section. Stephenville soils are on smoother ridge crests and side slopes, and have sola 20 to 40 inches thick over sandstone, an argillic horizon, and a fine-loamy control section. Vanoss soils are on smoother ridge crests than Derby soils and have a mollic epipedon and a fine-silty control section.

Typical pedon of Derby loamy fine sand, 3 to 15 percent slopes; about 2,100 feet east and 850 feet north from the southwest corner of sec. 15, T. 9 N., R. 3 W.

Ap—0 to 11 inches; brown (10YR 5/3) loamy fine sand, dark brown (10YR 4/3) moist; weak medium granular structure; soft, very friable; many fine and common very fine roots; mildly alkaline; clear wavy boundary.

A21—11 to 21 inches; light brown (7.5YR 6/4) loamy sand, brown (7.5YR 5/4) moist; weak fine granular structure; soft, very friable; many very fine and fine roots; neutral; gradual wavy boundary.

A22—21 to 52 inches; pink (7.5YR 7/4) loamy sand; light brown (7.5YR 6/4) moist; single grained; loose; common very fine roots; neutral; clear wavy boundary.

A2&B2t—52 to 84 inches; reddish yellow (7.5YR 7/6) loamy sand, light brown (7.5YR 6/4) moist (A2); single grained; loose; lamellae of reddish yellow (5YR 6/8) loamy fine sand, yellowish red (5YR 5/8) moist (B2t); massive; slightly hard, very friable; 0.1 to 0.3 cm thick and 15 to 30 cm apart; few very fine roots; clay bridging between sand grains; neutral.

Thickness of the solum is more than 72 inches. Depth to lamellae ranges from 48 to 72 inches.

The Ap or A1 horizon is 5 to 20 inches thick. It has hue of 7.5YR or 10YR, value of 4 to 6, and chroma of 2 to 4. When the thickness of this horizon is greater than 10 inches, the color chroma is 4, or the organic matter content is less than 1 percent. The Ap or A1 horizon ranges from medium acid to mildly alkaline.

The A2 horizon is 20 to 60 inches thick. It has hue of 5YR or 7.5YR, value of 5 to 7, and chroma of 3 to 8. The A2 horizon is loamy fine sand or loamy sand. It has quartz gravel from 2 mm to 10 mm in diameter that makes up from 0 to 2 percent by volume. The A2 horizon ranges from medium acid to mildly alkaline.

The A2&B2t horizon is 20 to more than 80 inches thick. The A2 part of the A2&B2t horizon has hue of 5YR or 7.5YR, value of 6 or 7, and chroma of 4 to 6. It is loamy fine sand or loamy sand. The A2 part has quartz gravel from 2 mm to 10 mm in diameter that makes up from 0 to 5 percent by volume. The B2t part of the A2&B2t horizon has hue of 5YR, value of 4 to 6, and chroma of 4 to 8. It is fine sandy loam or loamy fine sand. The lamellae range from 0.1 to 1.6 cm thick and from 2.5 to 30 cm apart. The combined thickness of the lamellae is less than 15 cm. The A2&B2t horizon ranges from medium acid to mildly alkaline.

Doolin Series

Soils of the Doolin series are deep, moderately well drained, and very slowly permeable. These nearly level to very gently sloping soils are formed in clayey material weathered from loess or Pleistocene alluvium underlain by Permian redbeds. They are on broad mantled upland plains. Slopes range from 0 to 3 percent. The soils of the Doolin series are fine, montmorillonitic, thermic Typic Natrustolls.

Doolin soils are associated with the Bethany, Grainola, Grant, Pawhuska, and Renfrow soils. Bethany soils are on slightly higher mantled upland ridge crests and do not have an abrupt textural change between the A horizon and B horizons or a natric horizon. Grainola soils are on side slopes, have a solum 20 to 40 inches thick over shale, and do not have a mollic epipedon or a natric horizon. Grant soils are forming in material weathered from siltstone or sandstone on slightly lower ridge crests than Doolin soils. The Grant soils have a fine-silty control section, sola 40 to 60 inches thick, and do not have a natric horizon or an abrupt textural change between the A horizon and B horizon. Pawhuska soils are intermingled with the Doolin soils. Pawhuska soils are in slightly depressional spots and do not have a mollic epipedon. Renfrow soils are well drained and occur on convex ridge crests and side slopes. They do not have an abrupt textural change between the A horizon and B horizon or a natric horizon.

Typical pedon of Doolin silt loam from an area of Doolin-Pawhuska complex, 0 to 3 percent slopes; about 1,470 feet south and 1,050 feet west from the northeast corner of sec. 33, T. 10 N., R. 3 W.

A1—0 to 11 inches; grayish brown (10YR 5/2) silt loam, very dark brown (10YR 2/2) moist; weak fine granular structure; slightly hard, friable; few fine and many very fine roots; strongly acid; clear smooth boundary.

A2—11 to 13 inches; light brownish gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) moist; weak fine granular structure; slightly hard, friable; few fine and many very fine roots; medium acid; abrupt smooth boundary.

B21t—13 to 22 inches; dark gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) moist; weak medium prismatic structure parting to moderate medium blocky; extremely hard, very firm; many very fine roots; grayish brown (10YR 5/2) caps on tops of prisms and black (10YR 2/1) coatings on sides of prisms; nearly continuous clay films on faces of peds; slightly acid; gradual smooth boundary.

B22t—22 to 28 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; weak medium prismatic structure parting to moderate medium blocky; extremely hard, very firm; many very fine roots; nearly continuous clay films on faces of peds; neutral; gradual smooth boundary.

B23tca—28 to 47 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; weak medium and coarse blocky structure; extremely hard, very firm; common very fine roots; nearly continuous clay films on faces of peds; few nonintersecting slickensides; common soft bodies of calcium carbonate; few calcium carbonate concretions; slightly effervescent; neutral; gradual smooth boundary.

B24tsa—47 to 60 inches; coarsely mottled dark grayish brown (10YR 4/2), gray (10YR 5/1), and reddish brown (5YR 5/4) silty clay, very dark grayish brown (10YR 3/2), dark gray (10YR 4/1), and reddish brown (5YR 4/4) moist; weak coarse blocky structure; extremely hard, very firm; common very fine roots; nearly continuous clay films on faces of peds; few nonintersecting slickensides; few fine black concretions; common soft crystals of soluble salts; few soft masses of calcium carbonate; slightly effervescent; neutral; gradual smooth boundary.

B21tbsa—60 to 75 inches; reddish brown (2.5YR 5/4) silty clay, reddish brown (2.5YR 4/4) moist; weak coarse blocky structure; extremely hard, very firm; few very fine roots; nearly continuous clay films on faces of peds; few vertical streaks of gray (10YR 5/1); few fine black concretions; common soft crystals of soluble salts; slightly effervescent; neutral; gradual smooth boundary.

B22tb—75 to 87 inches; red (2.5YR 5/6) silty clay, red (2.5YR 4/6) moist; weak coarse blocky structure; extremely hard, very firm; patchy clay films on faces of peds; few vertical streaks of dark grayish brown (10YR 4/2); few fine black concretions; neutral; gradual smooth boundary.

BCb—87 to 104 inches; red (2.5YR 5/6) silty clay loam, red (2.5YR 4/6) moist; weak coarse subangular blocky structure; very hard, very firm; patchy clay films on faces of peds; about 20 percent by volume shale fragments 2 mm to 76 mm in diameter; slightly effervescent; neutral.

Thickness of the solum and depth to bedrock are 60 to more than 80 inches. There is an abrupt textural change from the A horizon to the B21t horizon. The exchangeable sodium percentage ranges from about 15 to 36 percent in the B2t horizons. Buried horizons do not occur in all pedons.

The Ap or A1 horizon is 7 to 12 inches thick. It has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3. The Ap or A1 horizon ranges from strongly acid to mildly alkaline.

The A2 horizon is 0 to 4 inches thick and is usually absent where mixed with the plow layer. It has hue of 10YR, value of 5 or 6, and chroma of 2 or 3. The A2 horizon is similar to the Ap horizon in texture and soil reaction.

The B21t horizon is 4 to 17 inches thick. It has hue of 10YR, value of 3 or 4, and chroma of 1 to 3. The B21t horizon is silty clay loam or silty clay. The clay content ranges from about 38 to 55 percent. This horizon ranges from slightly acid to moderately alkaline.

The B22t horizon is 0 to 30 inches thick. It has hue of 10YR, value of 4 or 5, and chroma of 2 or 3. Mottles in shades of red or brown are in some pedons. The B22t horizon is silty clay loam or silty clay. The clay content ranges from about 38 to 50 percent. This horizon ranges from neutral to moderately alkaline.

The B23tca horizon is 0 to 27 inches thick. It has hue of 5YR to 10YR, value of 4 to 6, and chroma of 2 to 6. In some pedons, the B23tca horizon has reddish, yellowish, or brownish mottles. The B23tca horizon is silty clay loam or silty clay. The clay content ranges from about 33 to 50 percent. This horizon ranges from neutral to moderately alkaline.

The B24tsa horizon is 0 to 27 inches thick. It has hue of 2.5YR to 2.5Y, value of 4 to 6, and chroma of 2 to 6. In some pedons, the B24tsa horizon is coarsely mottled or has mottles in shades of gray, brown, or red. The B24tsa horizon is silty clay loam or silty clay. The clay content ranges from about 30 to 50 percent. This horizon ranges from neutral to moderately alkaline.

The B21tbsa horizon is 0 to 27 inches thick. It has hue of 2.5YR to 2.5Y, value of 4 to 6, and chroma of 2 to 6. In some pedons, the B21tbsa horizon is coarsely mottled or has mottles in shades of brown, red, or gray. The B21tbsa horizon is silty clay loam or silty clay. The clay content ranges from about 35 to 60 percent. This horizon ranges from neutral to moderately alkaline. Some pedons have B3 horizons of similar color and texture rather than buried Bt horizons.

The B22tb horizon is 0 to 15 inches thick. It has hue of 2.5YR to 2.5Y, value of 4 to 6, and chroma of 2 to 6. In some pedons, the B22tb horizon is coarsely mottled or has mottles in shades of red, brown, or gray. The B22tb horizon is silty clay loam or silty clay. The clay content ranges from about 35 to 50 percent. This horizon ranges from neutral to moderately alkaline.

The BCb horizon has hue of 2.5YR to 2.5Y, value of 4 to 6, and chroma of 2 to 6. In many pedons, it is mottled in shades of gray, brown, or red. The BCb horizon is silty clay loam or silty clay. The clay content ranges from about 30 to 45 percent. The BCb horizon has shale fragments from 2 mm to 76 mm in diameter that make up from 0 to 50 percent by volume. This horizon ranges from neutral to moderately alkaline.

The Doolin soils in this survey area are taxadjunct to the Doolin series because they do not have a lithologic discontinuity, which is typical for the Doolin series. Use, behavior, and management are similar to those of the Doolin series.

Dougherty Series

Soils of the Dougherty series are deep, well drained, and moderately permeable. These very gently sloping to sloping soils formed in sandy and loamy Pleistocene sediments. They are on undulating uplands (fig. 17). Slopes range from 2 to 8 percent. The soils of the Dougherty series are loamy, mixed, thermic Arenic Haplustalfs.

Dougherty soils are associated with Derby, Konawa, Norge, Slaughterville, Slaughterville Variant, Teller, and Vanoss soils. Derby and Konawa soils are in similar

Figure 17.—A profile of Dougherty loamy fine sand showing the A1 horizon, the A2 horizon between 5 and 34 inches, and the B2t horizon below.

positions on the landscape. Derby soils have a sandy control section with lamellae, and Konawa soils have an A horizon less than 20 inches thick. Norge soils are on higher ridge crests and side slopes than Dougherty soils and have a mollic epipedon and a fine-silty control section. Slaughterville and Slaughterville Variant soils are on lower ridge crests and side slopes than Dougherty soils and have a mollic epipedon and a coarse-loamy control section. Teller soils are on smoother ridge crests and side slopes than Dougherty soils and have a mollic epipedon and a higher base saturation. Vanoss soils are on smooth ridge crests and have a mollic epipedon and a fine-silty control section.

Typical pedon of Dougherty loamy fine sand from an area of Dougherty-Konawa complex, 2 to 8 percent slopes; about 1,680 feet east and 100 feet north from the southwest corner of sec. 17, T. 7 N., R. 1 W.

A1—0 to 7 inches; grayish brown (10YR 5/2) loamy fine sand, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; soft, very friable, many very fine and fine roots; neutral; clear wavy boundary.

A21—7 to 15 inches; brown (10YR 5/3) loamy fine sand, brown (10YR 4/3) moist; weak fine granular structure; soft, very friable; many very fine and fine roots; neutral; gradual wavy boundary.

A22—15 to 23 inches; light brown (7.5YR 6/4) loamy fine sand, brown (7.5YR 5/4) moist; weak fine granular structure; soft, very friable; common fine roots; slightly acid; clear wavy boundary.

B21t—23 to 27 inches; reddish brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; weak medium subangular blocky structure; very hard, friable; common fine roots; patchy clay films on faces of peds; strongly acid; gradual smooth boundary.

B22t—27 to 39 inches; yellowish red (5YR 5/6) sandy clay loam, yellowish red (5YR 4/6) moist; moderate coarse subangular blocky structure; very hard, friable; common very fine roots; nearly continuous clay films on faces of peds; strongly acid; gradual smooth boundary.

B3—39 to 65 inches; yellowish red (5YR 5/8) fine sandy loam, yellowish red (5YR 4/8) moist; weak coarse subangular blocky structure; few very fine roots; patchy clay films on faces of peds and bridging between some sand grains; strongly acid; gradual smooth boundary.

C—65 to 96 inches; reddish yellow (5YR 6/6) fine sandy loam, yellowish red (5YR 5/6) moist; massive; slightly hard, very friable; about 2 percent by volume small pockets of clean sand grains; medium acid.

Thickness of the solum ranges from 45 to more than 72 inches.

The A1 or Ap horizon is 4 to 10 inches thick. It has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3. The A1 or Ap horizon has quartz gravel from 2 mm to 10 mm in diameter that makes up from 0 to 2 percent by volume. This horizon is slightly acid. Where limed, it is slightly acid or neutral.

The A2 horizon is 14 to 25 inches thick. It has hue of 7.5YR or 10YR, value of 5 or 6, and chroma of 2 to 4. The A2 horizon has quartz gravel from 2 mm to 10 mm in diameter that makes from 0 to 2 percent by volume. The A2 horizon is slightly acid. Where limed, it can be neutral.

The B2t horizons are 10 to 20 inches thick. They have hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 4 to 6. The B2t horizons are fine sandy loam or sandy clay loam. The clay content ranges from 15 to 30 percent. The B2t horizons have quartz gravel from 2 mm to 10 mm in diameter that makes up from 0 to 5 percent by volume. These horizons range from strongly acid to slightly acid.

The B3 horizon is 10 to 30 inches thick. It has hue of 2.5YR or 5YR, value of 5 or 6, and chroma of 6 to 8. The B3 horizon is fine sandy loam or sandy clay loam. The clay content ranges from 12 to 25 percent. The B3 horizon has quartz gravel from 2 mm to 10 mm in diameter that makes up from 0 to 5 percent by volume. This horizon ranges from strongly acid to slightly acid.

The C horizon has hue of 5YR, value of 5 or 6, and chroma of 6 to 8. It is fine sandy loam or loamy fine sand. The C horizon has quartz gravel from 2 mm to 10 mm in diameter that makes up from 0 to 5 percent by volume. In some pedons, it has lamellae to 7 mm thick that ranges from 2 to 6 inches apart. This horizon ranges from strongly acid to neutral.

Gaddy Series

Soils of the Gaddy series are deep, somewhat excessively drained, and moderately rapid to rapidly permeable. These nearly level to very gently sloping soils formed in recent stratified sandy alluvium. These soils occur on convex, low flood plains along the South Canadian River. Slopes range from 0 to 2 percent. The soils of the Gaddy series are sandy, mixed, thermic Typic Ustifluvents.

Gaddy soils are associated with Asher, Asher Variant, Brewless, Canadian, Goodnight, Gracemont Variant, Gracemore, Keokuk, and Lomill soils. Asher, Asher Variant, Brewless, Canadian, Keokuk, and Lomill soils are in higher positions on flood plains and have a mollic epipedon. Asher soils have a fine-silty control section. Asher Variant soils have a fine-silty over sandy control section. Brewless soils have a fine control section. Canadian soils have a coarse-loamy control section. Keokuk soils have a coarse-silty control section, and Lomill soils have a clayey over loamy control section. Goodnight soils are in higher hummocky areas and do not have an irregular distribution of organic matter. Gracemont Variant soils are in similar positions on the landscape as Gaddy soils and have a coarse-silty over sandy control section. Gracemore soils are in concave areas or in lower positions on flood plains than Gaddy soils, and they have a water table near the surface most of the time.

Typical pedon of Gaddy loamy fine sand from an area of Gracemore-Gaddy complex, occasionally flooded, undulating; about 2,500 feet east and 1,300 feet south of the northwest corner of sec. 29, T. 6 N., R. 1 W.

Ap—0 to 9 inches; brown (7.5YR 5/4) loamy fine sand, brown (7.5YR 4/4) moist; weak fine platy and weak fine granular structure; soft, very friable; many fine and very fine roots; calcareous, moderately alkaline; clear smooth boundary.

C1—9 to 22 inches; light brown (7.5YR 6/4) loamy fine sand, brown (7.5YR 5/4) moist; massive; soft, very friable; common fine and very fine roots; many thin strata of finer texture and darker color; calcareous, moderately alkaline; clear wavy boundary.

C2—22 to 72 inches; pink (7.5YR 7/4) fine sand, brown (7.5YR 5/4) moist; many thin strata of finer texture and darker color; single grained; loose; calcareous, moderately alkaline.

The soils of the Gaddy series are moderately alkaline and calcareous in all horizons.

The A horizon is 3 to 9 inches thick. It has hue of 5YR or 7.5YR, value of 5, and chroma of 2 to 4.

The C horizons have hue of 5YR or 7.5YR, value of 5 to 7, and chroma of 2 to 4. They are loamy fine sand or fine sand stratified with thin strata of fine sandy loam to silt loam.

Goodnight Series

The soils of the Goodnight series are deep, excessively drained, and rapidly permeable. These very gently sloping to moderately steep soils formed in recent sandy eolian sediments. They are in hummocky areas of flood plains along the South Canadian River. Slopes range from 1 to 20 percent. The soils of the Goodnight series are mixed, thermic Typic Ustipsamments.

Goodnight soils are associated with Asher, Asher Variant, Brewless, Canadian, Gaddy, Gracemont Variant, Gracemore, Keokuk, and Lomill soils. Asher, Brewless, Canadian, and Keokuk soils are on smooth high flood plains that are rarely flooded, and they have a mollic epipedon. Asher soils have a fine-silty control section. Brewless soils have an argillic horizon, and a fine control section. Canadian soils have a coarse-loamy control section. Keokuk soils have a coarse-silty control section. Asher Variant, Gracemont Variant, and Lomill soils are on smooth flood plains that are occasionally flooded. Asher Variant and Lomill soils have a mollic epipedon. Asher Variant soils have a fine-silty over sandy control section, and Lomill soils have a clayey over loamy control section. Gracemont Variant soils have a coarse-silty over sandy control section. Gaddy soils are on undulating flood plains that are occasionally flooded, and they have strata of finer textures within a depth of 40 inches. Gracemore soils are on undulating to smooth flood plains that are occasionally or frequently flooded. They have strata of finer textures and have a high water table within 3 feet of the surface.

Typical pedon of Goodnight loamy fine sand, hummocky; about 2,320 feet north and 1,300 feet east from the southwest corner of sec. 26, T. 10 N., R. 4 W.

A1—0 to 5 inches; brown (7.5YR 5/4) loamy fine sand, dark brown (7.5YR 4/4) moist; weak fine granular structure; soft, very friable; many very fine and fine roots; mildly alkaline; clear wavy boundary.

C1—5 to 22 inches; reddish yellow (7.5YR 6/6) loamy fine sand, strong brown (7.5YR 5/6) moist; single grained; loose; many very fine and fine roots; moderately alkaline; clear wavy boundary.

C2—22 to 84 inches; reddish yellow (7.5YR 7/6) loamy fine sand, reddish yellow (7.5YR 6/6) moist; single grained; loose; common very fine roots; bedding planes from 1 mm to 2 mm thick of strong brown (7.5YR 5/6); slightly effervescent below a depth of 36 inches; moderately alkaline.

The depth to bedding planes or cross bedding ranges from 10 to about 60 inches. The high water table is 6 to 25 feet below the surface. Depth to calcareous material ranges from 10 to 60 inches.

The A1 horizon is 4 to 16 inches thick. It has hue of 7.5YR, value of 5 or 6, and chroma of 2 to 4. The A horizon ranges from neutral to moderately alkaline.

The C1 horizon is 17 to 45 inches thick. It has hue of 5YR or 7.5YR, value of 6 or 7, and chroma of 4 to 6. Very thin, slightly darker bedding planes or cross bedding are in some pedons. The C1 horizon is loamy fine sand or fine sand. This horizon is mildly alkaline or moderately alkaline.

The C2 horizon has hue of 5YR or 7.5YR, value of 6 or 7, and chroma of 4 to 6. Very thin, slightly darker bedding planes or cross bedding are evident. The C2 horizon is loamy fine sand or fine sand. Buried horizons of darker colors and finer textures are below a depth of 50 inches in some pedons. This horizon is mildly alkaline or moderately alkaline.

Gracemont Variant

Soils of the Gracemont Variant are deep, somewhat poorly drained, and moderately permeable. These nearly level to very gently sloping soils formed in recent stratified loamy alluvium. These soils are on low flood plains along the South Canadian River. Slopes range from 0 to 2 percent. The soils of the Gracemont Variant are coarse-silty over sandy, mixed (calcareous), thermic Aquic Udifluvents.

Gracemont Variant soils are associated with Asher, Asher Variant, Brewless, Canadian, Gaddy, Goodnight, Gracemore, Keokuk, and Lomill soils. Asher, Brewless, Canadian, Goodnight, and Keokuk soils are in higher positions on flood plains than the Gracemont Variant soils. Asher Variant and Lomill soils are in similar positions on the landscape as Gracemont Variant soils. Asher, Asher Variant, Brewless, Canadian, Keokuk, and Lomill soils have a mollic epipedon. Asher soils have a fine-silty control section. Asher Variant soils have a fine-silty over sandy control section. Brewless soils have an argillic horizon and a fine control section. Canadian soils have a coarse-loamy control section. Gaddy soils are on lower, convex landscapes than Gracemont Variant soils and have a sandy control section. Goodnight soils have a sandy control section and do not have a high water table within 40 inches of the surface. Gracemore soils are in lower positions on flood plains than Gracemont Variant soils, and they have a sandy control section. Keokuk soils have a cambic horizon, do not have a high water table within 40 inches of the surface, and have a coarse-silty control section. Lomill soils have a clayey over loamy control section.

Typical pedon of Gracemont Variant silt loam, occasionally flooded; about 2,450 feet east and 100 feet south from the northwest corner of sec. 29, T. 6 N., R. 1 W.

Ap—0 to 7 inches; brown (7.5YR 5/4) silt loam, dark brown (7.5YR 4/3) moist; weak fine platy structure parting to weak medium granular; hard, friable; many fine roots; violently effervescent; moderately alkaline; clear smooth boundary.

A1—7 to 15 inches; reddish brown (5YR 5/3) silt loam, reddish brown (5YR 4/3) moist; few fine distinct yellowish red (5YR 5/6) mottles; weak medium granular structure; hard, friable; many fine roots; violently effervescent; moderately alkaline; clear wavy boundary.

C1—15 to 21 inches; light reddish brown (5YR 6/3) very fine sandy loam, reddish brown (5YR 5/3) moist; few fine distinct yellowish red (5YR 4/6) mottles; massive; hard, friable; common fine roots; common fine darker strata; violently effervescent; moderately alkaline; clear wavy boundary.

C2—21 to 28 inches; reddish brown (5YR 5/3) silt loam, reddish brown (5YR 4/3) moist; common medium distinct yellowish red (5YR 4/6) mottles; massive; hard, friable; common fine roots; common fine darker strata; violently effervescent; moderately alkaline; clear wavy boundary.

C3—28 to 36 inches; light reddish brown (5YR 6/3) very fine sandy loam, reddish brown (5YR 5/3) moist; few medium distinct yellowish red (5YR 4/6) mottles; massive; slightly hard, very friable; few very fine roots; common fine darker strata; strongly effervescent; moderately alkaline; clear wavy boundary.

IIC—36 to 84 inches; pink (7.5YR 7/4) fine sand, brown (7.5YR 5/4) moist; single grained; loose; few very fine roots to a depth of 50 inches; common fine darker strata; slightly effervescent; moderately alkaline.

The soils of the Gracemont Variant are moderately alkaline and calcareous throughout. The depth to a lithologic discontinuity ranges from 20 to 36 inches. A high water table is between 0.5 foot to 3.5 feet below the surface from fall to spring.

The Ap or A1 horizon is 9 to 16 inches thick. It has hue of 5YR to 10YR, value of 4 or 5, and chroma of 3 or 4. In some pedons, the Ap or A1 horizon has reddish mottles in the lower part.

The C1 horizon is 5 to 16 inches thick. It has hue of 5YR or 7.5YR, value of 5 or 6, and chroma of 3 to 6. Mottles are in shades of brown or red. The C1 horizon is very fine sandy loam or loamy very fine sand. In some pedons, it has strata of coarser or finer textures up to 4 inches thick.

The C2 horizon is 0 to 23 inches thick. It has hue of 5YR or 7.5YR, value of 5 to 7, and chroma of 3 to 6. Mottles are in shades of red or brown. The C2 horizon is silt loam, very fine sandy loam, or loamy very fine sand. In some pedons, it has strata of coarser or finer textures up to 3 inches thick.

The C3 horizon is 0 to 20 inches thick. It has hue of 5YR or 7.5YR, value of 5 to 7, and chroma of 3 to 6. Mottles are in shades of red or brown. The C3 horizon is silt loam, very fine sandy loam, or loamy very fine sand. In some pedons, it has strata of coarser or finer textures up to 3 inches thick.

The IIC horizon has hue of 5YR or 7.5YR, value of 5 to 7, and chroma of 2 to 6. In some pedons, it has mottles in shades of red, brown, or gray. The IIC horizon is dominantly loamy fine sand or fine sand, but strata of finer textures are in some pedons.

The Gracemont Variant soils differ from the soils of the Gracemont series because they have less than 15 percent sand coarser than very fine sand in the control section, and they have a high water table between 0.5 foot and 3.5 feet below the surface.

Gracemore Series

Soils of the Gracemore series are deep, somewhat poorly drained, and moderately rapid to rapidly permeable. These nearly level to very gently sloping soils formed in recent stratified sandy alluvium. They are on low flood plains of the South Canadian River. Slopes range from 0 to 2 percent. The soils of the Gracemore series are sandy, mixed, thermic Aquic Udifluvents.

Gracemore soils are associated with Asher, Asher Variant, Brewless, Canadian, Gaddy, Goodnight, Gracemont Variant, Keokuk, and Lomill soils. Asher, Brewless, Canadian, Keokuk, and Lomill soils are in higher positions on flood plains than Gracemore soils and have a mollic epipedon. Asher soils have a fine-silty control section. Brewless soils have a fine control section. Canadian soils have a coarse-loamy control section. Keokuk soils have a coarse-silty control section, and Lomill soils have a clayey over loamy control section. Asher Variant soils are in slightly higher positions on the landscape and have a mollic epipedon and a fine-silty over sandy control section. Gaddy soils are on slightly higher, convex landscapes than Gracemore soils and do not have a high water table within 40 inches of the surface. Goodnight soils are on higher, hummocky landscapes and do not have a high water table within 40 inches of the surface. Gracemont Variant soils are in slightly higher positions on the landscape than Gracemore soils and have a coarse-silty over sandy control section.

Typical pedon of Gracemore loamy fine sand, frequently flooded; about 2,500 feet north and 200 feet east from the southwest corner of sec. 21, T. 8 N., R. 2 W.

Ap—0 to 7 inches; brown (7.5YR 5/4) loamy fine sand, dark brown (7.5YR 4/4) moist; weak fine granular structure; soft, very friable; many fine and very fine roots; strongly effervescent; moderately alkaline; clear wavy boundary.

A1—7 to 11 inches; light brown (7.5YR 6/4) loamy fine sand, brown (7.5YR 5/4) moist; weak fine granular structure; soft, very friable; many fine and very fine roots; strongly effervescent; moderately alkaline; abrupt wavy boundary.

C1—11 to 44 inches; pink (7.5YR 7/4) loamy fine sand, light brown (7.5YR 6/4) moist; single grained; loose; few very fine roots to a depth of about 30 inches; many thin strata of brown (7.5YR 5/4) fine sandy loam; slightly effervescent; moderately alkaline; clear wavy boundary.

C2—44 to 84 inches; pink (7.5YR 7/4) fine sand, light brown (7.5YR 6/4) moist; single grained; loose; many thin strata of brown (7.5YR 5/4) fine sandy loam; slightly effervescent; moderately alkaline.

The high water table is from 0.5 foot to 3.5 feet below the surface and averages about 3 feet below the surface. This soil is calcareous and moderately alkaline throughout. In some pedons, the soils of the Gracemore series are saline. The salinity ranges from slightly saline to strongly saline. It is strongest in the upper part of the pedon and decreases with depth.

The Ap or A1 horizon is 2 to 16 inches thick. It has hue of 5YR to 10YR, value of 4 to 6, and chroma of 2 to 4. The Ap or A1 horizon is loamy fine sand or silty clay loam.

The C1 horizon is 4 to 34 inches thick. It has hue of 5YR to 10YR, value of 5 to 7, and chroma of 2 to 4. Mottles in shades of red are in some pedons. The C1 horizon is loamy fine sand or fine sand, and it is stratified with thin, darker, and finer textured materials.

The C2 horizon has hue of 5YR to 10YR, value of 6 to 8, and chroma of 4 to 6. Mottles in shades of red are in some pedons. The C2 horizon is loamy fine sand or fine sand, and it is stratified with thin, darker, and finer textured strata. The stratification is more pronounced in this horizon than in the C1 horizon.

Grainola Series

Soils of the Grainola series are moderately deep, well drained, and slowly permeable. These gently sloping to moderately steep soils formed in material weathered from reddish Permian shale. They are on side slopes of prairie uplands in the central and western parts of the county. Slopes range from 3 to 20 percent. The soils of the Grainola series are fine, mixed, thermic Vertic Haplustalfs.

Grainola soils are associated with Doolin, Grant, Huska, Kingfisher, Lucien, Newalla, Norge, Renfrow, and Weswood soils. Doolin, Grant, and Huska soils are on broad, smooth ridge crests and have a solum more than 40 inches thick. Doolin and Grant soils have a mollic epipedon, and Doolin and Huska soils have a natric horizon. Kingfisher soils are in higher positions on the landscape than Grainola soils and have a mollic epipedon and a fine-silty control section. Lucien soils are on ridge crests and narrow contour bands on side slopes. They are less than 20 inches thick over sandstone bedrock and have a loamy control section. Norge soils are in lower positions on foot slopes than Grainola soils and have a mollic epipedon and a fine-silty control section. Renfrow soils are mostly in lower positions on side slopes than Grainola soils and on foot slopes and have a mollic epipedon and a solum more than 40 inches thick. Weswood soils are on adjoining flood plains, have an irregular decrease in organic matter, and have a fine-silty control section.

Typical pedon of Grainola silty clay loam from an area of Grainola-Weswood complex, 0 to 20 percent slopes; about 1,600 feet south and 250 feet west of northeast corner of sec. 17, T. 9 N., R. 2 W.

A1—0 to 3 inches; reddish brown (5YR 5/3) silty clay loam, reddish brown (5YR 4/3) moist; weak fine granular structure; slightly hard, friable; many very fine roots; calcareous, moderately alkaline; clear smooth boundary.

B1—3 to 8 inches; reddish brown (2.5YR 5/4) silty clay, reddish brown (2.5YR 4/4) moist; weak medium subangular blocky structure; hard, firm; many very fine roots; patchy clay films on faces of peds; 2 percent by volume of sandstone and shale fragments from 2 mm to 76 mm in diameter;

calcareous, moderately alkaline; gradual smooth boundary.

B2t—8 to 22 inches; red (2.5YR 5/6) shaly silty clay, red (2.5YR 4/6) moist; weak medium blocky structure; very hard, very firm; common very fine roots; nearly continuous clay films on faces of peds; 15 percent by volume shale fragments from 2 mm to 76 mm in diameter; few soft calcium carbonate bodies; calcareous, moderately alkaline; gradual smooth boundary.

B3—22 to 27 inches; red (2.5YR 5/6) very shaly silty clay, red (2.5YR 4/6) moist; weak medium blocky structure; very hard, very firm; few very fine roots; patchy clay films on faces of peds; 40 percent by volume shale fragments from 2 mm to 76 mm in diameter; few soft calcium carbonate bodies; calcareous, moderately alkaline; clear wavy boundary.

Cr—27 to 30 inches; red (2.5YR 4/6) weakly laminated shale; calcareous, moderately alkaline.

Thickness of the solum and depth to bedrock is 20 to 40 inches.

The A1 horizon is 3 to 8 inches thick. It has hue of 5YR or 7.5YR, value of 3 to 5, and chroma of 2 to 4. The A1 horizon is gravelly silty clay loam, very gravelly silty clay loam, or silty clay loam. The A1 horizon has fragments of sandstone or shale from 2 mm to 76 mm in diameter that range from 0 to 40 percent by volume. This horizon is mildly alkaline or moderately alkaline.

The B1 horizon is 0 to 8 inches thick. It has hue of 2.5YR, value of 3 to 5, and chroma of 4 to 6. The B1 horizon is silty clay loam or silty clay. The clay content ranges from 27 to 45 percent. The B1 horizon has fragments of sandstone or shale from 2 mm to 76 mm in diameter that make up from 0 to 10 percent by volume. This horizon is mildly alkaline or moderately alkaline.

The B2t horizon is 10 to 26 inches thick. It has hue of 2.5YR, value of 4 or 5, and chroma of 4 to 6. The B2t horizon is silty clay, shaley silty clay, or gravelly silty clay. The clay content ranges from 40 to 55 percent. This horizon has fragments of shale and sandstone from 2 mm to 76 mm in diameter that make up from 0 to 20 percent by volume.

The B3 horizon is 0 to 14 inches thick. It has hue of 2.5YR, value of 4 or 5, and chroma of 4 to 6. The B3 horizon is shaley silty clay, very shaley silty clay, or silty clay. The clay content ranges from 40 to 50 percent. The B3 horizon has fragments of shale from 2 mm to 76 mm in diameter that make up from 5 to 40 percent by volume. This horizon is moderately alkaline.

The Cr horizon has hue of 2.5YR, value of 3 to 5, and chroma of 4 to 6. The Cr horizon has shale that is fractured at intervals of less than 4 inches and has thin bedding planes. The shale is interbedded with thin layers of sandstone in some pedons.

Grant Series

Soils of the Grant series are deep, well drained, and moderately permeable. These very gently sloping to gently sloping soils formed in material weathered from Permian siltstone or sandstone. They are on ridge crests of prairie uplands. Slopes range from 1 to 5 percent. The soils of the Grant series are fine-silty, mixed, thermic Udic Argiustolls.

Grant soils are associated with Doolin, Grainola, Huska, Kingfisher, Lucien, Norge, Renfrow, and Teller soils. Doolin soils are in higher positions on broad ridge crests than Grant soils and have a fine control section, a natric horizon, and a solum more than 60 inches thick. Grainola soils are on side slopes, have a fine control section, do not have a mollic epipedon, and have a solum less than 40 inches thick. Huska soils are intermingled with Grant soils. Huska soils have a fine control section, an abrupt boundary between the A horizon and B horizon, and a natric horizon. Kingfisher and Lucien soils are in similar positions on the landscape as Grant soils. Kingfisher soils have a solum 20 to 40 inches thick, and Lucien soils have a solum 10 to 20 inches thick and do not have a mollic epipedon. Norge soils are on side slopes and foot slopes and have a solum more than 60 inches thick. Renfrow soils are in similar positions on the landscape as Grant soils and are forming in material weathered from shale, have a solum more than 60 inches thick, and have a fine control section. Teller soils are on side slopes and foot slopes and have a fine-loamy control section and a solum more than 60 inches thick.

Typical pedon of Grant silt loam from an area of Grant-Huska complex, 1 to 5 percent slopes; about 1,600 feet west and 1,450 feet north from from the southeast corner of sec. 27, T. 9 N., R. 2 W.

Ap—0 to 9 inches; brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; weak medium granular structure; slightly hard, friable; many fine roots; slightly acid; clear smooth boundary.

B1—9 to 15 inches; reddish brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) moist; moderate medium granular structure; hard, friable; many fine roots; slightly acid; clear smooth boundary.

B21t—15 to 24 inches; reddish brown (5YR 5/3) silty clay loam, reddish brown (5YR 4/3) moist; moderate medium subangular blocky structure; hard, friable; common fine roots; nearly continuous clay films on faces of peds; slightly acid; gradual smooth boundary.

B22t—24 to 32 inches; yellowish red (5YR 5/6) silty clay loam, yellowish red (5YR 4/6) moist; moderate medium subangular blocky structure; very hard, very firm; few fine roots; nearly continuous clay films on faces of peds; few fine black concretions; slightly acid; gradual smooth boundary.

B3—32 to 50 inches; red (2.5YR 5/6) silty clay loam, red (2.5YR 4/6) moist; weak medium subangular blocky structure; very hard, very firm; few very fine roots; patchy clay films on faces of peds; common fine black concretions; mildly alkaline; clear smooth boundary.

Cr—50 to 60 inches; light reddish brown (5YR 6/3) soft weakly laminated sandstone; moderately alkaline.

Thickness of the solum and depth to bedrock range from 40 to 60 inches.

The Ap or A1 horizon is 7 to 10 inches thick. It has hue of 7.5YR, value of 4 or 5, and chroma of 2 or 3. The Ap or A1 horizon is slightly acid or neutral.

The B1 horizon is 3 to 8 inches thick. It has hue of 5YR, value of 4 or 5, and chroma of 2 or 3. The B1 horizon is silt loam or silty clay loam. The clay content ranges from about 25 to 32 percent. This horizon is slightly acid or neutral.

The B21t horizon is 8 to 18 inches thick. It has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 3 to 6. The B21t horizon is silty clay loam. The clay content ranges from about 27 to 35 percent. This horizon is slightly acid or neutral.

The B22t horizon is 8 to 15 inches thick. It has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 4 to 6. The B22t horizon is silty clay loam. The clay content ranges from about 27 to 35 percent. This horizon is slightly acid or neutral.

The B3 horizon is 4 to 18 inches thick. It has hue of 2.5YR or 5YR, value of 5 or 6, and chroma of 6 to 8. The B3 horizon is silt loam or silty clay loam. The clay content ranges from about 25 to 34 percent. The B3 horizon has coarse fragments of siltstone, sandstone, or shale from 2 mm to 76 mm in diameter that make up from 0 to 15 percent by volume. This horizon ranges from neutral to moderately alkaline.

The Cr horizon is soft laminated siltstone, shale, or sandstone. It is dominantly red, but, in some pedons, the bedrock is streaked or mottled in shades of brown or gray. The Cr horizon is mildly alkaline or moderately alkaline, and, in some pedons, it is calcareous.

Harrah Series

Soils of the Harrah series are deep, well drained, and moderately permeable. These gently sloping to sloping soils formed in loamy and sandy colluvium weathered from Permian sandstone. They are on side slopes and foot slopes of uplands. Slopes range from 3 to 8 percent. The soils of the Harrah series are fine-loamy, siliceous, thermic Ultic Paleustalfs.

Harrah soils are associated with Darsil, Derby, Littleaxe, Newalla, Pulaski, Stephenville, and Tribbey soils. Darsil soils are on convex ridge crests and on side slopes above the Harrah soils, have a solum 10 to 20 inches thick over sandstone, and do not have an argillic horizon. Derby soils are on convex, hummocky ridge crests and side slopes and have a sandy control section with lamallae. Littleaxe soils are on broad ridge crests and have a solum 40 to 60 inches thick. Newalla soils are in higher positions on side slopes than Harrah soils and on ridge crests and have formed in materials weathered from sandstone and shale. They have a fine-loamy over clayey control section and a solum 40 to 60 inches thick. Pulaski soils are on adjoining flood plains and have a coarse-loamy control section and an irregular decrease in organic matter with depth. Stephenville soils are in higher positions on side slopes than Harrah soils and on ridge crests and have a solum 20 to 40 inches thick underlain by sandstone bedrock. Tribbey soils are on adjoining flood plains and have a coarse-loamy control section, an irregular decrease in organic matter with depth, and a high water table within 40 inches of the surface.

Typical pedon of Harrah fine sandy loam, 3 to 8 percent slopes, gullied; about 2,350 feet south and 900 feet east of the northwest corner of sec. 12, T. 9 N., R. 1 W.

Ap—0 to 9 inches; brown (7.5YR 5/2) fine sandy loam, dark brown (7.5YR 4/2) moist; weak fine granular structure; soft, very friable; neutral; clear smooth boundary.

A2—9 to 19 inches; light brown (7.5YR 6/4) loamy fine sand, brown (7.5YR 5/4) moist; weak fine granular structure; soft, very friable; neutral; clear smooth boundary.

B21t—19 to 34 inches; red (2.5YR 5/6) sandy clay loam, red (2.5YR 4/6) moist; weak fine blocky structure; hard, firm; thin nearly continuous clay films on faces of peds; slightly acid; gradual wavy boundary.

B22t—34 to 52 inches; red (2.5YR 5/8) sandy clay loam, red (2.5YR 4/8) moist; moderate medium prismatic structure parting to moderate medium blocky; hard, firm; thin nearly continuous clay films on faces of peds; about 5 percent by volume uncoated sand grains on vertical faces of peds and in pores; medium acid; gradual wavy boundary.

B21tb—52 to 76 inches; red (2.5YR 4/6) sandy clay loam, dark red (2.5YR 3/6) moist; moderate medium prismatic structure parting to moderate medium blocky; hard, firm; thin continuous clay films on faces of peds and in pores; medium acid; gradual wavy boundary.

B22tb—76 to 80 inches; red (2.5YR 4/6) sandy clay loam, dark red (2.5YR 3/6) moist; moderate medium blocky structure; hard, firm; thin continuous clay films on faces of peds; few fine dark concretions; about 10 percent by volume uncoated sand grains on vertical faces of peds and in pores; slightly acid.

Thickness of the solum is more than 60 inches. The clay content does not decrease by more than 20 percent from the maximum within a depth of 60 inches of the soil surface.

The A1 or Ap horizon is 2 to 10 inches thick. It has hue of 5YR to 10YR, value of 4 to 6, and chroma of 2 to 4. The A1 or Ap horizon ranges from medium acid to neutral.

The A2 horizon is 3 to 18 inches thick. It has hue of 2.5YR to 7.5YR, value of 5 to 7, and chroma of 4 to 6. The A2 horizon is fine sandy loam or loamy fine sand. It ranges from medium acid to neutral.

The B21t horizon is 10 to 21 inches thick. It has hue of 2.5YR or 5YR, value of 4 to 6, and chroma of 4 to 8. The B21t horizon is sandy clay loam. The clay content ranges from 20 to 32 percent. The B21t horizon has sandstone or barite gravel from 2 mm to 76 mm in diameter that makes up from 0 to 2 percent by volume. This horizon ranges from strongly acid to neutral.

The B22t horizon is 0 to 18 inches thick. It has hue of 2.5YR or 5YR, value of 4 to 6, and chroma of 4 to 8. The B22t horizon is sandy clay loam. The clay content ranges from 20 to 32 percent. The B22t horizon has sandstone or barite gravel from 2 mm to 76 mm in diameter that makes up from 0 to 2 percent by volume. This horizon ranges from strongly acid to neutral.

The B21tb horizon is 0 to 40 inches thick. It has hue of 2.5YR, value of 4 or 5, and chroma of 6 to 8. The B2tb horizon is sandy clay loam. The clay content ranges from 20 to 35 percent. The B2tb horizon has sandstone or barite gravel from 2 mm to 76 mm in diameter that makes up from 0 to 2 percent by volume. This horizon ranges from strongly acid to neutral.

Some pedons have a B3 horizon from 0 to 15 inches thick. The B3 horizon has hue of 2.5YR, value of 4 to 6, and chroma of 6 to 8. It is sandy clay loam or fine sandy loam. The clay content ranges from 12 to 30 percent. The B3 horizon has sandstone or barite gravel from 2 mm to 76 mm in diameter that makes up from 0 to 5 percent by volume. This horizon ranges from strongly acid to neutral.

The B22tb horizon has hue of 10R or 2.5YR, value of 4 or 5, and chroma of 6 to 8. It is sandy clay loam. The clay content ranges from 20 to 35 percent. The B22tb horizon has sandstone or barite gravel from 2 mm to 76 mm in diameter that ranges from 0 to 5 percent by volume. This horizon ranges from strongly acid to neutral.

Some pedons have a B3b horizon from 0 to 30 inches or more thick. The B3b horizon has hue of 10R or 2.5YR, value of 4 to 6, and chroma of 6 to 8. It is sandy clay loam or fine sandy loam. The clay content ranges from 12 to 30 percent. The B3b horizon has sandstone or barite gravel from 2 mm to 76 mm in diameter that makes up from 0 to 5 percent by volume. This horizon ranges from strongly acid to neutral.

Huska Series

Soils of the Huska series are deep, moderately well drained, and very slowly permeable. These very gently sloping to gently sloping sodic soils formed in clayey materials weathered from interbedded red Permian shale and sandstone. They are on slightly concave ridge crests and side slopes of uplands. Slopes range from 1 to 5 percent. The soils of the Huska series are fine, mixed, thermic Mollic Natrustalfs.

Huska soils are associated with Grainola, Grant, Kingfisher, Lucien, Pawhuska, and Renfrow soils. Grainola soils are in lower positions on side slopes than Huska soils, have a solum less than 40 inches thick, and do not have a natric horizon. Grant soils are on slightly convex landscapes that surround the Huska soils, have a mollic epipedon, do not have a natric horizon, and have a fine-silty control section. Kingfisher soils are on lower slightly convex ridge crests and have a fine-silty control section, a mollic epipedon, a solum less than 40 inches thick, and they do not have a natric horizon. Lucien soils are in lower positions on ridge crests and side slopes than Huska soils, have a solum less than 20 inches thick, do not have a natric horizon, and have a loamy control section. Pawhuska soils are in similar positions on the landscape as Huska soils but have a solum more than 60 inches thick. Renfrow soils are on convex landscapes that surround the Huska soils, have a solum more than 60 inches thick, do not have a natric horizon, and have a mollic epipedon.

Typical pedon of Huska silt loam from an area of Renfrow-Huska complex, 1 to 5 percent slopes; about 200 feet south and 100 feet west from the northeast corner of sec. 6, T. 9 N., R. 2 W.

A1—0 to 3 inches; brown (10YR 4/3) silt loam, very dark grayish brown (10YR 3/2) moist; weak medium platy structure parting to weak fine granular; hard, friable; many very fine and few fine roots; neutral; abrupt smooth boundary.

B21t—3 to 9 inches; brown (7.5YR 4/2) silty clay, dark brown (7.5YR 3/2) moist; moderate medium columnar structure parting to strong fine blocky; extremely hard, very firm; many very fine and few fine roots; brown (10YR 5/3) coatings on upper 2 inches of columns and very dark brown (10YR 2/2) organic stains on lower part of columns; nearly continuous clay films on faces of peds; moderately alkaline; clear smooth boundary.

B22t—9 to 17 inches; brown (7.5YR 5/4) silty clay, dark brown (7.5YR 4/4) moist; common medium distinct yellowish red (5YR 5/6) mottles; weak medium prismatic structure parting to moderate medium blocky; extremely hard, extremely firm; many very fine roots; nearly continuous clay films on faces of peds; darker soil materials in vertical cracks; moderately alkaline; gradual smooth boundary.

B23tsa—17 to 24 inches; brown (7.5YR 5/4) silty clay, dark brown (7.5YR 4/4) moist; many medium distinct yellowish red (5YR 5/6) mottles; weak medium blocky structure; extremely hard, extremely firm; common very fine roots; nearly continuous clay films on faces of peds; many soluble salt crystals; few soft bodies and concretions of calcium carbonate; few fine black concretions; slightly effervescent; moderately alkaline; gradual smooth boundary.

B24t—24 to 38 inches; red (2.5YR 5/6) silty clay, red (2.5YR 4/6) moist; many coarse distinct reddish yellow (5YR 6/6) mottles; weak medium blocky structure; extremely hard, extremely firm; few very fine roots; patchy clay films on faces of peds; common soft bodies of calcium carbonate; common fine black concretions; slightly effervescent; moderately alkaline; gradual smooth boundary.

B3—38 to 42 inches; red (2.5YR 5/6) silty clay loam, red (2.5YR 4/6) moist; weak medium blocky structure; very hard, very firm; few very fine roots; patchy clay films on faces of peds; few fine black concretions; strongly effervescent; moderately alkaline; clear wavy boundary.

Cr—42 to 45 inches; red (2.5YR 5/6), white (2.5Y 8/2), and yellow (2.5Y 7/6) soft laminated siltstone and shale; slightly effervescent in the seams.

Thickness of the solum and depth to bedrock are 40 to 60 inches. Depth to soft bodies of lime ranges from 10 to 35 inches. The exchangeable sodium percentage ranges from about 15 to 60 percent in the upper Bt horizons.

The A1 or Ap horizon is 1 to 10 inches thick. It has hue of 5YR to 10YR, value of 4 or 5, and chroma of 2 to 4. The A1 or Ap horizon is slightly acid or neutral.

The B21t horizon is 6 to 12 inches thick. It has hue of 2.5YR to 10YR, value of 4 or 5, and chroma of 2 to 4. The B21t horizon has columns or prisms that are often coated on top with grayish or brownish soil materials and on the sides with black or very dark brown organic stains. The B21t horizon is silty clay. The clay content ranges from about 40 to 55 percent. This horizon ranges from slightly acid to moderately alkaline.

The B22t horizon is 7 to 16 inches thick. It has hue of 2.5YR to 10YR, value of 4 to 6, and chroma of 2 to 6. Brownish or reddish mottles are in some pedons. The B22t horizon is silty clay or silty clay loam. The clay content ranges from about 37 to 55 percent. This horizon is moderately alkaline or strongly alkaline.

The B23tsa horizon is 0 to 18 inches thick. It has hue of 2.5YR to 10YR, value of 4 to 6, and chroma of 2 to 6. Brownish, grayish, yellowish, or reddish mottles are in some pedons, and some pedons are coarsely mottled. The B23tsa horizon is silty clay or silty clay loam. The clay content ranges from about 30 to 55 percent. This horizon is moderately alkaline or strongly alkaline.

The B24t horizon is 0 to 16 inches thick. It has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 5 or 6. Brownish, reddish, or yellowish mottles are in some pedons. The B24t horizon is silty clay. The clay content ranges from about 40 to 50 percent. Soluble salts are in this horizon in some pedons. This horizon is moderately alkaline or strongly alkaline.

The B3 horizon is 4 to 20 inches thick. It has hue of 2.5YR or 5YR, value of 4 to 6, and chroma of 2 to 8. Brownish, yellowish, grayish, or reddish mottles are in some pedons, and some pedons are coarsely mottled. The B3 horizon is silty clay loam, clay loam, or silty clay. The clay content ranges from about 27 to 50 percent. The B3 horizon has coarse fragments of siltstone, sandstone, or shale from 2 mm to 76 mm in diameter that make up from 0 to 20 percent by volume. Soluble salts are in this horizon in some pedons. This horizon is moderately alkaline or strongly alkaline.

The Cr horizon is mostly red, soft, laminated shale, sandstone, or siltstone that is often streaked or mottled in shades of gray, yellow, or olive. This horizon has thin lenses of sandstone interbedded in some pedons.

The Huska soils in this survey area are taxadjunct to the Huska series because they have secondary lime slightly higher in the solum than is typical for the Huska series. Use, behavior, and management are similar to those of the Huska soils.

Keokuk Series

Soils of the Keokuk series are deep, well drained, and moderately permeable. These nearly level to very gently sloping soils formed in loamy and sandy Pleistocene alluvium. They are on high flood plains along the South Canadian River. Slopes range from 0 to 2 percent. The soils of the Keokuk series are coarse-silty, mixed, thermic Fluventic Haplustolls.

Keokuk soils are associated with Asher, Asher Variant, Brewless, Canadian, Gaddy, Goodnight, Gracemont Variant, Gracemore, and Lomill soils. Asher soils are on a similar elevation as the Keokuk soils and have a fine-silty control section. Asher Variant, Gaddy, Gracemont Variant, Gracemore, and Lomill soils are in lower positions on flood plains than Keokuk soils. Asher Variant soils have a fine-silty over sandy control section. Gaddy soils do not have a mollic epipedon or cambic horizon and have a sandy control section. Gracemont Variant soils do not have a mollic epipedon or cambic horizon, have a coarse-silty over sandy control section, and have a high water table within 40 inches of the surface. Gracemore soils have a high water table within 40 inches of the surface, do not have a mollic epipedon, and have a sandy control section. Lomill soils have a clayey over loamy control section. Brewless and Canadian soils are in similar positions on the landscape as Keokuk soils. Brewless soils have a mollic epipedon more than 20 inches thick, an argillic horizon, and a fine control section. Canadian soils have a coarse-loamy control section. Goodnight soils are in higher hummocky areas, do not have a mollic epipedon or a cambic horizon, and have a sandy control section.

Typical pedon of Keokuk very fine sandy loam, rarely flooded; about 2,400 feet east and 1,950 feet north from the southwest corner of sec. 17, T. 9 N., R. 3 W.

Ap—0 to 7 inches; brown (10YR 4/3) very fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard, friable; common very fine roots; slightly acid; clear smooth boundary.

A1—7 to 12 inches; dark grayish brown (10YR 4/2) very fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak medium granular structure; slightly hard, friable; common very fine roots; neutral; clear smooth boundary.

B2—12 to 26 inches; brown (7.5YR 5/4) very fine sandy loam, dark brown (7.5YR 4/4) moist; weak medium subangular blocky structure; hard, friable; common very fine roots; violently effervescent; moderately alkaline; gradual smooth boundary.

C1—26 to 30 inches; light brown (7.5YR 6/4) very fine sandy loam, brown (7.5YR 5/4) moist; massive; slightly hard, very friable; few very fine roots; violently effervescent; moderately alkaline; clear smooth boundary.

C2—30 to 41 inches; brown (7.5YR 5/4) very fine sandy loam, dark brown (7.5YR 4/2) moist; massive; hard, very friable; few very fine roots; violently effervescent; moderately alkaline; clear smooth boundary.

B2tb—41 to 48 inches; brown (7.5YR 5/3) silty clay loam, dark brown (7.5YR 4/2) moist; weak medium subangular blocky structure; very hard, firm; few very fine roots; patchy clay films on faces of peds; violently effervescent; moderately alkaline; clear wavy boundary.

IIC—48 to 54 inches; light brown (7.5YR 6/4) very fine sandy loam, brown (7.5YR 4/4) moist; massive; hard, friable; few very fine roots; violently effervescent; moderately alkaline; clear wavy boundary.

IIIC—54 to 66 inches; pink (7.5YR 7/4) fine sandy loam, brown (7.5YR 5/4) moist; few fine distinct yellowish brown (10YR 5/4) and grayish brown (10YR 5/2) mottles; massive; soft, very friable; slightly effervescent; moderately alkaline; clear wavy boundary.

IVC—66 to 84 inches; light brown (7.5YR 6/4) very fine sandy loam, brown (7.5YR 5/4) moist; few fine distinct yellowish brown (10YR 5/4) and grayish brown (10YR 5/2) mottles; massive; slightly hard, very friable; violently effervescent; moderately alkaline.

Thickness of the solum is 20 to 35 inches. Depth to lime ranges from 0 to 13 inches. The depth to a high water table or a mottled horizon showing wetness is 42 to 84 inches or more and averages about 67 inches. The depth to buried horizons or a lithologic discontinuity is 40 to more than 80 inches.

The Ap or A1 horizon is 11 to 18 inches thick. It has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3. The Ap or A1 horizon ranges from slightly acid to moderately alkaline.

The B2 horizon is 8 to 20 inches thick. It has hue of 5YR or 7.5YR, value of 5 or 6, and chroma of 3 to 6. The B2 horizon is silt loam, loam, or very fine sandy loam that has less than 15 percent material coarser than very fine sand. The clay content ranges from about 12 to 24 percent.

The C1 horizon is 4 to 20 inches thick. It has hue of 5YR or 7.5YR, value of 5 or 6, and chroma of 3 to 6. The C1 horizon is silt loam or very fine sandy loam.

The C2 horizon is 0 to 15 inches thick. It has hue of 5YR or 7.5YR, value of 5 or 6, and chroma of 4 to 6. The C2 horizon is very fine sandy loam or loamy very fine sand.

The B2tb horizon is 0 to 24 inches thick. It has hue of 5YR to 10YR, value of 4 or 5, and chroma of 2 to 4. The B2tb horizon is silty clay loam or silty clay. The clay content ranges from about 25 to 45 percent.

The IIC, IIIC, and IVC horizons have hue of 5YR to 10YR, value of 5 to 7, and chroma of 4 to 6. In many pedons, they are mottled in shades of brown, red, or gray. The IIC, IIIC and IVC horizons range from fine sand to silty clay. Stratification within these horizons is in some pedons.

Kingfisher Series

Soils of the Kingfisher series are moderately deep, well drained, and moderately slowly permeable. These very gently sloping to sloping soils formed in material weathered from silty reddish Permian sandstone and siltstone. They are on ridge crests and side slopes of prairie uplands. Slopes range from 1 to 8 percent. The soils of the Kingfisher series are fine-silty, mixed, thermic Udic Argiustolls.

Kingfisher soils are associated with the Grainola, Grant, Huska, Lucien, Norge, Norge Variant, Renfrow, Teller, and Teller Variant soils. Grainola soils are in lower positions on side slopes than Kingfisher soils, do not have a mollic epipedon, and have a fine control section. Grant and Huska soils are in higher positions on ridge crests than Kingfisher soils and have a solum more than 40 inches thick. Huska soils have a natric horizon and a fine control section. Lucien soils are intermingled with Kingfisher soils on ridge crests and have a solum less than 20 inches thick. Norge soils are in lower positions on side slopes than Kingfisher soils and have a solum more than 60 inches thick. Norge Variant soils are on toe slopes and have a solum more than 40 inches thick and more coarse fragments in the IIC horizon than Kingfisher soils. Renfrow soils are in higher positions on ridge crests than Kingfisher soils and on foot slopes and have a solum more than 40 inches thick and a fine control section. Teller soils are in lower positions on side slopes than Kingfisher soils and have a fine-loamy control section and a solum more than 60 inches thick. Teller Variant soils are on toe slopes and have a solum more than 40 inches thick, a fine-loamy control section, and more coarse fragments in the IIC horizon than Kingfisher soils.

Typical pedon of Kingfisher silt loam from an area of Kingfisher-Lucien complex, 1 to 5 percent slopes; about 110 feet west and 120 feet north of the southeast corner of sec. 15, T. 9 N., R. 2 W.

A1—0 to 7 inches; reddish brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/2) moist; moderate fine granular structure; slightly hard, friable; common very fine and fine roots; neutral; gradual smooth boundary.

B1—7 to 12 inches; reddish brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) moist; weak fine subangular blocky structure parting to moderate fine granular; slightly hard, friable; common fine roots; few wormcasts; neutral; gradual smooth boundary.

B21t—12 to 18 inches; yellowish red (5YR 4/6) silty clay loam, dark reddish brown (5YR 3/4) moist; moderate medium subangular blocky structure; hard, firm; common fine roots; few wormcasts; nearly continuous clay films on faces of peds, neutral; gradual smooth boundary.

B22t—18 to 26 inches; yellowish red (5YR 5/6) silty clay loam; yellowish red (5YR 4/6) moist; moderate medium subangular blocky structure; hard, firm; common fine roots; few wormcasts; nearly continuous clay films on faces of peds; neutral; gradual smooth boundary.

B3—26 to 36 inches; red (2.5YR 5/8) silty clay loam, red (2.5YR 4/8) moist; weak medium subangular blocky structure; hard, firm; few fine roots; patchy clay films on faces of peds; neutral; clear wavy boundary.

Cr—36 to 40 inches; red (2.5YR 5/6) weakly cemented very fine grain sandstone; calcareous, moderately alkaline.

Thickness of the solum and depth to bedrock is 20 to 40 inches.

The A1 or Ap horizon is 4 to 11 inches thick. It has hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 2 or 3. The A1 or Ap horizon has coarse fragments of sandstone from 2 mm to 76 mm that make up from 0 to 2 percent by volume. This horizon ranges from slightly acid to mildly alkaline.

The B1 horizon is 3 to 10 inches thick. It has hue of 2.5YR to 7.5YR, value of 4 or 5, and chroma of 2 to 4. The B1 horizon is silt loam or silty clay loam. The clay content ranges from 20 to 30 percent. The B1 horizon has coarse fragments of sandstone from 2 mm to 76 mm in diameter that make up from 0 to 2 percent by volume. This horizon ranges from slightly acid to moderately alkaline.

The B21t horizon is 4 to 13 inches thick. It has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 3 to 6. The B21t horizon is silty clay loam. The clay content ranges from 27 to 32 percent. The B21t horizon has coarse fragments of sandstone from 2 mm to 76 mm in diameter that make up from 0 to 5 percent by volume. This horizon ranges from neutral to moderately alkaline.

The B22t horizon is 5 to 10 inches thick. It has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 4 to 6. The B22t horizon is silty clay loam. The clay content ranges from 27 to 35 percent. The B22t horizon has coarse fragments of sandstone from 2 mm to 76 mm in diameter that make up from 0 to 5 percent by volume. This horizon ranges from neutral to moderately alkaline.

The B3 horizon is 3 to 10 inches thick. It has hue of 2.5YR or 5YR, value of 4 to 6, and chroma of 6 to 8. In some pedons, the B3 horizon has brownish or yellowish mottles. It is silt loam or silty clay loam. The clay content ranges from 15 to 32 percent. The B3 horizon has coarse fragments of sandstone from 2 mm to 76 mm in diameter that make up from 0 to 30 percent by volume. This horizon ranges from neutral to moderately alkaline.

The Cr horizon is weakly cemented sandstone, siltstone, or shale. It has hue of 2.5YR or 5YR, value of 4 to 7, and chroma of 5 to 8. In some pedons, the Cr horizon has streaks of grayish hue. The bedrock is noncalcareous in some pedons.

Konawa Series

Soils of the Konawa series are deep, well drained, and moderately permeable. These very gently sloping to sloping soils formed in sandy and loamy Pleistocene sediments. They are on undulating uplands. Slopes range from 2 to 8 percent. The soils of the Konawa series are fine-loamy, mixed, thermic Ultic Haplustalfs.

Konawa soils are associated with Derby, Dougherty, Norge, Slaughterville, Slaughterville Variant, Teller, and Vanoss soils. Derby and Dougherty soils are in similar positions on the landscape as Konawa soils. Derby soils have a sandy control section with lamallae. Dougherty soils have a combined thickness of the A horizons of more than 20 inches. Norge soils are in higher positions on ridge crests and side slopes than Konawa soils and have a mollic epipedon and a fine-silty control section. Slaughterville and Slaughterville Variant soils are in lower positions on ridge crests and side slopes than Konawa soils and have a mollic epipedon and a coarse-loamy control section. Teller soils are on smoother ridge crests and side slopes than Konawa soils and have a mollic epipedon and a higher base saturation. Vanoss soils are on smoother ridge crests than Konawa soils and have a mollic epipedon and a fine-silty control section.

Typical pedon of Konawa loamy fine sand from an area of Dougherty-Konawa complex, 2 to 8 percent slopes; about 1,600 feet east and 70 feet north from the southwest corner of sec. 17, T. 7 N., R. 1 W.

A1—0 to 6 inches; grayish brown (10YR 5/2) loamy fine sand, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; soft, very friable; many very fine and fine roots; slightly acid; clear wavy boundary.

A2—6 to 15 inches; light brown (7.5YR 6/4) loamy fine sand, brown (7.5YR 5/4) moist; weak fine granular structure; soft, very friable; many very fine and fine roots; neutral; clear wavy boundary.

B21t—15 to 24 inches; reddish brown (5YR 5/4) sandy clay loam, reddish brown (5YR 4/4) moist; weak medium subangular blocky structure; very hard, friable; common very fine roots; patchy clay films on faces of peds; medium acid; gradual smooth boundary.

B22t—24 to 37 inches; yellowish red (5YR 5/6) sandy clay loam, yellowish red (5YR 4/6) moist; weak medium subangular blocky structure; very hard, friable; common very fine roots; nearly continuous clay films on faces of peds; strongly acid; gradual smooth boundary.

B3—37 to 58 inches; yellowish red (5YR 5/8) fine sandy loam, yellowish red (5YR 4/8) moist; weak coarse subangular blocky structure; hard, friable; few very fine roots; patchy clay films on faces of peds; strongly acid; gradual smooth boundary.

C—58 to 84 inches; reddish yellow (5YR 6/6) fine sandy loam, yellowish red (5YR 5/6) moist; massive; slightly hard, very friable; about 2 percent by volume of small pockets of clean sand grains; slightly acid.

Thickness of the solum ranges from 48 to more than 72 inches.

The A1 or Ap horizon is 4 to 10 inches thick. It has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3. The A1 or Ap horizon has quartz gravel from 2 mm to 10 mm in diameter that makes up from 0 to 2 percent by volume. This horizon is slightly acid. Where limed, it can be neutral.

The A2 horizon is 4 to 17 inches thick. It has hue of 7.5YR or 10YR, value of 5 or 6, and chroma of 2 to 4. The A2 horizon has quartz gravel from 2 mm to 10 mm in diameter that makes up from 0 to 2 percent by volume. This horizon is slightly acid. Where limed, it can be neutral.

The B2t horizon is 15 to 30 inches thick. It has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 4 to 6. The B2t horizon is fine sandy loam or sandy clay loam. The clay content ranges from 15 to 30 percent. The B2t horizon has quartz gravel from 2 mm to 10 mm in diameter that makes up from 0 to 5 percent by volume. This horizon is strongly acid to slightly acid.

The B3 horizon is 10 to 30 inches thick. It has hue of 2.5YR or 5YR, value of 5 or 6, and chroma of 6 to 8. The B3 horizon is fine sandy loam or sandy clay loam. The clay content ranges from 12 to 25 percent. The B3 horizon has quartz gravel from 2 mm to 10 mm in diameter that makes up from 0 to 5 percent by volume. This horizon ranges from strongly acid to slightly acid.

The C horizon has hue of 5YR, value of 5 or 6, and chroma of 6 to 8. It is fine sandy loam or loamy fine sand. The C horizon has quartz gravel from 2 mm to 10 mm in diameter that makes up from 0 to 5 percent by volume. In some pedons, it has lamellae that is up to 7 mm thick and from 2 to 6 inches apart. This horizon ranges from medium acid to neutral.

Littleaxe Series

The soils of the Littleaxe series are deep, well drained, and moderately permeable. These very gently sloping soils formed in material weathered from weakly cemented sandstone interbedded with Permian shale. They are on broad, smooth ridge crests of uplands. Slopes range from 1 to 3 percent. The soils of the Littleaxe series are fine-loamy, siliceous, thermic Ultic Haplustalfs.

Littleaxe soils are associated with Darsil, Derby, Harrah, Newalla, and Stephenville soils. Darsil soils are in lower positions on shoulders and side slopes of ridges than Littleaxe soils and have a sandy control section, a solum 10 to 20 inches thick underlain by sandstone, and do not have an argillic horizon. Derby soils are in higher, convex areas and have a sandy control section. Harrah soils are on foot slopes and have a solum more than 60 inches thick that does not decrease in clay content by 20 percent or more from the maximum within 60 inches of the surface. Newalla and Stephenville soils are on narrower ridge crests and side slopes than Littleaxe soils. Newalla soils have a fine-loamy over clayey control section, and Stephenville soils have a solum 20 to 40 inches thick over sandstone.

Typical pedon of Littleaxe loamy fine sand, 1 to 3 percent slopes; about 2,120 feet west and 380 feet south from the northeast corner of sec. 6, T. 8 N., R. 1 E.

A1—0 to 7 inches; grayish brown (10YR 5/2) loamy fine sand, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard, very friable; many fine and very fine roots; neutral; clear wavy boundary.

A2—7 to 16 inches; pink (7.5YR 7/4) loamy fine sand, brown (7.5YR 5/4) moist; weak fine granular structure; soft, very friable; many fine and very fine roots; slightly acid; clear wavy boundary.

B21t—16 to 28 inches; yellowish red (5YR 5/6) sandy clay loam, yellowish red (5YR 4/6) moist; moderate medium subangular blocky structure; very hard, friable; common very fine, fine, and medium roots; nearly continuous clay films on faces of peds; strongly acid; gradual smooth boundary.

B22t—28 to 37 inches; yellowish red (5YR 5/6) fine sandy loam, yellowish red (5YR 4/6) moist; weak medium subangular blocky structure; very hard, friable; common very fine, fine, and medium roots; patchy clay films on faces of peds; strongly acid; gradual smooth boundary.

B31—37 to 43 inches; reddish yellow (5YR 6/6) fine sandy loam, yellowish red (5YR 5/6) moist; weak medium subangular blocky structure; hard, friable; common very fine, fine, and medium roots; patchy clay films on faces of peds; strongly acid; clear smooth boundary.

B32—43 to 52 inches; coarsely mottled reddish yellow (7.5YR 7/6, 6/8) fine sandy loam, reddish yellow (7.5YR 6/6) and strong brown (7.5YR 5/8) moist; weak coarse subangular blocky structure; hard, friable; few very fine and fine roots; clay bridging sand grains; strongly acid; clear smooth boundary.

Cr—52 to 60 inches; reddish yellow (7.5YR 6/8) and yellowish red (5YR 5/6) weakly cemented sandstone interbedded with red (2.5YR 5/8) weakly cemented shale; strongly acid.

Thickness of the solum and depth to bedrock are 40 to 60 inches. Base saturation, by sum of cations, ranges from 50 to 70 in the B2t horizons and from 60 to 70 in the B3 horizons.

The A1 horizon is 3 to 8 inches thick. It has hue of 7.5YR or 10YR, value of 4 to 6, and chroma of 2 to 4. The A1 horizon ranges from medium acid to neutral. Where limed, it ranges from medium acid to moderately alkaline.

The A2 horizon is 0 to 11 inches thick. It has hue of 5YR or 7.5YR, value of 5 to 7, and chroma of 3 or 4. The A2 horizon is fine sandy loam or loamy fine sand. This horizon is medium acid or slightly acid. Where cultivated, the A2 horizon is mixed with the Ap horizon in some pedons.

The B21t horizon is 7 to 13 inches thick. It has hue of 5YR, value of 5 or 6, and chroma of 6. In some pedons, the B21t horizon has few mottles in shades of red. The B21t horizon is sandy clay loam. The clay content ranges from 20 to 35 percent. In some pedons, the upper 3 inches of the B21t horizon has coatings of A2 material on the faces of peds. This horizon ranges from strongly acid to slightly acid.

The B22t horizon is 0 to 18 inches thick. It has hue of 5YR, value of 5 or 6, and chroma of 6 to 8. In some pedons, the B22t horizon has few mottles in shades of red. It is fine sandy loam or sandy clay loam. The clay content ranges from about 18 to 33 percent. This horizon ranges from very strongly acid to slightly acid.

The B31 horizon is 6 to 18 inches thick. It has hue of 2.5YR to 7.5YR, value of 5 or 6, and chroma of 6 to 8. In many pedons, the B31 horizon is coarsely mottled or has mottles in shades of red, yellow, or brown. The B31 horizon is fine sandy loam or sandy clay loam. The clay content ranges from about 14 to 30 percent. In some pedons, the B31 horizon has streaks of clean sand on faces of peds. It has coarse fragments of sandstone from 2 mm to 76 mm in diameter that make up from 0 to 20 percent by volume. This horizon ranges from very strongly acid to slightly acid.

The B32 horizon is 0 to 11 inches thick. It has hue of 2.5YR to 7.5YR, value of 5 to 7, and chroma of 6 to 8. In many pedons, the B32 horizon is coarsely mottled or has mottles in shades of red, yellow, or brown. It is fine sandy loam or sandy clay loam. The clay content ranges from about 12 to 25 percent. In some pedons, the B32 horizon has streaks of clean sand on faces of peds. It has coarse fragments of sandstone from 2 mm to 76 mm in diameter that make up from 0 to 20 percent by volume. This horizon ranges from strongly acid to neutral.

The Cr horizon is reddish, yellowish, or brownish rippable sandstone interbedded with shale.

Lomill Series

Soils of the Lomill series are deep, somewhat poorly drained, and very slowly permeable. These nearly level soils formed in clayey and loamy Pleistocene alluvium. They are on slightly concave flood plains along the South Canadian River. Slopes range from 0 to 1 percent. The soils of the Lomill series are clayey over loamy, mixed, thermic Vertic Haplustolls.

Lomill soils are associated with Asher, Asher Variant, Brewless, Canadian, Gaddy, Goodnight, Gracemont Variant, Gracemore, Keokuk, Port, and Weswood soils. Asher and Brewless soils are in slightly higher positions on flood plains than Lomill soils. Asher soils have a fine-silty control section. Brewless soils have an argillic horizon and a fine control section. Asher Variant, Gaddy, Gracemont Variant, and Gracemore soils are in lower positions on flood plains than Lomill soils. Asher Variant soils have a fine-silty over sandy control section and a high water table within 40 inches of the surface. Gaddy soils have a sandy control section and do not have a mollic epipedon. Gracemont Variant soils have a coarse-silty over sandy control section and do not have a mollic epipedon. Gracemore soils have a high water table within 40 inches of the surface, do not have a mollic epipedon, and have a sandy control section. Canadian soils are in higher positions on flood plains than Lomill soils and have a coarse-loamy control section. Goodnight soils are in higher hummocky areas and have a sandy control section. Keokuk soils are in higher positions on flood plains than Lomill soils and have a coarse-silty control section. Port and Weswood soils are in the highest areas of the landscape where minor streams cross the area and have a fine-silty control section. Weswood soils do not have a mollic epipedon.

Typical pedon of Lomill silty clay, occasionally flooded; about 275 feet east and 200 feet north from the southwest corner of sec. 21, T. 9 N., R. 3 W.

Ap—0 to 9 inches; brown (7.5YR 5/2) silty clay, dark brown (7.5YR 3/2) moist; moderate medium granular structure; hard, firm; many very fine and few fine roots; slightly effervescent; moderately alkaline; clear smooth boundary.

A1—9 to 13 inches; brown (7.5YR 4/2) silty clay, dark brown (7.5YR 3/2) moist; moderate fine subangular blocky structure; very hard, very firm; common very fine roots; slightly effervescent; moderately alkaline; clear smooth boundary.

B2—13 to 25 inches; dark reddish gray (5YR 4/2) silty clay, dark reddish gray (5YR 4/2) moist; weak medium blocky structure; extremely hard, extremely firm; common very fine roots; strongly effervescent; moderately alkaline; clear smooth boundary.

C—25 to 34 inches; brown (7.5YR 5/2) silty clay, dark brown (7.5YR 4/2) moist; massive; very hard, very firm; faint stratification; common very fine roots; few threads of calcium carbonate; violently effervescent; moderately alkaline; clear smooth boundary.

IIC—34 to 60 inches; stratified brown (7.5YR 5/3) loam, light brown (7.5YR 6/4) very fine sandy loam, and reddish brown (5YR 4/3) silty clay, dark brown (7.5YR 4/3), brown (7.5YR 5/4), and reddish brown (5YR 4/3) moist; common medium distinct dark grayish brown (10YR 4/2) mottles below a depth of 50 inches; massive; hard, friable; few very fine roots; few soft masses and threads of calcium carbonate; violently effervescent; moderately alkaline.

Depth to stratified material ranges from 25 to 38 inches. A high water table is between 3.5 and 6 feet below the surface most of the year. The mollic epipedon ranges from 10 to 27 inches thick. Depth to soft powdery lime ranges from 7 to 28 inches. In most years, this soil has cracks that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some parts, and that extend to the surface.

The Ap or A1 horizon is 7 to 13 inches thick. It has hue of 5YR to 10YR, value of 3 to 5, and chroma of 1 to 3. The Ap or A1 horizon is mildly alkaline or moderately alkaline.

The B2 horizon is 6 to 18 inches thick. It has hue of 2.5YR to 7.5YR, value of 3 to 5, and chroma of 2 to 6. The B2 horizon is silty clay. The clay content ranges from 42 to 50 percent, and COLE ranges from 0.07 to 0.09. The B2 horizon has vertical streaks of material similar to the A horizon in some pedons. The B2 horizon is moderately alkaline.

Some pedons have a B3 horizon that is similar in color, texture, and reaction to the B2 horizon. In most pedons, the B3 horizon has soft bodies or mycelia forms of calcium carbonate.

The C horizon is 0 to 14 inches thick. It has hue of 2.5YR to 7.5YR, value of 4 or 5, and chroma of 2 to 6. In some pedons, the C horizon has mottles in shades of red or gray. The C horizon is silty clay or silty clay loam. It is moderately alkaline. In some pedons, the C horizon has vertical streaks of material similar to the A horizon.

The IIC horizon is stratified and variable in texture and color. It has hue of 2.5YR to 10YR, value of 4 to 7, and chroma of 2 to 6. Mottles in shades of brown, red, or gray are in some strata. The IIC horizon ranges from loamy very fine sand to silty clay loam above 40 inches. Below 40 inches, it is loamy fine sand to silty clay. The clay content ranges from 5 to 45 percent. The weighted average clay content ranges from 7 to 30 percent and typically ranges from 10 to 20 percent. The IIC horizon is moderately alkaline.

Lucien Series

Soils of the Lucien series are shallow, well drained, and moderately rapidly permeable. These very gently sloping to sloping soils formed in material weathered from fine grain Permian sandstone, siltstone, or sandstone conglomerate. They are on convex ridge crests and side slopes of prairie uplands (fig. 18). Slopes are from 1 to 8 percent. The soils of the Lucien series are loamy, mixed, thermic, shallow Typic Haplustolls.

Lucien soils are associated with the Grainola, Grant, Huska, Kingfisher, Norge Variant, Renfrow, and Teller Variant soils. Grainola soils are mostly in lower positions on side slopes than Lucien soils and on foot slopes and have an argillic horizon, a solum more than 20 inches thick, and a fine control section. Grant and Huska soils are in higher positions on ridge crests than Lucien soils and have an argillic horizon and a solum more than 40 inches thick. Grant soils have a fine-silty control section, and Huska soils have a fine control section. Kingfisher soils are in similar positions on the landscape as Lucien soils and have an argillic horizon, a solum more than 20 inches thick, and a fine-silty control section. Norge Variant soils are on toe slopes and have an argillic horizon, a solum more than 20 inches thick, and a fine-silty control section. Renfrow soils are in higher positions on ridge crests and in lower positions on side slopes than Lucien soils and have an argillic horizon, a fine control section, and a solum more than 60 inches thick. Teller Variant soils are on toe slopes and have an argillic horizon, a solum more than 20 inches thick, and a fine-loamy control section.

Typical pedon of Lucien very fine sandy loam from an area of Kingfisher-Lucien complex, 1 to 5 percent slopes; about 900 feet west and 800 feet north from the southeast corner of sec. 14, T. 8 N., R. 2 W.

A1—0 to 6 inches; brown (7.5YR 4/2) very fine sandy loam, dark brown (7.5YR 3/2) moist; moderate fine granular structure; slightly hard, very friable; many fine and very fine roots; moderately alkaline; clear smooth boundary.

B2—6 to 10 inches; reddish brown (5YR 5/3) very fine sandy loam, reddish brown (5YR 4/3) moist; moderate medium granular structure; hard, friable; many fine and very fine roots; about 15 percent by volume sandstone fragments from 2 mm to 76 mm in diameter; slightly effervescent; moderately alkaline; clear wavy boundary.

Cr—10 to 36 inches; red (2.5YR 5/6) fine grained laminated weakly cemented sandstone; strongly effervescent; moderately alkaline.

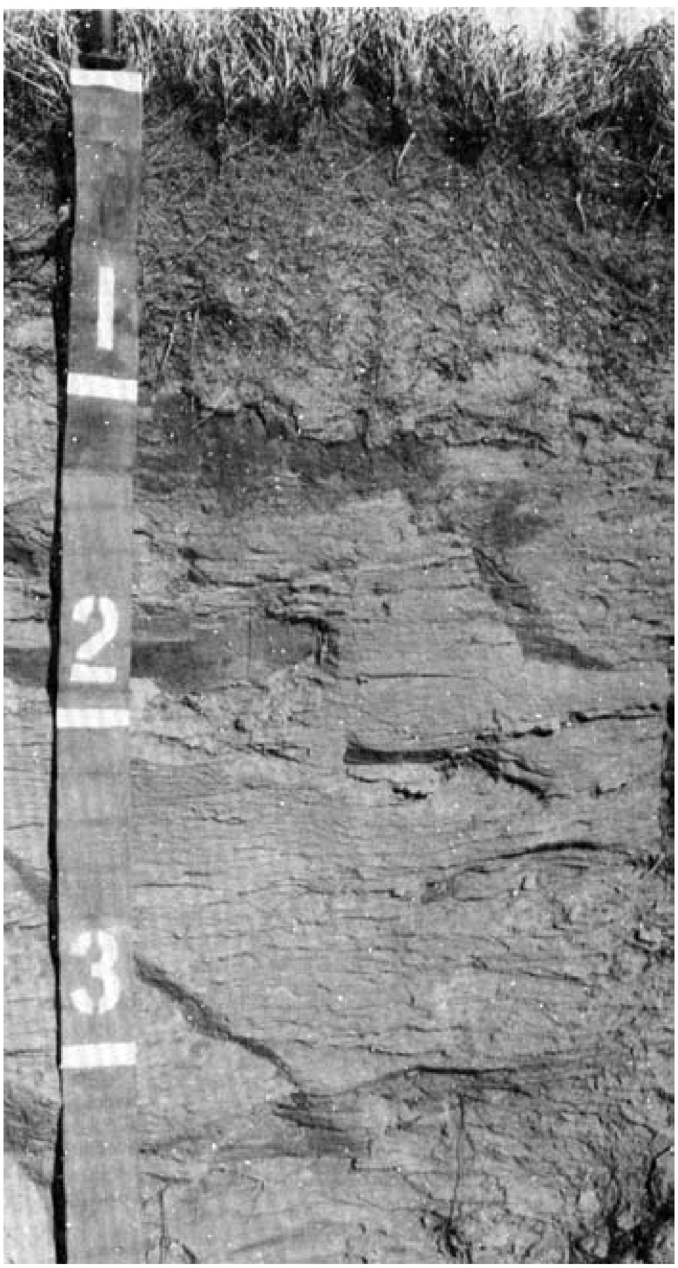


Figure 18.—A profile of Lucien very fine sandy loam showing soft laminated sandstone below a depth of about 1 foot.

Thickness of the solum and depth to bedrock are 10 to 20 inches.

The A1 or Ap horizon is 2 to 10 inches thick. It has hue of 2.5YR to 7.5YR, value of 4 or 5, and chroma of 2 to 6. In pedons where the thickness of the A1 or Ap horizon is 7 inches or more, the chroma is 4 or more. The A1 or Ap horizon has coarse fragments of sandstone from 2 mm to 76 mm in diameter that make up from 0 to 10 percent by volume. This horizon ranges from slightly acid to moderately alkaline. In some pedons, it is calcareous.

The B2 horizon is 3 to 12 inches thick. It has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 3 to 8. The B2 horizon is silt loam, loam, very fine sandy loam, or fine sandy loam. The clay content ranges from 12 to 25 percent. The B2 horizon has coarse fragments of sandstone from 2 mm to 76 mm in diameter that make up from 0 to 35 percent by volume. This horizon ranges from neutral to moderately alkaline.

Some pedons have a B3 horizon that is similar in color, texture, content of coarse fragments, and reaction to the B2 horizon.

The Cr horizon is weakly cemented sandstone, siltstone, or sandstone conglomerate. It has hue of 2.5YR or 5YR, value of 3 to 6, and chroma of 4 to 8. In some pedons, the Cr horizon has bands or streaks in shades of gray or yellow.

The Lucien soils in this survey area are taxadjunct to the Lucien series because they have mollic colors slightly thinner and the solum is slightly more alkaline than is typical for the Lucien series. Use, behavior, and management are similar to those of the Lucien soils.

Newalla Series

The soils of the Newalla series are deep, moderately well drained, and very slowly permeable. These very gently sloping to sloping soils formed in loamy over clayey materials weathered from reddish Permian sandstone and shale. They are on side slopes and ridge crests of uplands. Slopes range from 1 to 8 percent. The soils of the Newalla series are fine-loamy over clayey, siliceous, thermic Udic Haplustalfs.

Newalla soils are associated with Darsil, Derby, Grainola, Harrah, Littleaxe, and Stephenville soils. Darsil soils are in narrow contour bands between Newalla soils. They have a solum 10 to 20 inches thick underlain by sandstone, a sandy control section, and do not have an argillic horizon. Derby soils are on high convex dunes on the ridges, do not have an argillic horizon and have a sandy control section. Grainola soils are on prairie side slopes, and have a fine control section and a solum 20 to 40 inches thick. Harrah soils are on foot slopes and have a fine-loamy control section and a solum more than 60 inches thick. Littleaxe soils are on broad, higher ridge crests than Newalla soils, have a fine-loamy control section, and formed in material weathered from sandstone. Stephenville soils are in similar positions on the landscape as Newalla soils, have a solum 20 to 40 inches thick underlain by sandstone, and have a fine-loamy control section.

Typical pedon of Newalla fine sandy loam from an area of Stephenville-Darsil-Newalla complex, 3 to 8 percent slopes; about 1,900 feet east and 150 feet south of the northwest corner of sec. 21, T. 7 N., R. 1 E.

A1—0 to 3 inches; brown (7.5YR 4/2) fine sandy loam, dark brown (7.5YR 3/2) moist; moderate fine granular structure; slightly hard, very friable; many very fine and fine roots and common medium roots; strongly acid; clear smooth boundary.

A2—3 to 6 inches; light brown (7.5YR 6/4) fine sandy loam, brown (7.5YR 5/4) moist; weak medium granular structure; slightly hard, very friable; many very fine and fine roots and common medium roots; very strongly acid; abrupt wavy boundary.

B2t—6 to 10 inches; red (2.5YR 5/6) sandy clay loam, red (2.5YR 4/6) moist; moderate medium subangular blocky structure; hard, firm; common very fine, fine, and medium roots and few coarse roots; patchy clay films on faces of peds; many faces of peds coated with light brown (7.5YR 6/4) fine sandy loam; very strongly acid; clear wavy boundary.

IIB21t—10 to 16 inches; red (2.5YR 4/6) clay, dark red (2.5YR 3/6) moist; moderate fine and medium blocky structure; very hard, very firm; common very fine and fine roots and few medium and coarse roots; nearly continuous clay films on faces of peds; very strongly acid; gradual wavy boundary.

IIB22t—16 to 30 inches; red (2.5YR 4/6) clay, dark red (2.5YR 3/6) moist; weak medium subangular blocky structure; extremely hard, extremely firm; common very fine and fine roots and few medium and coarse roots; few nonintersecting slickensides; nearly continuous clay films on faces of peds; few fine dark concretions; medium acid; gradual wavy boundary.

IIB23tca—30 to 42 inches; red (2.5YR 4/6) clay, dark red (2.5YR 3/6) moist; weak medium subangular blocky and blocky structure; extremely hard, extremely firm; few very fine, fine, medium, and coarse roots; few nonintersecting slickensides; nearly continuous clay films on faces of peds; few fine dark concretions; common fine and medium soft bodies of calcium carbonate; slightly effervescent; mildly alkaline; gradual wavy boundary.

IIB24t—42 to 51 inches; red (2.5YR 4/6) clay, dark red (2.5YR 3/6) moist; weak medium and coarse blocky structure; extremely hard, extremely firm; few very fine and fine roots; common nonintersecting slickensides; nearly continuous clay films on faces of peds; few dark concretions; slightly effervescent; mildly alkaline; gradual wavy boundary.

IIB3—51 to 58 inches; red (2.5YR 4/6) shaly silty clay, dark red (2.5YR 3/6) moist; common fine distinct yellowish red (5YR 4/6) mottles; weak medium subangular blocky structure; very hard, very firm; few very fine roots; patchy clay films on faces of peds; 25 percent by volume shale fragments from 2 mm to 76 mm in diameter; slightly effervescent; mildly alkaline; clear wavy boundary.

IICr—58 to 80 inches; red (2.5YR 4/6) weakly laminated, soft shale; mildly alkaline.

Thickness of the solum and depth to bedrock range from 40 to 60 inches.

The A1 or Ap horizon is 2 to 9 inches thick. It has hue of 2.5YR to 7.5YR, value of 4 to 6, and chroma of 2 to 6. Base saturation (by sum of cations) ranges from 35 to 50 percent. This horizon ranges from strongly acid to neutral.

The A2 horizon is 0 to 7 inches thick. It has hue of 5YR or 7.5YR, value of 5 to 7, and chroma of 3 to 6. This horizon is mixed with the Ap horizon in some pedons. Base saturation (by sum of cations) ranges from 25 to 35 percent. This horizon ranges from very strongly acid to neutral.

The B2t horizon is 4 to 15 inches thick. It has hue of 2.5YR or 5YR, value of 4 to 6, and chroma of 4 to 6. The B2t horizon is sandy clay loam or clay loam. The clay content ranges from 20 to 35 percent. In some eroded pedons, the B2t horizon is mixed with the Ap horizon. Base saturation (by sum of cations) ranges from 25 to 50 percent. This horizon ranges from very strongly acid to neutral.

The IIB21t horizon is 4 to 19 inches thick. It has hue of 10R to 5YR, value of 4 to 6, and chroma of 6 to 8. The IIB21t horizon is silty clay or clay. The clay content ranges from 40 to 55 percent. Base saturation (by sum of cations) ranges from 35 to 85 percent. This horizon ranges from very strongly acid to moderately alkaline.

The IIB22t horizon is 0 to 16 inches thick. It has hue of 10R to 5YR, value of 4 to 6, and chroma of 6 to 8. The IIB22t horizon is silty clay or clay. The clay content ranges from 40 to 55 percent. Exchangeable sodium ranges from 0 to 2 percent. Base saturation (by sum of cations) ranges from 35 to 85 percent. This horizon ranges from very strongly acid to moderately alkaline.

The IIB23tca horizon is 0 to 28 inches thick. It has hue of 10R or 5YR, value of 4 to 6, and chroma of 4 to 8. The IIB23tca horizon is silty clay or clay. The clay content ranges from 40 to 55 percent. The IIB23tca horizon has soft bodies of calcium carbonate that range from 0 to 10 percent by volume. Exchangeable sodium ranges from 3 to 7 percent. Base saturation (by sum of cations) ranges from 55 to 98 percent. This horizon ranges from neutral to moderately alkaline.

The IIB24t horizon is 0 to 9 inches thick. It has hue of 10R to 5YR, value of 4 to 6, and chroma of 4 to 8. The IIB24t horizon is silty clay or clay. The clay content ranges from 40 to 55 percent. The IIB24t horizon has soft bodies of calcium carbonate that range from 0 to 10 percent by volume. Exchangeable sodium ranges from 3 to 7 percent. Base saturation (by sum of cations) ranges from 55 to 98. This horizon is mildly alkaline or moderately alkaline.

The IIB3 or IIB3ca horizon is 0 to 18 inches thick. It has hue of 10R to 5YR, value of 4 to 6, and chroma of 4 to 8. In some pedons, the IIB3 or IIB3ca horizon has mottles in shades of brown, yellow, or red. The IIB3 or IIB3ca horizon is silty clay, clay, or their shaly or very shaly analogs. The clay content ranges from 40 to 55 percent. The IIB3 or IIB3ca horizon has shale fragments from 2 mm to 76 mm in diameter that make up from 0 to 50 percent by volume. Exchangeable sodium ranges from 5 to 10 percent. Base saturation (by sum of cations) ranges from 75 to 79 percent. This horizon is mildly alkaline or moderately alkaline.

The IICr horizon is soft, laminated siltstone or shale. It is interbedded with thin lenses of sandstone in some pedons. The IICr horizon has hue of 10R or 2.5YR, value of 4 to 6, and chroma of 2 to 8. In some pedons, the IICr horizon is streaked or mottled in shades of gray, brown, yellow, or olive. This horizon is mildly alkaline or moderately alkaline.

Norge Series

The soils of the Norge series are deep, well drained, and moderately slowly permeable. These very gently sloping to sloping soils formed in loamy Pleistocene alluvium and colluvium. They are on ridge crests and side slopes of mantled uplands. Slopes range from 1 to 8 percent. The soils of the Norge series are fine-silty, mixed, thermic Udic Paleustolls.

Norge soils are associated with Bethany, Derby, Dougherty, Grainola, Grant, Kingfisher, Konawa, Norge Variant, Port, Renfrow, Slaughterville, Slaughterville Variant, Teller, Teller Variant, Vanoss, and Weswood soils. Bethany soils are on mantled uplands and have a fine control section. Grainola soils are in higher positions on side slopes than Norge soils, do not have a mollic epipedon, and have a fine control section and a solum 20 to 40 inches thick. Grant and Kingfisher soils are in higher positions on ridge crests than Norge soils. Grant soils have a solum 40 to 60 inches thick over bedrock, and Kingfisher soils have a solum 20 to 40 inches thick. Derby soils are in higher hummocky areas and have a sandy control section. Dougherty and Konawa soils are lower in elevation than Norge soils. Dougherty soils have a loamy control section, and Konawa soils have a fine-loamy control section. Port soils are on adjoining flood plains and do not have an argillic horizon. Norge Variant, Slaughterville, Slaughterville Variant, Teller, and Teller Variant soils are in similar positions on the landscape as Norge soils. Renfrow soils are on uplands and have a fine control section. Norge Variant soils have a solum 20 to 60 inches thick over gravel beds. Slaughterville and Slaughterville Variant soils have a coarse-loamy control section, and Teller and Teller Variant soils have a fine-loamy control section. Vanoss soils are in higher positions on broad ridges than Norge soils and have an argillic horizon that decreases in clay content by more than 20 percent from the maximum within a depth of 60 inches. Weswood soils are on adjoining flood plains and do not have a mollic epipedon or an argillic horizon.

Typical pedon of Norge silt loam, 3 to 5 percent slopes; about 1,500 feet north and 700 feet east from the southwest corner of sec. 5, T. 9 N., R. 2 W.

A1—0 to 12 inches; brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; slightly hard, very friable; many very fine and fine roots; slightly acid; clear smooth boundary.

B1—12 to 18 inches; reddish brown (5YR 5/3) silty clay loam, dark reddish brown (5YR 3/3) moist; weak medium subangular blocky structure; hard, friable; many very fine and fine roots; slightly acid; gradual smooth boundary.

B21t—18 to 36 inches; reddish brown (5YR 5/4) silty clay loam, reddish brown (5YR 4/4) moist; moderate medium subangular blocky structure; very hard, firm; common very fine roots; nearly continuous clay films on faces of peds; neutral; gradual smooth boundary.

B22t—36 to 47 inches; red (2.5YR 5/6) silty clay loam, red (2.5YR 4/6) moist; moderate medium subangular blocky structure; very hard, very firm; common very fine roots; nearly continuous clay films on faces of peds; few fine black concretions; neutral; gradual smooth boundary.

B3—47 to 58 inches; red (2.5YR 5/6) silty clay loam, red (2.5YR 4/6) moist; weak medium subangular blocky structure; very hard, very firm; few very fine roots; patchy clay films on faces of peds; few fine black concretions; neutral; clear smooth boundary.

B2tb—58 to 84 inches; red (2.5YR 5/6) silty clay, red (2.5YR 4/6) moist; moderate medium blocky structure; extremely hard, very firm; nearly continuous clay films on faces of peds; few fine black concretions; mildly alkaline.

Thickness of the solum is 60 to more than 84 inches. The depth to silty clay texture is 50 to more than 80 inches.

The A1 or Ap horizon is 4 to 12 inches thick. It has hue of 5YR to 10YR, value of 4 or 5, and chroma of 2 or 3. In some pedons, the A1 and B1 horizons have been mixed by plowing. The A1 horizon is slightly acid or neutral. Where limed, it ranges from slightly acid to moderately alkaline.

The B1 horizon is 0 to 8 inches thick. It has hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 2 to 4. The B1 horizon is silt loam or silty clay loam. The clay content ranges from about 24 to 32 percent. This horizon is slightly acid to neutral.

The B21t horizon is 9 to 20 inches thick. It has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 4 to 6. The B21t horizon is silty clay loam. The clay content ranges from about 27 to 35 percent. This horizon ranges from medium acid to mildly alkaline.

The B22t horizon is 9 to 37 inches thick. It has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 4 to 8. In some pedons, the B22t horizon has brownish or reddish mottles or coatings on the faces of peds. The B22t horizon is silty clay loam. The clay content ranges from about 27 to 38 percent. This horizon ranges from medium acid to mildly alkaline.

Some pedons have a B23t horizon from 0 to 20 inches thick. Color, texture, and reaction of the B23t horizon is similar to the B3 horizon.

The B3 horizon is 0 to 30 inches thick. It has hue of 2.5YR or 5YR, value of 4 to 6, and chroma of 4 to 8. In some pedons, the B3 horizon has brownish or reddish mottles or coatings on the faces of peds. The B3 horizon is silty clay loam, silty clay, or clay loam. The clay content ranges from about 27 to 50 percent. In some pedons, the B3 horizon has coarse fragments from 2 mm to 76 mm in diameter that make up from 0 to 15 percent by volume. This horizon ranges from slightly acid to moderately alkaline.

The B2tb horizon is absent or is below a depth of 80 inches in some pedons. Where present, it has hue of 2.5YR or 5YR, value of 4 to 6, and chroma of 4 to 8. The B2tb horizon is silty clay loam or silty clay. The clay content ranges from about 32 to 50 percent. This horizon ranges from neutral to moderately alkaline.

Some pedons have a IIC horizon below 60 inches that is coarser textured than the solum.

Norge Variant

Soils of the Norge Variant are moderately deep to deep, well drained, and moderately slowly permeable. These gently sloping to sloping soils formed in loamy Pleistocene alluvium and colluvium. They are on side slopes and toe slopes of mantled uplands. Slopes range from 3 to 8 percent. The soils of the Norge Variant are fine-silty, mixed, thermic Typic Argiustolls.

Norge Variant soils are associated with Kingfisher, Lucien, Norge, Renfrow, Teller, and Teller Variant soils. Kingfisher and Lucien soils are on high ridge crests. Kingfisher soils have a solum from 20 to 40 inches thick underlain by sandstone and shale bedrock and do not have a IIC horizon that has coarse fragments. Lucien soils have a solum less than 20 inches thick underlain by sandstone bedrock. Norge, Teller, and Teller Variant soils are in similar positions on the landscape as Norge Variant soils. Norge soils do not have a IIC horizon that has coarse fragments. Teller and Teller Variant soils have a fine-loamy control section. Renfrow soils are on high ridge crests and in higher positions on side slopes than Norge Variant soils. They have a fine control section.

Typical pedon of Norge Variant silt loam from an area of Norge Variant and Teller Variant soils, 3 to 8 percent slopes; about 2,150 feet west and 1,600 feet north from the southeast corner of sec. 11, T. 8 N., R. 2 W.

Ap—0 to 5 inches; reddish brown (5YR 5/3) silt loam, dark reddish brown (5YR 3/3) moist; weak fine granular structure; slightly hard, friable; many very fine and fine roots; slightly acid; clear smooth boundary.

B1—5 to 11 inches; reddish brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) moist; weak medium subangular blocky structure parting to moderate medium granular; hard, friable; many very fine and fine roots; slightly acid; gradual smooth boundary.

B2t—11 to 29 inches; reddish brown (5YR 5/3) silty clay loam, reddish brown (5YR 4/3) moist; moderate medium subangular blocky structure; hard, firm; nearly continuous clay films on faces of peds; common very fine roots; about 2 percent by volume gravel from 2 mm to 76 mm in diameter; neutral; clear wavy boundary.

IIC—29 to 80 inches; yellowish red (5YR 5/6) extremely gravelly sandy loam, yellowish red (5YR 4/6) moist; massive; hard, friable; few very fine roots to 46 inches; about 60 percent by volume gravel from 2 mm to 76 mm in diameter and about 2 percent by volume cobbles greater than 76 mm; stratified with thin layers of sand and gravelly sand; strongly effervescent; moderately alkaline.

Thickness of the solum and depth to gravel bedrock are 20 to 60 inches. Depth to secondary lime ranges from 20 to 36 inches.

The A1 or Ap horizon is 5 to 12 inches thick. It has hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 2 or 3. The A1 or Ap horizon has gravel from 2 mm to 76 mm in diameter that makes up from 0 to 5 percent by volume. This horizon ranges from slightly acid to moderately alkaline.

The B1 horizon is 0 to 8 inches thick. It has hue of 5YR, value of 4 or 5, and chroma of 3 or 5. The B1 horizon is silt loam, loam, or silty clay loam. It has gravel from 2 mm to 76 mm in diameter that makes up from 0 to 5 percent by volume. This horizon ranges from slightly acid to moderately alkaline.

The B2t horizon is 14 to 40 inches thick. It has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 4 to 6. The B2t horizon is silty clay loam or gravelly silty clay loam. The clay content ranges from 27 to 35 percent. The B2t horizon has gravel from 2 mm to 76 mm in diameter that makes up from 0 to 30 percent by volume. This horizon ranges from slightly acid to moderately alkaline. In some pedons, it is calcareous.

The IIC horizon is 24 inches to more than 15 feet thick. It is underlain with red shale or sandstone in most pedons. The IIC horizon has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 4 to 8. This horizon consists of stratified layers of very gravelly or extremely gravelly phases of fine sand, sandy loam, loam, clay loam, or sandy clay loam. The IIC horizon has gravel from 2 mm to 76 mm in diameter that makes up from 35 to 90 percent by volume. It has cobbles more than 76 mm in diameter that make up from 0 to 5 percent by volume.

The Norge Variant soils differ from the soils of the Norge series because they have secondary lime higher in the profile, have more than 20 percent decrease in clay content within 60 inches, and have a IIC horizon that has coarse fragments.

Pawhuska Series

Soils of the Pawhuska series are deep, moderately well drained, and very slowly permeable. These nearly level to very gently sloping sodic soils formed in clayey Pleistocene alluvium over clayey materials weathered from Permian shale. They are on slightly concave ridge crests of uplands. Slopes range from 0 to 3 percent. The soils of the Pawhuska series are fine, mixed, thermic Mollic Natrustalfs.

Pawhuska soils are associated with Bethany, Doolin, and Huska soils. Bethany soils are in slightly convex areas surrounding the Pawhuska soils and have a mollic epipedon more than 20 inches thick and do not have a natric horizon. Doolin soils are in smooth areas surrounding the Pawhuska soils and have a thicker A horizon than Pawhuska soils and a mollic epipedon. Huska soils are in similar positions on the landscape as Pawhuska soils and have a solum 40 to 60 inches thick.

Typical pedon of Pawhuska silt loam from an area of Doolin-Pawhuska complex, 0 to 3 percent slopes; about 1,440 feet south and 1,500 feet west from the northeast corner of sec. 33, T. 10 N., R. 3 W.

A1—0 to 10 inches; grayish brown (10YR 5/2) silt loam, very dark gray (10YR 3/1) moist; massive; hard, friable; few fine and many very fine roots; slightly acid; abrupt smooth boundary.

B21t—10 to 19 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate medium columnar structure parting to moderate fine blocky; extremely hard, very firm; very dark brown (10YR 2/2) coatings on sides of columns; few fine and many very fine roots; nearly continuous clay films on faces of peds; neutral; gradual smooth boundary.

B22t—19 to 26 inches; grayish brown (10YR 5/2) silty clay, dark grayish brown (10YR 4/2) moist; weak medium prismatic structure parting to moderate medium blocky; extremely hard, very firm; many very fine roots; nearly continuous clay films on faces of peds; moderately alkaline; gradual smooth boundary.

B23tca—26 to 33 inches; brown (10YR 5/3) silty clay, dark brown (10YR 4/3) moist; weak coarse prismatic structure parting to weak medium blocky; extremely hard, very firm; common very fine roots; nearly continuous clay films on faces of peds; common soft bodies of calcium carbonate; few calcium carbonate concretions; strongly effervescent; moderately alkaline; gradual smooth boundary.

B24tsa—33 to 43 inches; brown (10YR 5/3) silty clay, dark brown (10YR 4/3) moist; common medium faint grayish brown (10YR 5/2) and common fine distinct yellowish red (5YR 5/6) mottles; weak medium blocky structure; extremely hard, very firm; few very fine roots; nearly continuous clay films on faces of peds; many crystals of soluble salts; few black concretions; common soft bodies of calcium carbonate; few calcium carbonate concretions; strongly effervescent; moderately alkaline; gradual smooth boundary.

B3sa—43 to 57 inches; coarsely mottled yellowish red (5YR 5/6), brown (10YR 5/3), and dark gray (10YR 4/1) silty clay loam, yellowish red (5YR 4/6), dark brown (10YR 4/3), and very dark gray (10YR 3/1) moist; weak medium subangular blocky structure; extremely hard, very firm; few fine roots; nearly continuous clay films on faces of peds; few black concretions; many crystals of soluble salts; few soft bodies and concretions of calcium carbonate; slightly effervescent; moderately alkaline; clear smooth boundary.

B21tb—57 to 65 inches; yellowish red (5YR 5/6) silty clay, yellowish red (5YR 4/6) moist; common medium and coarse distinct grayish brown (10YR 5/2) mottles; moderate medium blocky structure; extremely hard, very firm; few very fine roots; nearly continuous clay films on faces of peds; slightly effervescent in spots; moderately alkaline; clear smooth boundary.

B22tcab—65 to 87 inches; reddish brown (2.5YR 4/4) silty clay, reddish brown (2.5YR 4/4) moist; moderate medium blocky structure; extremely hard, very firm; nearly continuous clay films on faces of peds; few black concretions; many soft bodies of calcium carbonate; violently effervescent; moderately alkaline; clear smooth boundary.

B3b—87 to 99 inches; red (2.5YR 4/6) silty clay, red (2.5YR 4/6) moist; weak medium blocky structure; extremely hard, very firm; patchy clay films on faces of peds; few black concretions; about 50 percent by volume shale fragments 2 mm to 76 mm in diameter; strongly effervescent; moderately alkaline; gradual smooth boundary to red (2.5YR 4/6) weakly laminated moderately alkaline shale.

Thickness of the solum and depth to bedrock are 60 to more than 80 inches. Depth to soft bodies of calcium carbonate ranges from 15 to 35 inches. Some pedons do not have buried horizons below 50 inches. The exchangeable sodium ranges from about 15 to 50 percent in the upper Bt horizons.

The Ap or A1 horizon is 2 to 10 inches thick. It has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3. The Ap or A1 horizon has brownish or reddish mottles in the lower part of some pedons. The Ap or A1 horizon is silt loam. Where the plow layer is mixed with the B21t horizon, it can be silty clay loam. This horizon ranges from slightly acid to moderately alkaline.

Some pedons have an A2 horizon up to 2 inches thick. The A2 horizon has colors that are similar to the A1 horizon, but the value and chroma are 1 to 3 units higher than the A1 horizon. The A2 horizon is silt loam. Where the plow layer is mixed with the upper B21t horizon, it can be silty clay loam. This horizon ranges from slightly acid to moderately alkaline.

The B21t horizon is 7 to 12 inches thick. It has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3. Grayish caps are common on tops of columns or prisms, and black or very dark brown organic stains are common on sides of columns or prisms. The B21t horizon is silty clay or silty clay loam. The clay content ranges from about 38 to 50 percent. This horizon ranges from neutral to moderately alkaline.

The B22t horizon is 0 to 13 inches thick. It has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3. In some pedons, the B22t horizon has brownish or reddish mottles. The B22t horizon is silty clay. The clay content ranges from about 40 to 55 percent. This horizon ranges from neutral to moderately alkaline.

Some pedons have a B22tca horizon that ranges from 0 to 15 inches thick. It has hue of 7.5YR or 10YR, value of 5, and chroma of 2 or 3. Texture is the same as the B22t horizon.

The B23tca horizon is 0 to 20 inches thick. It has hue of 5YR to 10YR, value of 4 to 5, and chroma of 2 to 4. In some pedons, the B23tca horizon is coarsely mottled or has mottles in shades of red or brown. The B23tca horizon is silty clay. The clay content ranges from about 40 to 55 percent.

Some pedons have a B23t horizon that ranges from 0 to 25 inches thick. It has hue of 7.5YR or 10YR, value of 5 or 6, and chroma of 2 or 3. In some pedons, the B23t horizon has mottles in shades of red, brown, or gray. The B23t horizon is silty clay. The clay content ranges from about 40 to 55 percent. This horizon is moderately alkaline.

The B24tsa horizon is 10 to 25 inches thick. It has hue of 2.5YR to 2.5Y, value of 3 to 7, and chroma of 2 to 8. In most pedons, the B24tsa horizon is coarsely mottled or has mottles in shades of brown, red, or gray. The B24tsa horizon is silty clay or silty clay loam. The clay content ranges from about 35 to 50 percent.

The B3sa, B21tb, B22tcab, and B3b horizons have hue of 2.5YR to 2.5Y, value of 3 to 7, and chroma of 1 to 8. In some pedons, they are coarsely mottled or have mottles in shades of brown, red, or gray. These horizons are silty clay loam or silty clay. The clay content ranges from about 35 to 50 percent. In some pedons, the B3sa, B21tb, B22tcab, and B3b horizons have coarse fragments of shale in the lower horizons that range from 2 mm to 76 mm in diameter and make up from 0 to 50 percent by volume.

Most pedons have C, Cr, or Crb horizons below 60 inches. The C horizon is similar in color, texture, and reaction to the B3b horizon. The Cr or Crb horizon is reddish shale.

Port Series

Soils of the Port series are deep, well drained, and moderately permeable. These nearly level to very gently sloping soils formed in recent loamy calcareous alluvium. They are on low flood plains along minor streams. Slopes range from 0 to 2 percent. The soils of the Port series are fine-silty, mixed, thermic Cumulic Haplustolls.

Port soils are associated with Lomill, Norge, Pulaski, Renfrow, Tribbey, and Weswood soils. Lomill soils are in lower positions on flood plains in slightly depressional areas, and they have a mollic epipedon less than 20 inches thick and a clayey over loamy control section. Norge and Renfrow soils are on adjoining uplands and have a mollic epipedon less than 20 inches thick and an argillic horizon. Pulaski soils are closer to the stream channel than Port soils, and they do not have a mollic epipedon and have a coarse-loamy control section. Tribbey soils are in slightly lower concave areas than Port soils, and they do not have a mollic epipedon and have a coarse-loamy control section and a high water table within 40 inches of the surface most of the time. Weswood soils are in slightly lower areas closer to the stream channel than Port soils. They do not have a mollic epipedon and are calcareous throughout the control section.

Typical pedon of Port silt loam, occasionally flooded; about 1,900 feet south and 50 feet east from the northwest corner of sec. 8, T. 9 N., R. 2 W.

Ap—0 to 7 inches; brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; weak medium platy structure parting to weak medium granular; slightly hard, very friable; many fine and few medium roots; moderately alkaline; clear smooth boundary.

A11—7 to 14 inches; brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; moderate medium granular structure; hard, friable; many fine and few medium roots; moderately alkaline; gradual smooth boundary.

A12—14 to 23 inches; reddish brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) moist; moderate medium granular structure; hard, friable; many fine roots; mildly alkaline; gradual smooth boundary.

B2—23 to 42 inches; reddish brown (5YR 5/3) silty clay loam, reddish brown (5YR 4/3) moist; weak medium subangular blocky structure; very hard, firm; few fine roots; few fine black concretions; moderately alkaline; gradual smooth boundary.

C—42 to 65 inches; yellowish red (5YR 5/6) silty clay loam, yellowish red (5YR 4/6) moist; massive; very hard, firm; few fine roots; few fine black concretions; few fine soft masses of calcium carbonate; slightly effervescent; moderately alkaline; clear smooth boundary.

IIC1b—65 to 78 inches; reddish brown (2.5YR 5/4) silty clay, reddish brown (2.5YR 4/4) moist; massive; extremely hard, very firm; few fine roots; few fine black concretions; many soft masses of calcium carbonate; violently effervescent; moderately alkaline; gradual smooth boundary.

IIC2b—78 to 84 inches; light red (2.5YR 6/6) clay loam, red (2.5YR 5/6) moist; massive; very hard, firm; few fine black concretions; few soft masses of calcium carbonate; strongly effervescent; moderately alkaline.

Thickness of the solum is 30 to 60 inches. The depth to secondary lime ranges from 30 to 60 inches. The depth to a lithologic discontinuity or buried horizon is 40 to more than 60 inches.

The A horizon is 21 to 44 inches thick. It has hue of 5YR or 7.5YR, value of 3 to 5, and chroma of 2 or 3. The upper part of the A horizon is silt loam and the lower part is silt loam or silty clay loam. In some pedons, the A horizon has fine sandy loam or loam overwash from 4 to 20 inches thick and has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 4 to 6. This horizon ranges from medium acid to mildly alkaline. Where limed, it ranges from medium acid to moderately alkaline.

The B2 horizon is 8 to 34 inches thick. It has hue of 2.5YR to 7.5YR, value of 4 or 5, and chroma of 2 to 6. The B2 horizon is silt loam or silty clay loam. The clay content ranges from about 20 to 35 percent. This horizon ranges from slightly acid to moderately alkaline.

The C horizon is 0 to 30 inches thick. It has hue of 2.5YR or 5YR, value of 4 to 6, and chroma of 4 to 6. In some pedons, the C horizon has brownish or grayish mottles. The C horizon is silt loam, silty clay loam, or clay loam. It has thin strata of darker or lighter colors in some pedons. This horizon is mildly alkaline or moderately alkaline.

The IICb or IIC horizon has hue of 2.5YR to 7.5YR, value of 4 to 6, and chroma of 1 to 6. In some pedons, it has mottles in shades of red, brown, or gray. The IICb or IIC horizon ranges from very fine sandy loam to silty clay. In some pedons, it has thin strata of coarser textures. The IICb or IIC horizon has strata that have coarse fragments from 2 mm to 76 mm in diameter that make up from 0 to 50 percent by volume in some pedons. This horizon is moderately alkaline.

Pulaski Series

Soils of the Pulaski series are deep, well drained, and moderately rapidly permeable. These nearly level to very gently sloping soils formed in recent loamy and sandy stratified alluvium. They are on low flood plains. Slopes range from 0 to 2 percent. The soils of the Pulaski series are coarse-loamy, mixed, nonacid, thermic Typic Ustifluvents.

Pulaski soils are associated with Harrah, Port, Stephenville, Tribbey, and Weswood soils. Harrah and Stephenville soils are on adjoining uplands and have a fine-loamy control section and an argillic horizon. Stephenville soils have a solum 20 to 40 inches thick underlain by sandstone. Port soils are in slightly higher areas than Pulaski soils and have a mollic epipedon more than 20 inches thick, a cambic horizon, and a fine-silty control section. Tribbey soils are in slightly lower areas than Pulaski soils and have a high water table within 40 inches of the surface most of the year. Weswood soils are in similar positions on the landscape and have a cambic horizon and a fine-silty control section.

Typical pedon of Pulaski fine sandy loam, occasionally flooded; about 2,350 feet south and 100 feet east from the northwest corner of sec. 28, T. 10 N., R. 1 E.

A1—0 to 8 inches; reddish brown (2.5YR 5/4) fine sandy loam, reddish brown (2.5YR 4/4) moist; weak medium granular structure; slightly hard, very friable; many fine roots; slightly acid; clear smooth boundary.

C1—8 to 18 inches; red (2.5YR 5/6) fine sandy loam, red (2.5YR 4/6) moist; massive; hard, very friable; many fine roots; slightly acid; clear wavy boundary.

C2—18 to 25 inches; yellowish red (5YR 5/6) fine sandy loam, yellowish red (5YR 4/6) moist; massive; slightly hard, very friable; common fine roots; slightly acid; clear wavy boundary.

C3—25 to 35 inches; red (2.5YR 5/6) fine sandy loam, red (2.5YR 4/6) moist; massive; very hard, friable; common fine roots; slightly acid; clear wavy boundary.

C4—35 to 40 inches; red (2.5YR 5/6) loamy fine sand, red (2.5YR 4/6) moist; massive; slightly hard, very friable; few very fine roots; slightly acid; clear wavy boundary.

C5—40 to 53 inches; light reddish brown (5YR 6/4) loamy fine sand, reddish brown (5YR 5/4) moist; massive; soft, very friable; few very fine roots; medium acid; clear wavy boundary.

C6—53 to 64 inches; stratified reddish yellow (5YR 6/6) loamy very fine sand and yellowish red (5YR 5/6) fine sandy loam, yellowish red (5YR 5/6, 4/6) moist; massive; slightly hard, very friable; few very fine roots; neutral; clear wavy boundary.

C7—64 to 84 inches; reddish brown (5YR 5/3) loam, reddish brown (5YR 4/3) moist; massive; hard, friable; many thin strata of loamy fine sand; neutral.

The A horizon is 6 to 16 inches thick. It has hue of 2.5YR or 7.5YR, value of 4 to 6, and chroma of 3 to 6. Where the moist value and chroma is 3 or less, the thickness is 10 inches or less. In some pedons, the A horizon has up to 15 inches of loamy fine sand overwash sediments covering the normal pedon. The A horizon ranges from medium acid to neutral. Where limed, it ranges from medium acid to moderately alkaline.

The C horizon has hue of 2.5YR to 7.5YR, value of 4 to 6, and chroma of 3 to 6. It is dominantly fine sandy loam, but thin strata of loam, very fine sandy loam, loamy very fine sand, or loamy fine sand also occur. Above a depth of 40 inches, the C horizon has a weighted average of less than 18 percent clay content and more than 15 percent material coarser than very fine sand. This horizon ranges from medium acid to neutral to a depth of 40 inches and ranges from medium acid to moderately alkaline below that.

The Pulaski soils have buried horizons or lithologic discontinuity below a depth of 30 inches in some pedons. Buried horizons or horizons of lithologic discontinuity, where present, have hue of 2.5YR to 10YR, value of 4 to 6, and chroma of 2 to 6. They range from fine sand to silty clay. These horizons range from medium acid to moderately alkaline. In some pedons, they are calcareous below a depth of 40 inches.

Renfrow Series

Soils of the Renfrow series are deep, well drained, and very slowly permeable. These very gently sloping to gently sloping soils formed in materials weathered from clayey Permian shale. They are on convex ridge crests and side slopes of uplands (fig. 19). Slopes range from 1 to 5 percent. The soils of the Renfrow series are fine, mixed, thermic Udertic Paleustolls.

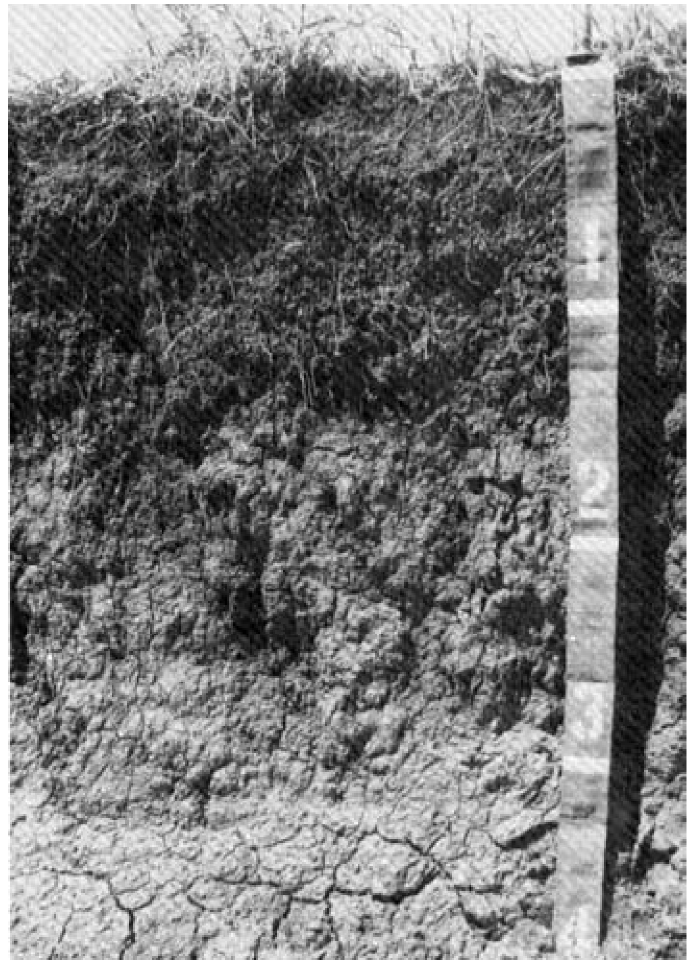


Figure 19.—A profile of Renfrow silt loam. The fibrous root system of native grasses helps form moderate granular structure in upper 12 inches of the mollic epipedon. Shrinkage cracks are evident throughout the clayey subsoil.

Renfrow soils are associated with Bethany, Doolin, Grainola, Grant, Huska, Kingfisher, Lucien, Norge, Norge Variant, Port, Teller Variant, and Weswood soils. Bethany soils are on broad, upland ridge crests and have a mollic epipedon more than 20 inches thick and a COLE value less than 0.07. Doolin soils are on broad, smooth plains at slightly higher elevations than Renfrow soils and have an abrupt textural change from the A horizon to the B horizon and a natric horizon. Grainola soils are in lower or higher positions on side slopes than Renfrow soils, do not have a mollic epipedon, and have a solum 20 to 40 inches thick. Grant and Kingfisher soils are in similar positions on the landscape and are fine-silty. Huska soils are intermingled with Renfrow soils and have a natric horizon. Lucien soils are in lower positions on ridge crests and side slopes than Renfrow soils and are shallow over sandstone. Norge and Norge Variant soils are on foot slopes and have a fine-silty control section.

Port and Weswood soils are on adjoining flood plains to Renfrow soils, do not have an argillic horizon, and have a fine-silty control section. Port soils have a mollic epipedon more than 20 inches thick, and Weswood soils do not have a mollic epipedon. Teller Variant soils are on foot slopes and have a fine-loamy control section.

Typical pedon of Renfrow silt loam from an area of Renfrow-Huska complex, 1 to 5 percent slopes; about 1,300 feet west and 50 feet south from the northeast corner of sec. 6, T. 9 N., R. 2 W.

A1—0 to 8 inches; brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; weak medium platy structure parting to moderate medium granular; slightly hard, friable; many very fine and few fine roots; neutral; clear smooth boundary.

B1—8 to 12 inches; reddish brown (5YR 5/3) silty clay loam, dark reddish brown (5YR 3/3) moist; weak fine subangular blocky structure parting to moderate medium granular; hard, firm; many very fine and few fine roots; slightly acid; clear smooth boundary.

B21t—12 to 29 inches; reddish brown (5YR 5/4) silty clay, reddish brown (5YR 4/4) moist; weak medium prismatic structure parting to moderate medium blocky; very hard, very firm; many very fine roots; nearly continuous clay films on faces of peds; few fine black concretions; neutral; gradual smooth boundary.

B22t—29 to 43 inches; yellowish red (5YR 5/6) silty clay, yellowish red (5YR 4/6) moist; weak medium subangular blocky structure; extremely hard, extremely firm; common very fine roots; nearly continuous clay films on faces of peds; common fine black concretions; few soft bodies of calcium carbonate; moderately alkaline; gradual smooth boundary.

B3—43 to 60 inches; red (2.5YR 5/6) silty clay, red (2.5YR 4/6) moist; weak medium blocky structure; extremely hard, extremely firm; few very fine roots; nearly continuous clay films on faces of peds; few fine black concretions; about 50 percent by volume shale fragments from 2 mm to 76 mm in diameter in lower 2 inches; few calcium carbonate concretions; common soft bodies of calcium carbonate; slightly effervescent; moderately alkaline; clear wavy boundary.

Cr—60 to 84 inches; streaked light red (2.5YR 6/6), red (2.5YR 5/6), and very pale brown (10YR 7/3) soft laminated shale, red (2.5YR 5/6, 4/6) and pale brown (10YR 6/3) moist; slightly effervescent; moderately alkaline.

Thickness of the solum and depth to bedrock are 60 inches or more.

The A1 or Ap horizon is 4 to 12 inches thick. It has hue of 5YR to 10YR, value of 4 to 5, and chroma of 2 or 3. The A1 or Ap horizon is silt loam or silty clay loam. This horizon ranges from slightly acid to mildly alkaline.

The B1 horizon is 0 to 8 inches thick. It has hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 2 or 3. The B1 horizon is silty clay loam. The clay content ranges from about 27 to 35 percent. This horizon is mixed with the plow layer in some pedons. The B1 horizon ranges from slightly acid to mildly alkaline.

The B21t horizon is 6 to 20 inches thick. It has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 3 to 6. The B21t horizon is silty clay loam or silty clay. The clay content ranges from about 36 to 50 percent. This horizon ranges from neutral to moderately alkaline.

The B22t horizon is 6 to 28 inches thick. It has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 4 to 6. The B22t horizon is silty clay. The clay content ranges from about 40 to 55 percent. This horizon ranges from neutral to moderately alkaline.

Some pedons have B23t and B24t horizons from 0 to 27 inches thick. They have hue of 2.5YR, value of 4 or 5, and chroma of 4 to 6. The B23t and B24t horizons are silty clay. The clay content ranges from about 40 to 55 percent. These horizons are moderately alkaline.

The B3 horizon is 4 to 25 inches thick. It has hue of 10R or 2.5YR, value of 4 or 5, and chroma of 6 to 8. In some pedons, the B3 horizon has brownish or grayish mottles. The B3 horizon is silty clay loam or silty clay. The clay content ranges from about 35 to 50 percent. The B3 horizon has coarse fragments of siltstone or shale from 2 mm or 76 mm in diameter that make up from 0 to 50 percent by volume in the lower few inches. This horizon is moderately alkaline.

The Cr horizon is red siltstone or shale streaked or mottled in shades of gray, white, or olive. It has thin lenses of sandstone interbedded in some pedons.

The Renfrow soils in map units 64 and 65 are taxadjunct to the Renfrow series because they have mollic colors thinner than is typical for the Renfrow series because of thinning of the surface layer by erosion. Use, behavior, and management are similar to the Renfrow soils.

Slaughterville Series

Soils of the Slaughterville series are deep, well drained, and moderately rapidly permeable. These very gently sloping to steep soils formed in loamy and sandy eolian Pleistocene materials. They are on side slopes and ridge crests of uplands. Slopes range from 1 to 25 percent. The soils of the Slaughterville series are coarse-loamy, mixed, thermic Udic Haplustolls.

Slaughterville soils are associated with Canadian, Derby, Dougherty, Konawa, Norge, Slaughterville Variant, Teller, and Vanoss soils. Canadian soils are on adjoining flood plains. Derby soils are in higher positions on hummocky or undulating landscapes than Slaughterville soils and have an ochric epipedon and a sandy control section. Dougherty and Konawa soils are on undulating side slopes and ridge crests and have an ochric epipedon, an argillic horizon, and a fine-loamy control section. Dougherty soils have an A horizon more than 20 inches thick. Norge soils are in higher positions on the landscape than Slaughterville soils and have an argillic horizon and a fine-silty control section. Slaughterville Variant and Teller soils are in similar positions on the landscape as Slaughterville soils. Slaughterville Variant soils have a buried horizon that is more clayey than Slaughterville soils within 50 inches of the surface. Teller soils have an argillic horizon and a fine-loamy control section. Vanoss soils are on broad, higher ridge crests than Slaughterville soils and have an argillic horizon and a fine-silty control section.

Typical pedon of Slaughterville fine sandy loam, 3 to 5 percent slopes; about 2,040 feet east and 580 feet north from the southwest corner of sec. 29, T. 10 N., R. 3 W.

A—0 to 9 inches; brown (10YR 5/3) fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard, very friable; many very fine and few medium roots; slightly acid; clear smooth boundary.

A1—9 to 18 inches; brown (10YR 4/3) fine sandy loam, dark brown (10YR 3/3) moist; moderate medium granular structure; slightly hard, very friable; many very fine roots; slightly acid; gradual smooth boundary.

B2—18 to 30 inches; brown (7.5YR 5/4) fine sandy loam, dark brown (7.5YR 4/4) moist; weak fine subangular blocky structure; slightly hard, very friable; many very fine roots; neutral; gradual smooth boundary.

C1—30 to 58 inches; yellowish red (5YR 5/6) fine sandy loam, yellowish red (5YR 4/6) moist; massive; soft, very friable; common very fine roots; mildly alkaline; gradual smooth boundary.

C2—58 to 76 inches; yellowish red (5YR 5/6) loamy fine sand, yellowish red (5YR 5/6) moist; massive; soft, very friable; few very fine roots; moderately alkaline.

Thickness of the solum is 20 to more than 50 inches thick.

The Ap or A1 horizon is 8 to 20 inches thick. It has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3. The Ap or A1 horizon ranges from medium acid to neutral.

The B2 horizon is 10 to 56 inches thick. It has hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 2 to 4. The B2 horizon is fine sandy loam. The clay content ranges from about 10 to 18 percent. This horizon ranges from slightly acid to moderately alkaline.

The C horizon has hue of 5YR or 7.5YR, value of 5 to 7, and chroma of 4 to 6. It is mainly fine sandy loam but in some pedons, it includes loamy fine sand below a depth of 45 inches. The C horizon is stratified below a depth of 50 inches in some pedons. This horizon ranges from neutral to moderately alkaline.

Slaughterville Variant

Soils of the Slaughterville Variant are deep, well drained, and moderately permeable. These sloping soils formed in loamy and sandy eolian Pleistocene materials. They are on side slopes of uplands. Slopes range from 5 to 8 percent. The soils of the Slaughterville Variant are coarse-loamy, mixed, thermic Udic Haplustolls.

Slaughterville Variant soils are associated with Derby, Dougherty, Konawa, Norge, Slaughterville, Teller, and Vanoss soils. Derby soils are in higher positions on hummocky or undulating landscapes than Slaughterville Variant soils and have an ochric epipedon and a sandy control section. Dougherty and Konawa soils are on undulating side slopes and ridge crests and have an ochric epipedon, an argillic horizon, and a fine-loamy control section. Dougherty soils have an A horizon more than 20 inches thick. Norge soils are in higher positions on the landscape than Slaughterville Variant soils and have an argillic horizon and a fine-silty control section. Slaughterville and Teller soils are in similar positions on the landscape as Slaughterville Variant soils. Slaughterville soils do not have buried horizons that are more clayey within a depth of 50 inches of the surface. Teller soils have an argillic horizon and a fine-loamy control section. Vanoss soils are on broad, higher ridge crests than Slaughterville Variant soils and have an argillic horizon and a fine-silty control section.

Typical pedon of Slaughterville Variant fine sandy loam, 5 to 8 percent slopes; about 2,600 feet south and 1,200 feet west from the northeast corner of sec. 20, T. 6 N., R. 1 W.

Ap—0 to 7 inches; brown (10YR 5/3) fine sandy loam, dark brown (10YR 3/3) moist; weak thin platy structure parting to weak fine granular; slightly hard, very friable; many very fine and fine roots; medium acid; clear smooth boundary.

A1—7 to 11 inches; brown (7.5YR 5/2) fine sandy loam, dark brown (7.5YR 3/2) moist; weak fine granular structure; slightly hard, very friable; many very fine roots; slightly acid; gradual smooth boundary.

B2—11 to 26 inches; brown (7.5YR 5/4) fine sandy loam, dark brown (7.5YR 4/4) moist; weak medium subangular blocky structure; slightly hard, very friable; common very fine roots; neutral; gradual smooth boundary.

C1—26 to 38 inches; light brown (7.5YR 6/4) fine sandy loam, brown (7.5YR 5/4) moist; massive; slightly hard, very friable; few very fine roots; neutral; clear smooth boundary.

C2—38 to 45 inches; pink (7.5YR 7/4) fine sandy loam, brown (7.5YR 5/4) moist; massive; hard, friable; few very fine roots; many soft bodies and mycelia forms of calcium carbonate; few calcium carbonate concretions; violently effervescent; moderately alkaline; clear smooth boundary.

IIB2tb—45 to 64 inches; light brown (7.5YR 6/4) silty clay loam, brown (7.5YR 5/4) moist; weak medium subangular blocky structure; very hard, firm; patchy clay films on faces of peds; common mycelia forms of calcium carbonate; violently effervescent; moderately alkaline; gradual smooth boundary.

IIB3b—64 to 74 inches; light brown (7.5YR 6/4) loam, brown (7.5YR 5/4) moist; common fine distinct dark yellowish brown (10YR 4/4) mottles; hard, friable; common mycelia forms of calcium carbonate; strongly effervescent; moderately alkaline.

Thickness of the solum is 25 to 45 inches. Depth to the IIB2tb horizon ranges from 35 to 50 inches.

The A horizon is 11 to 18 inches thick. It has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3. The A horizon is medium acid or slightly acid.

The B2 horizon is 10 to 29 inches thick. It has hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 2 to 4. The B2 horizon ranges from slightly acid to moderately alkaline.

The C1 horizon is 0 to 25 inches thick. It has hue of 5YR or 7.5YR, value of 5 or 6, and chroma of 4 to 6. The C1 horizon ranges from neutral to moderately alkaline.

The C2 horizon is 0 to 25 inches thick. It has hue of 5YR or 7.5YR, value of 5 to 7, and chroma of 4 to 6. The C2 horizon is moderately alkaline.

The IIB2tb and IIB3b horizons have hue of 5YR or 7.5YR, value of 4 to 6, and chroma of 4 to 6. They are silt loam, silty clay loam, clay loam, loam, or sandy clay loam. The IIB2tb and IIB3b horizons range from neutral to moderately alkaline.

The Slaughterville Variant soils differ from the soils of the Slaughterville series because they have a coarse-loamy control section underlain by buried fine-silty or fine-loamy argillic horizons between a depth of 35 to 50 inches, and they are moderately permeable.

Stephenville Series

The soils of the Stephenville series are moderately deep, well drained, and moderately permeable. These very gently sloping to sloping soils formed in materials weathered from Permian sandstone. They are on convex ridge crests and side slopes of uplands. Slopes range from 1 to 8 percent. The soils of the Stephenville series are fine-loamy, siliceous, thermic Ultic Haplustalfs.

Stephenville soils are associated with Darsil, Derby, Harrah, Littleaxe, Newalla, Pulaski, and Tribbey soils. Darsil soils are intermingled with the Stephenville soils. Darsil soils have a sandy control section, have a solum 10 to 20 inches thick, and do not have an argillic horizon. Derby soils are on undulating uplands and have a solum more than 72 inches thick, an argillic horizon that has lamallae, and a sandy control section. Harrah soils are on foot slopes and have a solum more than 60 inches thick. Littleaxe soils are on broad ridge crests and have a solum 40 to 60 inches thick over bedrock. Newalla soils are in similar positions on the landscape and have a fine-loamy over clayey control section and a solum 40 to 60 inches thick over shale. Pulaski and Tribbey soils are on adjoining flood plains, do not have an argillic horizon, and have an irregular decrease in organic matter content. Tribbey soils have a high water table within 40 inches of the surface.

Typical pedon of Stephenville fine sandy loam, from an area of Stephenville-Darsil-Newalla complex, 3 to 8 percent slopes; about 1,550 feet east and 50 feet south of the northwest corner of sec. 16, T. 9 N., R. 1 E.

A1—0 to 4 inches; brown (10YR 5/3) fine sandy loam, dark brown (10YR 3/3) moist; weak medium granular structure; soft, very friable; many fine roots; medium acid; clear smooth boundary.

A2—4 to 10 inches; pinkish gray (7.5YR 6/2) loamy fine sand, brown (7.5YR 5/2) moist; weak fine granular structure; soft, very friable; many fine roots; strongly acid; clear smooth boundary.

B21t—10 to 16 inches; reddish yellow (5YR 6/6) sandy clay loam, yellowish red (5YR 5/6) moist; weak medium subangular blocky structure; very hard, friable; patchy clay films on faces of peds; common fine roots; very strongly acid; gradual smooth boundary.

B22t—16 to 25 inches; light red (2.5YR 6/6) sandy clay loam, red (2.5YR 5/6) moist; moderate medium subangular blocky structure; very hard, friable; patchy clay films on faces of peds; common fine roots; very strongly acid; gradual smooth boundary.

B3—25 to 28 inches; light red (2.5YR 5/8) sandy clay loam, red (2.5YR 5/8) moist; weak medium subangular blocky structure; few fine roots; patchy clay films on faces of peds; 10 percent by volume sandstone fragments from 2 mm to 76 mm in diameter; strongly acid; clear smooth boundary.

Cr—28 to 36 inches; red (2.5YR 4/8) and yellowish red (5YR 5/8) soft fine grained sandstone; slightly acid.

Thickness of the solum and depth to bedrock are 20 to 40 inches.

The A1 or Ap horizon is 2 to 10 inches thick. It has hue of 5YR to 10YR, value of 4 or 5, and chroma of 2 to 4. Chroma of 6 is in some pedons, where plowed. The A1 or Ap horizon ranges from strongly acid to slightly acid. Where limed, it is slightly acid or neutral.

The A2 horizon is 0 to 12 inches thick. It has hue of 5YR or 7.5YR, value of 4 to 7, and chroma of 3 or 4. The A2 horizon is fine sandy loam or loamy fine sand. This horizon is absent in some pedons, where plowed. It ranges from strongly acid to slightly acid. Where limed, it ranges from strongly acid to neutral.

The B21t horizon is 6 to 17 inches thick. It has hue of 2.5YR or 5YR, value of 4 to 6, and chroma of 6 to 8. The B21t horizon is sandy clay loam. The clay content ranges from 20 to 35 percent. This horizon ranges from very strongly acid to slightly acid.

The B22t horizon is 0 to 10 inches thick. It has hue of 2.5YR, value of 5 or 6, and chroma of 6 to 8. The B22t horizon is sandy clay loam. The clay content ranges from 20 to 30 percent. This horizon ranges from very strongly acid to medium acid.

The B3 horizon is 0 to 12 inches thick. It has hue of 2.5YR or 5YR, value of 4 to 6, and chroma of 6 to 8. The B3 horizon is sandy clay loam or fine sandy loam. The clay content ranges from 12 to 25 percent. The B3 horizon has fragments of soft sandstone from 2 mm to 76 mm in diameter that make up from 0 to 35 percent by volume. It ranges from strongly acid to slightly acid.

The Cr horizon is soft, fine grained sandstone in shades of red, brown, and yellow in hue of 2.5YR or 5YR. In some pedons, it is streaked in shades of brown or yellow.

Teller Series

Soils of the Teller series are deep, well drained, and moderately permeable. These very gently sloping to sloping soils formed in loamy Pleistocene sediments. They are on ridge crests and side slopes of upland terraces (fig. 20). Slopes range from 1 to 8 percent. The soils of the Teller series are fine-loamy, mixed, thermic Udic Argiustolls.

Teller soils are associated with Derby, Dougherty, Grant, Konawa, Kingfisher, Norge, Norge Variant, Slaughterville, Slaughterville Variant, and Vanoss soils. Derby soils are in higher hummocky or undulating areas than Teller soils and have an ochric epipedon and a sandy control section. Dougherty and Konawa soils are in higher positions on ridge crests and side slopes than Teller soils and have an ochric epipedon. Dougherty soils have an A horizon that is more than 20 inches thick. Grant soils are in higher positions on ridge crests than Teller soils and have a fine-silty control section and a solum 40 to 60 inches thick over bedrock. Kingfisher soils are on higher upland ridge crests, are moderately deep, and have a fine-silty control section. Norge, Norge Variant, Slaughterville, and Slaughterville Variant soils are in similar positions on the landscape as Teller soils. Norge and Norge Variant soils have a fine-silty control section. Slaughterville and Slaughterville Variant soils have a cambic horizon and a coarse-loamy control section. Vanoss soils are on higher, broad ridge crests than Teller soils and have brown hue in the Bt horizon and a fine-silty control section.

Typical pedon of Teller fine sandy loam, 1 to 3 percent slopes; about 1,600 feet south and 1,050 feet west from the northeast corner of sec. 17, T. 8 N., R. 2 W.

Ap—0 to 6 inches; brown (7.5YR 5/2) fine sandy loam, dark brown (7.5YR 3/2) moist; weak fine granular structure; slightly hard, very friable; many fine and common medium roots; slightly acid; clear smooth boundary.

A1—6 to 13 inches; brown (7.5YR 4/2) fine sandy loam, dark brown (7.5YR 3/2) moist; moderate fine granular structure; slightly hard, very friable; many fine and common medium roots; slightly acid; clear smooth boundary.

B1—13 to 19 inches; brown (7.5YR 5/2) fine sandy loam, dark brown (7.5YR 3/2) moist; weak medium prismatic structure parting to moderate medium granular; hard, friable; many fine and few medium roots; slightly acid; gradual smooth boundary.

B2t—19 to 37 inches; reddish brown (5YR 5/4) sandy clay loam, reddish brown (5YR 4/4) moist; weak medium prismatic structure parting to moderate medium subangular blocky; very hard, friable; common fine and few medium roots; patchy clay films on faces of peds; neutral; gradual smooth boundary.

B3—37 to 60 inches; yellowish red (5YR 5/6) fine sandy loam, yellowish red (5YR 4/6) moist; weak medium subangular blocky structure; hard, very friable; few fine roots; patchy clay films on faces of peds; neutral; clear smooth boundary.

IIB21tb—60 to 69 inches; brown (7.5YR 5/4) silty clay loam, dark brown (7.5YR 4/4) moist; moderate medium subangular blocky structure; hard, firm; few fine roots; patchy clay films on faces of peds; moderately alkaline; gradual smooth boundary.

IIB22tb—69 to 84 inches; yellowish brown (10YR 5/4) silty clay loam, dark yellowish brown (10YR 4/4) moist; moderate medium blocky structure; very hard, very firm; nearly continuous clay films on faces of peds; moderately alkaline.

Thickness of the solum is 50 to more than 80 inches. The depth to the IIB2tb horizon ranges from 30 to more than 60 inches.

The A horizon is 5 to 16 inches thick. It has hue of 5YR to 10YR, value of 4 or 5, and chroma of 2 or 3. The A horizon is medium acid or slightly acid. Where limed, it ranges from medium acid to mildly alkaline.

The B1 horizon is 0 to 8 inches thick. It has hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 2 to 4. The B1 horizon is fine sandy loam or loam. The clay content ranges from about 15 to 25 percent. This horizon is medium acid or slightly acid. Where limed, it ranges from medium acid to mildly alkaline.

The B2t horizon is 10 to 45 inches thick. It has hue of 2.5YR or 5YR, value of 4 to 6, and chroma of 3 to 8. In some pedons, the B2t horizon has brownish or reddish mottles in the lower part of the horizon. The B2t horizon is sandy clay loam or clay loam. The clay content ranges from about 20 to 34 percent. This horizon ranges from medium acid to neutral.

The B3 horizon is 0 to 30 inches thick. It has hue of 2.5YR or 5YR, value of 5 or 6, and chroma of 4 to 8. In some pedons, the B3 horizon has reddish, brownish, or yellowish mottles. The B3 horizon is fine sandy loam or very fine sandy loam. In some pedons, it has quartzite gravel from 2 mm to 76 mm in diameter that makes up from 0 to 5 percent by volume. This horizon ranges from medium acid to mildly alkaline.

The IIB2tb horizon, where present, has hue of 2.5YR to 10YR, value of 4 to 6, and chroma of 3 to 8. It is silty clay loam or silty clay. The clay content ranges from about 27 to 45 percent. The IIB2tb horizon is mildly alkaline or moderately alkaline.

The C horizon, where present, has hue of 2.5YR or 5YR, value of 4 to 6, and chroma of 6 to 8. It is very fine sandy loam or fine sandy loam. The C horizon ranges from medium acid to moderately alkaline.

Teller Variant

Soils of the Teller Variant are moderately deep to deep, well drained, and moderately permeable. These

Figure 20.—A profile of Teller fine sandy loam that shows the mollic epipedon from about 0 to 13 inches and the argillic horizon extending to a depth of 60 inches or more. The buried horizons begin at about 48 inches in this profile.

gently sloping to sloping soils formed in loamy Pleistocene alluvium and colluvium. They are on side slopes and toe slopes of mantled uplands. Slopes range from 3 to 8 percent. The soils of the Teller Variant are fine-loamy, mixed, thermic Typic Argiustolls.

Teller Variant soils are associated with Kingfisher, Lucien, Norge, Norge Variant, and Renfrow soils. Kingfisher soils are on ridge crests and have a fine-silty control section and a solum from 20 to 40 inches thick over sandstone and shale bedrock and do not have a IIC horizon that has coarse fragments. Lucien soils are on ridge crests, have a solum less than 20 inches thick over sandstone bedrock, and do not have a IIC horizon that has coarse fragments. Norge and Norge Variant soils are in similar positions on the landscape as Teller Variant soils and have a fine-silty control section. Norge soils do not have a IIC horizon that has coarse fragments. Renfrow soils are on ridge crests and are in higher positions on side slopes than Teller Variant soils and have a fine control section.

Typical pedon of Teller Variant loam from an area of Norge Variant and Teller Variant soils, 3 to 8 percent slopes; about 2,350 feet west and 1,300 feet north from the southeast corner of sec. 12, T. 8 N., R. 2 W.

A1—0 to 10 inches; reddish brown (5YR 5/3) loam, dark reddish brown (5YR 3/3) moist; weak fine granular structure; slightly hard, friable; many fine and common medium roots; about 2 percent by volume gravel from 2 mm to 76 mm in diameter; moderately alkaline; clear smooth boundary.

B1—10 to 18 inches; reddish brown (5YR 5/4) loam, reddish brown (5YR 4/4) moist; weak medium subangular blocky structure; hard, friable; common fine and few medium roots; about 4 percent by volume gravel from 2 mm to 76 mm in diameter; moderately alkaline; clear wavy boundary.

B2t—18 to 32 inches; yellowish red (5YR 5/6) gravelly sandy clay loam; yellowish red (5YR 4/6) moist; weak medium subangular blocky structure; very hard, friable; common fine roots; patchy clay films on faces of peds; about 15 percent by volume gravel from 2 mm to 76 mm in diameter; strongly effervescent; moderately alkaline; clear wavy boundary.

IIC—32 to 72 inches; red (2.5YR 5/6) extremely gravelly loam, red (2.5YR 4/6) moist; massive; slightly hard, friable; few fine roots; about 85 percent by volume gravel from 2 mm to 76 mm in diameter; thin strata of fine sand and gravelly fine sand; violently effervescent; moderately alkaline.

Thickness of the solum and depth to gravel bedrock are 20 to 60 inches. Depth to secondary lime ranges from 15 to 36 inches.

The A1 or Ap horizon is 5 to 12 inches thick. It has hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 2 or 3. The A1 or Ap horizon has gravel from 2 mm to 76 mm in diameter that makes up from 0 to 5 percent by volume. This horizon ranges from slightly acid to moderately alkaline.

The B1 horizon is 0 to 8 inches thick. It has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 4 to 6. The B1 horizon is loam or clay loam. The clay content ranges from 15 to 28 percent. The B1 horizon has gravel from 2 mm to 76 mm in diameter that makes up from 0 to 5 percent by volume. This horizon ranges from slightly acid to moderately alkaline.

The B2t horizon is 14 to 40 inches thick. It has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 4 to 8. The B2t horizon is clay loam, gravelly clay loam, gravelly sandy clay loam, or sandy clay loam. The clay content ranges from 20 to 32 percent. The B2t horizon has gravel from 2 mm to 76 mm in diameter that makes up from 0 to 35 percent by volume. This horizon is mildly alkaline or moderately alkaline.

The IIC horizon is 24 inches to more than 15 feet thick. It is underlain by red shale or sandstone in most pedons. The IIC horizon has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 4 to 8. This horizon is stratified layers of very gravelly or extremely gravelly phases of fine sand, sandy loam, loam, clay loam, or sandy clay loam. It has gravel from 2 mm to 76 mm in diameter that makes up from 35 to 90 percent by volume, and has cobbles more than 76 mm in diameter that makes up from 0 to 5 percent.

The Teller Variant soils differ from the soils of the Teller series because they have secondary lime higher in the profile than the soils of the Teller series and have a IIC horizon that has coarse fragments.

Tribbey Series

Soils of the Tribbey series are deep, somewhat poorly drained, and moderately permeable to moderately rapidly permeable. These nearly level to very gently sloping soils formed in recent loamy and sandy alluvium. They are on low flood plains. Slopes range from 0 to 2 percent. The soils of the Tribbey series are coarse-loamy, mixed, nonacid, thermic Aquic Udifluvents.

Tribbey soils are associated with Harrah, Port, Pulaski, Stephenville, and Weswood soils. Harrah and Stephenville soils are on adjoining uplands to Tribbey soils and have an argillic horizon. Harrah soils do not have a high water table, and Stephenville soils have a solum 20 to 40 inches thick over sandstone. Port, Pulaski, and Weswood soils are in slightly higher positions on flood plains than Tribbey soils and do not have a high water table. Port and Weswood soils have a fine-silty control section. Port soils have a mollic epipedon, and Weswood soils have a cambic horizon.

Typical pedon of Tribbey fine sandy loam, frequently flooded; about 2,100 feet south and 50 feet east from the northwest corner of sec. 22, T. 9 N., R. 1 W.

A1—0 to 4 inches; reddish brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; weak fine granular structure; slightly hard, very friable; many very fine and fine roots; slightly acid; abrupt wavy boundary.

C1—4 to 24 inches; reddish brown (2.5YR 5/4) fine sandy loam, reddish brown (2.5YR 4/4) moist; massive; slightly hard, very friable; common very fine and fine roots; thin strata of red (2.5YR 5/6) clay loam and light red (2.5YR 6/6) loamy fine sand; high water table at a depth of 12 inches; medium acid; clear wavy boundary.

C2—24 to 72 inches; yellowish red (5YR 5/6) loamy very fine sand, yellowish red (5YR 4/6) moist; massive; slightly hard, very friable; thin strata of reddish brown (5YR 5/4) loam and light reddish brown (5YR 6/4) loamy fine sand; few very fine roots to a depth of 42 inches; medium acid.

The high water table is 0.5 foot to 3.5 feet below the surface most of the year, averaging about 24 inches. Some pedons have buried horizons below a depth of 30 inches.

The A1 or Ap horizon is 3 to 10 inches thick. It has hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 3 to 6. In some pedons, the A1 or Ap horizon has lighter colored recent overwash up to 10 inches thick. This horizon ranges from slightly acid to moderately alkaline.

The C horizon has hue of 2.5YR to 7.5YR, value of 4 to 6, and chroma of 3 to 6. In some pedons, it has mottles in shades of brown or red. The C horizon is loamy very fine sand, fine sandy loam, or loam. Thin strata of sandy clay loam, loamy fine sand, loam, or clay loam ranges from 1/2 inch to 15 inches thick. The clay content ranges from 6 to 30 percent, and the weighted average of clay content in the 10- to 40-inch control section is about 15 percent. The sand content is 15 percent or more fine sand or coarser. The C horizon ranges from medium acid to moderately alkaline.

Vanoss Series

Soils of the Vanoss series are deep, well drained, and moderately permeable. These nearly level to very gently sloping soils formed in loamy Pleistocene alluvium. They are on smooth, broad ridge crests of upland terraces. Slopes range from 0 to 3 percent. The soils of the Vanoss series are fine-silty, mixed, thermic Udic Argiustolls.

Vanoss soils are associated with Bethany, Derby, Dougherty, Konawa, Norge, Slaughterville, Slaughterville Variant, and Teller soils. Bethany soils are in similar positions on the landscape as Vanoss soils and have a mollic epipedon more than 20 inches thick and a fine control section. Derby soils are in higher undulating or hummocky areas, do not have a mollic epipedon or continuous argillic horizon, and have a sandy control section. Dougherty and Konawa soils are in slightly higher positions on the landscape than Vanoss soils and do not have a mollic epipedon. Dougherty soils have a loamy control section, and Konawa soils have a fine-loamy control section. Norge, Slaughterville, Slaughterville Variant, and Teller soils are on side slopes and in lower positions on ridge crests than Vanoss soils. Norge soils have hue of 5YR or redder in the B2t horizon and do not decrease in clay content by 20 percent or more within 60 inches of the surface. Slaughterville and Slaughterville Variant soils have a cambic horizon and a coarse-loamy control section. Teller soils have redder hue in the upper Bt horizons and a fine-loamy control section.

Typical pedon of Vanoss silt loam, 0 to 1 percent slopes; about 600 feet west and 100 feet south from the northeast corner of sec. 20, T. 6 N., R. 1 W.

Ap—0 to 8 inches; brown (7.5YR 5/2) silt loam, dark brown (7.5YR 3/2) moist; weak fine granular structure; slightly hard, very friable; many very fine and fine roots; medium acid; clear smooth boundary.

A1—8 to 11 inches; brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; moderate fine granular structure; slightly hard, very friable; many very fine roots; slightly acid; gradual smooth boundary.

B1—11 to 19 inches; brown (7.5YR 5/2) silt loam, dark brown (7.5YR 3/2) moist; weak fine subangular blocky structure parting to moderate fine granular; hard, friable; common very fine roots; common wormcasts; neutral; gradual smooth boundary.

B21t—19 to 42 inches; brown (7.5YR 5/4) silty clay loam, dark brown (7.5YR 4/4) moist; weak medium subangular blocky structure; hard, friable; common very fine roots; patchy clay films on faces of peds; common wormcasts; neutral; gradual smooth boundary.

B22t—42 to 53 inches; light brown (7.5YR 6/4) silty clay loam, brown (7.5YR 5/4) moist; moderate medium subangular blocky structure; hard, friable; few very fine roots; patchy clay films on faces of peds; few fine black concretions; neutral; clear smooth boundary.

IIC1—53 to 70 inches; reddish brown (5YR 5/4) loam, reddish brown (5YR 4/4) moist; massive; hard, friable; few very fine roots; neutral; gradual smooth boundary.

IIC2—70 to 90 inches; light reddish brown (5YR 6/4) sandy clay loam, reddish brown (5YR 5/4) moist; common fine faint yellowish red (5YR 5/6) mottles; massive; hard, friable; neutral.

Thickness of the solum is 40 to more than 60 inches.

The A horizon is 11 to 20 inches thick. It has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3. The A horizon ranges from medium acid to neutral.

The B1 horizon is 0 to 9 inches thick. It has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 3 or 4.

The B1 horizon is silt loam or silty clay loam. The clay content ranges from 20 to 30 percent. This horizon is slightly acid or neutral.

The B21t horizon is 8 to 25 inches thick. It has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 3 or 4. The B21t horizon is silty clay loam. The clay content ranges from about 27 to 35 percent. This horizon is slightly acid or neutral.

The B22t horizon is 0 to 20 inches thick. It has hue of 7.5YR or 10YR, value of 5 or 6, and chroma of 4 to 6. In some pedons, the B22t horizon has brownish or yellowish mottles. The B22t horizon is silty clay loam. The clay content ranges from about 27 to 35 percent. This horizon is slightly acid or neutral.

Some pedons have a B3 horizon from 0 to 25 inches thick. It has hue of 5YR to 10YR, value of 5 or 6, and chroma of 4 to 8. In some pedons, the B3 horizon has mottles in shades of red, yellow, or brown. The B3 horizon is loam, silt loam, clay loam, or silty clay loam. The clay content ranges from about 12 to 32 percent. This horizon is slightly acid or neutral.

The C or IIC horizon has hue of 5YR to 10YR, value of 5 or 6, and chroma of 4 to 8. In most pedons, it has mottles in shades of red, brown, yellow, or gray. The C or IIC horizon is loam, very fine sandy loam, fine sandy loam, or sandy clay loam. It has coarse fragments from 2 mm to 76 mm in diameter that make up from 0 to 10 percent by volume. The C or IIC horizon ranges from neutral to moderately alkaline.

Some pedons have B2tb and B3b horizons below the argillic horizon. They have hue of 5YR to 10YR, value of 4 to 6, and chroma of 2 to 6. The B2tb and B3b horizons are loam or silty clay loam. The clay content ranges from about 20 to 35 percent. These horizons range from neutral to moderately alkaline.

Weswood Series

Soils of the Weswood series are deep, well drained, and moderately permeable. These nearly level to very gently sloping soils formed in recent loamy alluvium. They are on low flood plains. Slopes range from 0 to 2 percent. The soils of the Weswood series are fine-silty, mixed, thermic Fluventic Ustochrepts.

Weswood soils are associated with Grainola, Lomill, Norge, Port, Pulaski, Renfrow, and Tribbey soils. Grainola soils are on adjoining uplands and have an argillic horizon and a fine control section. Lomill soils are on lower flood plains in slightly depressional areas and have a mollic epipedon and a clayey over loamy control section. Norge soils are on adjoining uplands and have a mollic epipedon, an argillic horizon, and a solum more than 60 inches thick. Port soils are in slightly higher areas, farther from the stream channel than Weswood soils, have a mollic epipedon more than 20 inches thick, and do not have secondary lime in the upper part of the control section. Pulaski and Tribbey soils are in similar positions on the landscape as Weswood soils, do not have a cambic horizon, and have a coarse-loamy control section. Renfrow soils are on adjoining uplands and have a mollic epipedon, an argillic horizon, and a fine control section. Tribbey soils have a high water table within 40 inches of the surface most of the time.

Typical pedon of Weswood silt loam, occasionally flooded; about 2,100 feet north and 400 feet east from the southwest corner of sec. 2, T. 9 N., R. 2 W.

Ap—0 to 9 inches; reddish brown (5YR 5/3) silt loam, reddish brown (5YR 4/3) moist; weak medium platy structure parting to weak medium granular; slightly hard, very friable; many fine and few medium roots; neutral; clear smooth boundary.

B2—9 to 20 inches; reddish brown (5YR 5/4) silt loam, reddish brown (5YR 4/4) moist; weak medium subangular blocky structure; slightly hard, friable; many fine roots; slightly effervescent; moderately alkaline; gradual smooth boundary.

C1—20 to 32 inches; reddish yellow (5YR 6/6) silt loam, yellowish red (5YR 5/6) moist; massive; hard, friable; common fine roots; few mycelia forms of calcium carbonate; violently effervescent; moderately alkaline; gradual wavy boundary.

C2—32 to 49 inches; reddish brown (5YR 5/4) silt loam; reddish brown (5YR 4/4) moist; massive; very hard, firm; few fine roots; common thin strata; few mycelia forms of calcium carbonate; strongly effervescent; moderately alkaline; clear wavy boundary.

Ab—49 to 66 inches; reddish brown (5YR 5/3) silty clay loam, dark reddish brown (5YR 3/3) moist; moderate medium granular structure; hard, friable; few fine roots; slightly effervescent; gradual wavy boundary.

B2b—66 to 84 inches; reddish brown (5YR 5/4) silty clay loam, reddish brown (5YR 4/4) moist; weak fine subangular blocky structure; very hard, firm; few mycelia forms and few fine bodies of calcium carbonate; strongly effervescent; moderately alkaline.

Thickness of the solum is 16 to 36 inches. Stratification or bedding planes is between a depth of 20 and 40 inches. The depth to a buried horizon ranges from 40 to more than 60 inches.

The Ap or A1 horizon is 6 to 16 inches thick. It has hue of 2.5YR to 10YR, value of 4 or 5, and chroma of 2 to 6. Where the chroma is 3 or less, the thickness of the horizon is less than 10 inches. In some pedons, the Ap or A1 horizon has up to 12 inches of very fine sandy loam or fine sandy loam overwash. This horizon ranges from neutral to moderately alkaline.

The B2 horizon is 8 to 25 inches thick. It has hue of 2.5YR to 7.5YR, value of 4 to 6, and chroma of 3 to 6. The B2 horizon is silt loam or silty clay loam. The clay content ranges from about 18 to 30 percent.

The C horizon has hue of 2.5YR or 5YR, value of 4 to 7, and chroma of 3 to 8. It is silt loam or silty clay loam, but, in some pedons, it is thin strata of fine sandy loam to silty clay loam.

The Ab and B2b horizons, where present, have hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 3 to 6. They are silt loam or silty clay loam.

The Weswood soils in this survey area are taxadjunct to the Weswood series because they have slightly lower chroma in the A and B horizons than is typical for the Weswood series, and some pedons are slightly thinner to bedrock than allowed for the series. Use, behavior, and management are similar to the Weswood soils.

Formation of the Soils

The general geology of the survey area is described in this section. Also described are the major factors of soil formation and the processes of soil formation as they relate to the soils in Cleveland County.

Geology

Kenneth S. Johnson, Oklahoma Geological Survey, The University of Oklahoma, helped to prepare this section.

Outcropping rock units in Cleveland County consist of Permian sandstone and shale deposited near the shores of shallow seas that once covered much of western Oklahoma. Cleveland County was close to the eastern shoreline of this ancient sea. It was the site for deposition of interbedded sandstones, siltstones, and shales laid down in alternating river, delta, tidal-flat, and shallow-sea environments. In many parts of the county, these sedimentary rocks are mantled by unconsolidated alluvium laid down by ancient or modern rivers and streams. The outcropping sandstones and the unconsolidated alluvium are major sources of fresh ground water. These outcropping strata are underlain by additional sedimentary rocks that are important reservoirs for petroleum. For information on the geological formations in Cleveland County, see the general geology map at the back of this publication.

Subsurface rock units of sedimentary origin are about 10,000 feet thick in the eastern part of the county and about 14,000 feet thick in the western part. These strata rest upon a so-called "basement" of granite and other igneous or metamorphic rocks that are 20 to 25 miles deep. The subsurface sedimentary rocks were deposited in great, shallow seas that bordered the famous Anadarko Basin of western Oklahoma. These seas inundated the Cleveland County area intermittently from the Cambrian age, about 525 million years ago, until the middle of the Permian age, about 250 million years ago. Cleveland County is considered part of the central Oklahoma arch that was uplifted gently in several episodes before the Permian age. The various rock formations that underlie the county dip gently to the west.

Outcropping rocks are mostly red, reddish brown, or yellowish red, although locally they are light gray or olive gray. The red results from the presence of iron oxides in the form of oxidized minerals, such as hematite, distributed uniformly throughout the rock. Iron is also present in the gray or other nonred rocks, but the iron is not in the oxidized state. Soils developed from the reddish rocks tend to retain the hematite stain of the parent material, thus explaining the reddish soils in Cleveland County.

The oldest rocks exposed in Cleveland County crop out along the eastern border. These rocks are overlain by successively younger Permian strata to the west. Outcropping strata dip gently across the county to the west at an angle of less than one degree.

The soils in most areas result from the weathering and disaggregation of outcropping rock units. The character of these rock formations and the soils that develop from them are closely related. A description of the outcropping rock units helps to explain the character and distribution of soils.

The oldest rock unit exposed in Cleveland County is the Wellington Formation. It is exposed only in the east-central part of the county, where Little River and its tributaries have cut deeply through overlying strata. The Wellington Formation consists mainly of reddish brown shale with interbeds of reddish brown and orangish brown sandstone and siltstone. Sandstone beds in this formation and beds in the overlying Garber Sandstone make up the Garber-Wellington aquifer. Although the Wellington Formation is about 400 to 500 feet thick in the area, only the uppermost 50 feet of the formation is exposed. Outcrops of the Wellington Formation are mantled by soils of the Stephenville-Harrah-Newalla general soil map unit. These soils are typically loamy sand or sandy loam that formed in materials weathered from sandstones, siltstones, and shales. The soils are moderately deep or deep, moderately well drained or well drained, and very gently sloping to sloping. Soils developed from the Wellington sandstones are typically moderately permeable, whereas those developed from the shales are very slowly permeable.

Overlying the Wellington Formation is the Garber Sandstone, which crops out throughout the eastern half of the county. It consists mainly of orangish brown to reddish brown sandstone beds irregularly interlayered with reddish brown shale and siltstone. The area of Garber Sandstone is rolling, sloping hills that are forested with scrub post oak, blackjack oak, and other small, slow-growing deciduous trees that are common on sandy soils that receive about 32 to 38 inches of rainfall each year. The Garber Sandstone ranges from about

300 to 500 feet thick. Soils that are weathering from the Garber Sandstone are of the Stephenville-Harrah-Newalla and the Stephenville-Littleaxe-Darsil general soil map units. These soils typically are loamy sand and sandy loam that weathered from sandstone. The soils are shallow to deep, moderately well drained to excessively drained, and very gently sloping to sloping. They are moderately permeable to rapidly permeable.

In the southern third of the county, the western outcrops of the Garber Sandstone are mantled by soils in the Renfrow-Grainola-Grant and Norge-Teller-Vanoss general soil map units. These soils are finer grained than other soils overlying the Garber. They are loamy and are weathering from the shales or in old alluvium that overlies the sandstones and shales. These soils are very slowly permeable to moderately permeable, very gently sloping to moderately steep, moderately deep or deep, and well drained.

Rose rocks, also known as "barite roses" or "sand-barite rosettes," (see fig. 16) are abundant in the Darsil and Stephenville soils that form on outcrops of the Garber Sandstone. Rose rocks, designated as the official State rock in 1968, are restricted to outcrops of the Garber Sandstone in central Oklahoma. The growth of the mineral barite as a cluster of divergent blades (or crystals) within the red sandstones formed the rose-like appearance of rose rocks. The barite crystals enveloped and incorporated the quartz grains of the sandstone, and thus acquired the red color of the host rock. Rose rocks generally occur as isolated individuals scattered through sandstone, although, in some places, they occur as intergrown clusters. The rose rocks are harder and more durable than the host rock, and they weather into positive relief on outcrops. On further weathering, they are detached from the sandstone and occur as individual specimens or are scattered within residual sandy soils. Slow weathering and erosion of the host rock continually expose additional rose rocks.

The Hennessey Group, which overlies the Garber Sandstone, has an outcrop that is nearly level to gently sloping grass-covered prairies, largely barren of trees except along the valleys of intermittent streams where precipitation from runoff is more concentrated. The Hennessey consists mainly of reddish brown shale with some interbeds of siltstone and fine grained sandstone. The formation is about 600 feet thick in the northwestern part of the county, but, in some places, the upper part of the formation has been removed by erosion. Only the lower 100 to 200 feet of the Hennessey remains in the Norman area. Outcrops of the Hennessey are mantled mainly by soils of the Renfrow-Grainola-Grant general soil map unit and less extensively by soils of the Doolin-Bethany-Urban land general soil map unit. Soils in both map units typically are moderately deep to deep, nearly level to moderately steep, moderately well drained to well drained, and very slowly permeable to moderately permeable. Most of these soils are silt loam, silty clay loam, or silty clay and are typical of soils weathered from predominantly shale bedrock.

Overlying the Hennessey is the Duncan Sandstone, the youngest of the Permian formations in the county. Duncan outcrops are restricted to about 3 square miles in the extreme northwest corner of the county, where only the lowest 50 feet of the formation is exposed. The Duncan Sandstone consists mainly of orangish brown sandstones interbedded with reddish brown shales and siltstones. Soils that have weathered from the Duncan Sandstone are mainly of the Renfrow-Grainola-Grant and Norge-Teller-Vanoss general soil map units. These soils are moderately deep or deep, very gently sloping to moderately steep, well drained, loamy soils formed in materials weathered from sandstones and shales or from old alluvium underlain by sandstones and shales.

Quaternary alluvium and terrace deposits in Cleveland County range from about 10 to 100 feet thick. They consist mainly of sand, silt, clay, and some gravel. These sediments eroded from Permian strata within and to the west of the county and from many other rock units lying west and northwest of the county within the South Canadian River drainage basin. Quaternary sediments, generally deposited within the past million years, were laid down mainly as flood plain or alluvial terrace deposits along major rivers and streams flowing to the east, southeast, and south across the county. Some of the sands and silts have been windblown into dunes.

Terrace deposits consist of older alluvium that was left behind after a river shifts position or after a river cuts more deeply into the underlying material. These deposits occur on broad, nearly level to sloping plains or on hummocky, undulating dunes that are higher and lay mostly adjacent to flood plains. They are mainly northeast and east of the South Canadian River flood plain and in smaller areas of the Little River drainage basin. These terrace deposits are mantled mostly by soils of the Norge-Teller-Vanoss general soil map unit, and less extensively by soils of the Doolin-Bethany-Urban land general soil map unit in areas around Norman and farther to the north and northwest. Soils in these map units are deep, nearly level to sloping, well drained or moderately well drained, very slowly permeable to moderately permeable silt loam to fine sandy loam formed in old unconsolidated alluvial and windblown sediments.

Alluvial deposits are the unconsolidated sediments in stream channels or flood plains of rivers and streams, such as the main stem and tributaries of the South Canadian River and Little River. The South Canadian River alluvium is mantled by soils of the Gracemore-Gracemont Variant-Gaddy, Asher-Keokuk-Canadian, and Lomill-Brewless general soil map units. Little River sediments and tributaries to the South Canadian River and Little River typically are covered by soils of the Port-Weswood and Pulaski-Tribbey general soil map units. These map units consist of deep, nearly level to very gently sloping soils weathering in unconsolidated materials. They range from somewhat excessively drained to somewhat poorly drained, sandy to clayey, and rapidly permeable to very slowly permeable.

The mineral and water resources of Cleveland County are important to the development and progress of the county. Petroleum production is the most important mineral activity. Production in the county in 1983 amounted to about 2.8 million barrels of crude oil (valued at nearly 85 million dollars) and about 8.8 billion cubic feet of natural gas (valued at 21.4 million dollars). Cleveland County ranks near the middle of the petroleum-producing counties in the state. Sand and gravel have been mined from a number of sites in the alluvial and terrace deposits in the county. Some of the sandstone and siltstone beds have been quarried locally as native stone for building and for fill material.

Good-quality ground water is abundant in some of the major alluvial and terrace deposits and also in the Garber-Wellington aquifer that underlies most of the county. The Garber-Wellington aquifer surrounds the Garber Sandstone and the upper part of the Wellington Formation (see cross section of the general geology map). It includes those parts of both formations that contain permeable sandstone layers where the pores in the sandstones are filled with fresh water. The aquifer ranges in thickness from about 500 to 700 feet.

Water wells drilled into the Garber-Wellington aquifer commonly yield 25 to 400 gallons per minute of water containing only 200 to 700 milligrams per liter of dissolved solids. The aquifer is recharged by precipitation and runoff that percolates down through the soil into the porous and permeable sandstones of the Garber Sandstone and Wellington Formation. This ground water then moves slowly downward and flows laterally to the west within the downdip sandstone layers. The aquifer water is salty in the lower part of the Wellington Formation and farther to the west where the Garber Sandstone extends beneath the South Canadian River. (See the cross section on that general geology map.)

Where the Garber Sandstone or Wellington Formation crop out, ground water generally can be encountered in any sandstone bed at or below the ground-water surface. Farther west, where the relatively impermeable Hennessey Group overlies the Garber Sandstone, wells must be drilled into the water-bearing sands of the Garber-Wellington aquifer. Upon encountering a fresh-water sand, the water will be forced up the drill hole several hundred feet under artesian pressure to the potentiometric surface, which is some 100 to 200 feet below the sand surface *(3, 6)*.

Factors of Soil Formation

Soil is the product of five major factors of soil formation—parent material, climate, plants and animals (especially plants), relief, and time. If a given factor, vegetation for example, differs from one area to another, but the other four factors remain the same, the soil formed in the two areas differs.

Parent Material

Parent material is the unconsolidated material from which soil is formed. It is one of the major factors of soil formation in the county. Parent material establishes the limits of the physical properties and chemical and mineral composition of the soil, and it influences the rate of soil development.

The soils on the uplands of Cleveland County formed in parent materials weathered from sandstone, siltstone, shale, alluvial and colluvial mantle sediments, and eolian deposits. Darsil, Littleaxe, and Stephenville soils formed in material weathered from acid sandstone. Grant, Kingfisher, and Lucien soils formed in material weathered from alkaline sandstone or siltstone. Grainola, Newalla, and Renfrow soils formed in material weathered from alkaline shales. Norge, Teller, and Vanoss soils formed in loamy mantle alluvial sediments, and Bethany, Doolin, and Pawhuska soils formed in clayey mantle alluvial sediments. Harrah soils formed in loamy colluvial sediments predominantly from sandstone.

In many areas the mantled upland soils and colluvial soils have buried soil horizons within three to five feet of the soil surface. These buried horizons are commonly more clayey and are similar in color or slightly darker than the soil material above. These buried horizons formed in older materials deposited during a previous depositional period.

Eolian sediments and wind reworked alluvial sediments are common on the uplands paralleling the South Canadian River to the east and north. Derby and Goodnight soils formed in sandy eolian sediments that have been mostly deposited as large dunes. Dougherty, Konawa, and Slaughterville soils formed in wind-reworked alluvial sediment.

Alluvial sediment is extensive along the South Canadian River and Little River and the many tributaries throughout the county. The sediment deposited and soil that formed in it depends largely on the source of sediment and the velocity of the floodwater. Asher, Canadian, Gracemont Variant, Keokuk, Port, and Weswood soils formed in loamy sediments deposited by streams where they overflowed. Gaddy and Gracemore soils formed in sandy sediment deposited by fast moving water near the South Canadian River. Pulaski and Tribbey soils formed in loamy and sandy sediments deposited on low flood plains along small streams in the eastern part of the county. Brewless and Lomill soils formed in clayey and loamy alluvium deposited by slow moving water on high flood plains of major streams.

Climate

The moist, subhumid, continental climate of Cleveland County is characterized by high-intensity rainfall. Moisture and warm temperatures have promoted the formation of distinct horizons in many of the soils. Differences in soils, however, cannot be attributed to climate because the climate is uniform throughout the county. Heavy rains have caused rapid runoff that has eroded many of the soils. This erosion is an indirect effect of climate.

Plants and Animals

Plants, burrowing animals, insects, and micro-organisms have a direct influence on the formation of soils. The native grasses and trees have had different effects on the losses and gains of organic matter and plant nutrients and on the soil structure and porosity. For example, Bethany soils, which developed under prairie vegetation, have a dark grayish brown surface layer and a moderately high content of organic matter. Stephenville and Newalla soils, which developed under forest vegetation, have a brown surface layer and a low content of organic matter.

Relief

Relief influences the formation of soils through its effect on water movement, erosion, soil temperature, and plant cover. In Cleveland County, relief is determined largely by the resistance of the underlying formations to weathering, the activity of the South Canadian and Little Rivers and the major tributaries, and geologic erosion. About 13 percent of the acreage in Cleveland County is nearly level soils on flood plains, and 87 percent is nearly level to steep soils on uplands.

Renfrow and Grainola soils formed in similar shale parent material; however, their development was controlled to a large extent by relief. The deep Renfrow soils are less sloping than the moderately deep Grainola soils.

Time

As a factor in soil formation, time is difficult to measure strictly in years. The length of time needed for development of genetic horizons depends on the intensity and the interactions of soil-forming factors in promoting the loss, gain, transfer, or transformation of the constituents necessary to form soil horizons. Soils that do not have definite genetic horizons are young or immature. Mature soils have approached equilibrium with their environment and tend to have well defined horizons.

The soils in Cleveland County range from young to old. Doolin and Bethany soils are mature soils on uplands. Grant and Teller soils are younger, but they have well expressed horizons. Lucien and Darsil soils are considered young. They have had sufficient time to develop well expressed horizons; but because they are sloping, geologic erosion takes away the soil material almost as fast as it forms. Gaddy and Pulaski soils are young. They formed in recent sediments on flood plains and show little horizon development.

Active Processes of Soil Formation

Active processes that have influenced the formation of horizons in the soils of Cleveland County are accumulation of organic matter, leaching of calcium carbonate and bases, and translocation of silicate clay minerals. In most soils, more than one of these processes have been active.

Native grasses add organic matter to the surface layer and contributes a more developed granular structure. A surface layer that is high in content of organic matter, such as in Bethany soils, is called a mollic epipedon. Konawa soils formed under trees and contain less organic matter than Bethany soils. Their surface layer is called an ochric epipedon.

Leaching of carbonates and bases is active in the formation of soils. The accumulation of calcium carbonate and bases in the lower part of the B horizon of Renfrow soils indicates the depth to which water has percolated. Harrah soils have been leached to the extent that they lack accumulation of calcium carbonate. More bases have been leached from the B horizon of these soils; this is reflected by their base saturation. Soils on flood plains, such as Gracemont Variant soils, are recharged with bases when flooding occurs. The more acid Pulaski soils have not been leached, but they receive sediments from neutral to acid soils. Doolin soils, which formed over weathered shale beds and clayey sediments, are high in carbonates and soluble salts. Calcium carbonates and soluble salts in Doolin soils are related to the nature of the parent materials.

The translocation of silicate clay minerals is a very important factor in establishing the properties and classification of soils. Clay films on faces of peds, bridging sand grains, and increases in total clay are evidence of argillic horizons. Many soils, including Norge and Grant soils, have an argillic horizon. The varying degrees of translocation of silicate clay minerals and the kind of parent material in which a soil formed have resulted in wide variations in the texture and other properties of the argillic horizon in different soils. Konawa and Dougherty soils have a subsurface layer that is more intensely leached of silicate clay minerals than the surface layer of other soils in the county.

Grasses bring bases to the surface. This retards leaching and the formation of an A2 horizon. Geologic erosion on such soils as Lucien soils hinders horizon development. The sediment on Gracemore and Tribbey soils and on other soils on flood plains was deposited so recently that there has not been enough time for the formation of horizons.

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Glossary

ABC soil. A soil having an A, a B, and a C horizon.

AC soil. A soil having only an A and a C horizon. Commonly such soil formed in recent alluvium or on steep rocky slopes.

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well-aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali (sodic) soil. Soil having so high a degree of alkalinity (pH 8.5 or higher), or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

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

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

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

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

	Inches
Very low	0 to 3
Low	3 to 6
Medium	6 to 9
High	9 to 12
Very high	more than 12

Base saturation. The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, K), expressed as a percentage of the total cation-exchange capacity.

Bedding planes. Fine stratifications, less than 5 millimeters thick, in unconsolidated alluvial, eolian, lacustrine, or marine sediments.

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

Bisequum. Two sequences of soil horizons, each of which consists of an illuvial horizon and the overlying eluvial horizons.

Blowout. A shallow depression from which all or most of the soil material has been removed by wind. A blowout has a flat or irregular floor formed by a resistant layer or by an accumulation of pebbles or cobbles. In some blowouts the water table is exposed.

Bottom land. The normal flood plain of a stream, subject to flooding.

Boulders. Rock fragments larger than 2 feet (60 centimeters) in diameter.

Broad-base terrace. A ridge-type terrace built to control erosion by diverting runoff along the contour at a nonscouring velocity. The terrace is 10 to 20 inches high and 15 to 30 feet wide and has gently sloping sides, a rounded crown, and a dish-shaped channel along the upper side. It may be nearly level or have a grade toward one or both ends.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Capillary water. Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena. A sequence, or "chain," of soils on a landscape that formed in similar kinds of parent material but that have different characteristics as a result of differences in relief and drainage.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity, but is more precise in meaning.

Channery soil. A soil that is, by volume, more than 15 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches along the longest axis. A single piece is called a fragment.

Chiseling. Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard compacted layers to a depth below normal plow depth.

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.

Claybeds. Old buried alluvial clay sediment. In Cleveland County, Norge soils are underlain by this sediment.

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

Claypan. A slowly permeable soil horizon that contains much more clay than the horizons above it. A claypan is commonly hard when dry and plastic or stiff when wet.

Climax vegetation. The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse fragments. If round, mineral or rock particles 2 millimeters to 25 centimeters (10 inches) in diameter; if flat, mineral or rock particles (flagstone) 15 to 38 centimeters (6 to 15 inches) long.

Coarse textured soil. Sand or loamy sand.

Cobblestone (or cobble). A rounded or partly rounded fragment of rock 3 to 10 inches (7.5 to 25 centimeters) in diameter.

Colluvium. Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex slope. Irregular or variable slope. Planning or constructing terraces, diversions, and other water-control measures on a complex slope is difficult.

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

Compressible (in tables). The volume of soft soil decreases excessively under load.

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

Conservation tillage. A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

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

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

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

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

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

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

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

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

Cemented.—Hard; little affected by moistening.

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

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Corrosive. High risk of corrosion to uncoated steel or deterioration of concrete.

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

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Decreasers. The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Deferred grazing. Postponing grazing or resting grazingland for a prescribed period.

Dense layer (in tables). A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

Depth to rock (in tables). Bedrock is too near the surface for the specified use.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

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

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

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

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

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

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

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

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

Drainage, surface. Runoff, or surface flow of water, from an area.

Eluviation. The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

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

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

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

Excess sodium (in tables). Excess exchangeable sodium is in the soil. The resulting poor physical properties restrict the growth of plants.

Excess fines (in tables). Excess silt and clay are in the soil. The soil is not a source of gravel or sand for construction purposes.

Excess salts (in tables). Excess water-soluble salts in the soil restrict the growth of most plants.

Fallow. Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grains are grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fast intake (in tables). The movement of water into the soil is rapid.

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

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity.*

Fine textured soil. Sandy clay, silty clay, and clay.

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

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

Foot slope. The inclined surface at the base of a hill.

Forb. Any herbaceous plant that is not a grass or a sedge.

Fragile (in tables). The soil is easily damaged by use or disturbance.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Gleyed soil. Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors and mottles.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

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

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

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

Ground water (geology). Water filling all the unblocked pores of underlying material below the water table.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hardpan. A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an upper case letter represents the major horizons. Numbers or lower case letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the *Soil Survey Manual.* The major horizons of mineral soil are as follows:

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

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

E horizon.—The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon.—The mineral horizon below an O, A, or E horizon. The B horizon is, in part, a layer of transition from the overlying horizon to the underlying C horizon. The B horizon also has distinctive characteristics, such as accumulation of clay, sesquioxides, humus, or a combination of these; prismatic or blocky structure; redder or browner colors than those in the A horizon; or a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil does not have a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, the Arabic numeral 2 precedes the letter C.

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

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Illuviation. The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil. A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Increasers. Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the plants that are the less palatable to livestock.

Infiltration. The downward entry of water into the immediate surface of soil or other material. This contrasts with percolation, which is movement of water through soil layers or material.

Infiltration capacity. The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate. The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake in inches per hour is expressed as follows:

Less than 0.2	very low
0.2 to 0.4	low
0.4 to 0.75	moderately low
0.75 to 1.25	moderate
1.25 to 1.75	moderately high
1.75 to 2.5	high
More than 2.5	very high

Invaders. On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, invader plants follow disturbance of the surface.

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are—

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Basin.—Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Controlled flooding.—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle).—Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow.—Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler.—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation.—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding.—Water, released at high points, is allowed to flow onto an area without controlled distribution.

Lamellae. Thin bands of fibers of translocated clay that constitute illuvial, and in many cases argillic, horizons in sandy upland soils.

Landslide. The rapid downhill movement of a mass of soil and loose rock, generally when wet or saturated. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Large stones (in tables). Rock fragments that are 3 inches (7.5 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Leaching. The removal of soluble material from soil or other material by percolating water.

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

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

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

Low strength. The soil is not strong enough to support loads.

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

Metamorphic rock. Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement. Nearly all such rocks are crystalline.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

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

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

Moderately coarse textured soil. Sandy loam and fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, and silty clay loam.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

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

Munsell notation. A designation of color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

Narrow-base terrace. A terrace no more than 4 to 8 feet wide at the base. A narrow-base terrace is similar to a broad-base terrace, except for the width of the ridge and channel.

Neutral soil. A soil having a pH value between 6.6 and 7.3. (See Reaction, soil.)

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Open space. A relatively undeveloped green or wooded area provided mainly within an urban area to minimize feelings of congested living.

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

High—soils with a pachic or cumulic epipedon
Medium—soils with a mollic epipedon
Low—soils with an ochric epipedon or an eroded mollic epipedon

Pan. A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan*.

Parent material. The unconsolidated organic and mineral material in which soil forms.

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

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil adversely affects the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are:

Very slow	less than 0.06 inch
Slow	0.06 to 0.2 inch
Moderately slow	0.2 to 0.6 inch
Moderate	0.6 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Piping (in tables). Subsurface tunnels or pipelike cavities are formed by water moving through the soil.

Pitting (in tables). Pits are caused by melting ground ice. They form on the soil after plant cover is removed.

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

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

Plowpan. A compacted layer formed in the soil directly below the plowed layer.

Ponding. Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poorly graded. Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Poor filter (in tables). Because of rapid permeability, the soil may not adequately filter effluent from a waste disposal system.

Poor outlets (in tables). In these areas, surface or subsurface drainage outlets are difficult or expensive to install.

Productivity, soil. The capability of a soil for producing a specified plant or sequence of plants under specific management.

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

Rangeland. Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Range condition. The present composition of the plant community on a range site in relation to the potential natural plant community for that site. Range condition is expressed as excellent, good, fair, or poor, on the basis of how much the present plant community has departed from the potential.

Range site. An area of rangeland where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. A range site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other range sites in kind or proportion of species or total production.

Reaction, soil. A measure of the acidity or alkalinity of a soil expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH
Extremely acid	below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Regolith. The unconsolidated mantle of weathered rock and soil material on the earth's surface; the loose earth material above the solid rock.

Relief. The elevations or inequalities of a land surface, considered collectively.

Residuum (residual soil material). Unconsolidated, weathered, or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Rill. A steep sided channel resulting from accelerated erosion. A rill is generally a few inches deep and not wide enough to be an obstacle to farm machinery.

Rippable. Rippable bedrock or hardpan can be excavated using a single-tooth ripping attachment mounted on a tractor with a 200-300 draw bar horsepower rating.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rooting depth (in tables). There is a shallow root zone. The soil is shallow over a layer that greatly restricts roots.

Root zone. The part of the soil that can be penetrated by plant roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Saline soil. A soil containing soluble salts in an amount that impairs the growth of plants. A saline soil does not contain excess exchangeable sodium.

Salty water (in tables.) Water is too salty for consumption by livestock.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone. Sedimentary rock containing dominantly sand-size particles.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil adversely affects the specified use.

Sequum. A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the underlying material. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Shale. Sedimentary rock formed by the hardening of a clay deposit.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silica. A combination of silicon and oxygen. The mineral form is called quartz.

Silica-sesquioxide ratio. The ratio of the number of molecules of silica to the number of molecules of alumina and iron oxide. The more highly weathered soils or their clay fractions in warm-temperate, humid regions, and especially those in the tropics, generally have a low ratio.

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

Siltstone. Sedimentary rock made up of dominantly silt-sized particles.

Site index. A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75 feet.

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on the steeper slopes; on faces of blocks, prisms, and columns; and in swelling clayey soils, where there is marked change in moisture content.

Slick spot. A small area of soil having a puddled, crusted, or smooth surface and an excess of exchangeable sodium. The soil is generally silty or clayey, is slippery when wet, and is low in productivity.

Slippage (in tables). The soil mass is susceptible to movement downslope when loaded, excavated, or wet.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope (in tables). Slope is great enough that special practices are required to ensure satisfactory performance of the soil for a specific use.

Slow intake (in tables). The slow movement of water into the soil.

Slow refill (in tables). The slow filling of ponds, resulting from restricted permeability in the soil.

Small stones (in tables). Rock fragments less than 3 inches (7.5 centimeters) in diameter. Small stones adversely affect the specified use of the soil.

Sodicity. The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium absorption ratio (SAR) of a saturation extract, or the ratio of Na^+ to $Ca^{++} + Mg^{++}$. The degrees of sodicity are—

	SAR
Slight	less than 13:1
Moderate	13-30:1
Strong	more than 30:1

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows:

	Millimeters
Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and plant and animal activities are largely confined to the solum.

Stone line. A concentration of coarse fragments in a soil. Generally it is indicative of an old weathered surface. In a cross section, thickness of the line can be one fragment or more. It generally overlies material that weathered in place, and it is overlain by recent sediment of variable thickness.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter.

Stony. Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stripcropping. Growing crops in a systematic arrangement of strips or bands that provide vegetative barriers to wind and water erosion.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Stubble mulch. Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

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

Subsoiling. Breaking up a compact subsoil by pulling a special chisel through the soil.

Substratum. The part of the soil below the solum.

Subsurface layer. Technically, the A2 horizon. Generally refers to a leached horizon lighter in color and lower in organic matter content than the overlying surface layer.

Summer fallow. The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior.

Terrace. An embankment, or ridge, constructed on the contour or at a slight angle to the contour across sloping soils. The terrace intercepts surface runoff, so that water soaks into the soil or flows slowly to a prepared outlet.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt 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."

Thin layer (in tables). An otherwise suitable soil material that is too thin for the specified use.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toe slope. The outermost inclined surface at the base of a hill; part of a foot slope.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Toxicity (in tables). An excessive amount of toxic substances in the soil, such as sodium or sulfur, severely hinders the establishment of vegetation or severely restricts plant growth.

Trace elements. Chemical elements, such as zinc, cobalt, manganese, copper, and iron, are in soils in extremely small amounts. They are essential to plant growth.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Valley fill. In glaciated regions, material deposited in stream valleys by glacial melt water. In nonglaciated regions, alluvium deposited in stream valleys by heavily loaded streams.

Variant, soil. A soil having properties sufficiently different from those of other known soils to justify a new series name, but occurring in such a limited geographic area that creation of a new series is not justified.

Weathering. All physical and chemical changes produced by atmospheric agents in rocks or other deposits at or near the earth's surface. These changes result in disintegration and decomposition of the material.

Well graded. Refers to soil material consisting of course grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. This contrasts with poorly graded soil.

Wilting point (or permanent wilting point). The moisture content of soil, on an ovendry basis, at which a plant (specifically sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.